# The field performance of tissue culture-derived plantain cultivars

J. K. OSEI
*University of Ghana Agricultural Research Station, P. O. Box 43, Kade, Ghana*

SUMMARY

Tissue culture-derived local true horn plantain cultivar, Asamienu, grown under adequate moisture and fertility conditions, showed somaclonal variation in the geotropic orientation of the fingers that make up the fruit hand, in the number of hands per fruit bunch, and in bunch weight. The culture procedures were found to be satisfactory for the growth and yield of a French cultivar, Oniaba, and a false horn cultivar, Apantu. The cucumber mosaic virus was present in some of the tissue-culture-derived plants. These observations indicate that there is the need to modify the existing culture techniques to reduce somaclonal variation in the local true horn plantains, and to eliminate viruses in the ex-plant before adopting *in vitro* procedures for mass propagation of plantains in Ghana.

Original scientific paper. Received 22 Jan 96; revised 13 May 96.

RÉSUMÉ

OSEI, J. K.: *La performance terroir de varietés de plantain dérivé de culture de tissus.* Cultivé sous conditions de humidité et de fertilité adéquate, Asamienu, une variété de plantain indigéne, véritable et corné dérivé de culture de tissus montrait une variation somaclonale dans l' orientation géotropique des doigts qui composent la main par régime de fruit et dans le légime de poids. Les procédure culturelles se montraient satisfaisantes pour la croissance et le rendement d' Oniaba, une variété fraçaise et d' Apantu, une fausse variété cornée. Le virus mosaïque de concombre était préesent dans quelques plantes dérivées de culture de tissus. Ces observation indiquent qu' il est nécessaire de modifier les techniques culturelles afin de réduire la variation somaclonale dans les plantains indigènes véritables cornés et d' éliminer les virus dans les plantes anciennes avant d' adopter les procédures *in-vitro* pour la propagation en masses de plantain au Ghana.

## Introduction

Although plantain is a priority starchy staple in Ghana (Anon., 1993), its production is steadily declining. The rate of decline can be inferred from the proportion used to prepare fufu, a favourite Ghanaian dish. Fufu is prepared by pounding together boiled peeled plantain fruit and cassava tuber into a thick paste which is eaten with soup and meat.

In a survey conducted by Hemeng *et al.* (1995) on plantain production in Ghana, it was found that the lack of sufficient numbers of planting materials free from nematode and insect pests was among the major constraints in plantain production. The major insect pest of plantain in Ghana is *Cosmopolites sordidus*. The major nematodes that attack plantains in Ghana are *Helicotylenchus* spp., *Pratelenchus* spp., and *Radopholus* spp. (Afreh-Nuamah, 1994).

Shoot-tip culture is a well established, adequate and relatively simple *in vitro* method that is routinely used in the rapid clonal multiplication of selected plantain genotypes, and in the production of clean planting materials. Its major advantages are that *in vitro* propagules are free from non-obscure pathogens, and can be multiplied at rates that are several orders of magnitude higher than those obtained with conventional methods (Jarret, 1986; Vuylsteke, 1989).

Protocols developed at IITA (International Institute of Tropical Agriculture, Ibadan, Nigeria) (Vuylsteke, 1989) have been adopted by the Department of Botany, University of Ghana, Legon, to produce plantain plantlets from local cultivars.

There are over 20 local plantain cultivars which have been classified into three major groups namely: Apem (French plantain), Apantu (Falsehorn) and Asamienu (Truehorn) (Karikari, 1971, 1973; Hemeng *et al.*, 1995). Because tissue culture-induced somaclonal variation occurs frequently in some plantain cultivars (Vuylsteke & Swennen, 1992), it was necessary to study the field performance of the tissue culture-derived local plantain cultivars before recommending their adoption to farmers.

## Materials and methods

The study was carried out at ARS, Kade (University of Ghana Agricultural Research Station, Kade). The climate, vegetation and soils of ARS, Kade are representative of the forest zone of Ghana. The annual rainfall of 1200 mm is distributed between two seasons. The major season is from March to July with a peak in June. The minor season is from September to November. The period from December to February is dry.

A hydromorphic area which had fallowed for 6 years was used for the study. The area was cleared and burnt in November, 1993. Drainage was constructed in June, 1994 to drain excess water. Weeds were controlled by regular weeding.

Six-month old tissue culture plants of local plantain cultivars listed in Table 1 were obtained from the Department of Botany, University of Ghana, Legon. The ex-plants were from ARS, Kade. They were planted at 3 m apart in December 1993 in a randomized complete block design with five replications. Each replication consisted of two rows of at least six plants per cultivar. Field-derived Apantu suckers were included as controls. One hundred grams N:P:K: 15:15:15 compound fertilizer was applied to each plant 2 weeks after planting. Measurements were taken on the height, girth and number of leaves at flowering, days from planting to flowering and harvest, bunch weight, mean number of hands per bunch and mean number of fingers per bunch.

Leaf samples of plants with abnormal growth and mosaic leaf symptoms were sent to Dr B. Lockhart, of the Department of Plant Pathology, University of Minnesota, USA, for virus identifica-

TABLE 1

*Vegetative Growth, Yield and Yield Components of Tissue-Culture-Derived Local Plantain Cultivars*

| *Cultivars* | *Mean no. of leaves at flowering* | *Mean height at flowering (cm)* | *Mean girth at flowering (cm)* | *Mean no. of days to flowering* | *Mean no. of days from flowering to harvesting* | *Mean bunch weight (kg)* | *Mean no. of hands per bunch* | *Mean no. of fingers per bunch* |
|---|---|---|---|---|---|---|---|---|
| Tissue-culture-derived Oniaba | 10.0 | 360 | 60.0 | 288 | 74.9 | 18.1 | 7.1 | 106 |
| Tissue-culture-derived Apantu | 9.6 | 337 | 57.9 | 274 | 72.5 | 13.8 | 7.4 | 38.4 |
| Field-derived-Apantu | 10.7 | 325 | 57.3 | 292 | 83.1 | 13.0 | 6.8 | 33.5 |
| Tissue-culture-derived Asamienu | 10.6 | 423 | 73.6 | 297 | 90.4 | 17.0 | 2.0 | 30.3 |
| *Variants* | | | | | | | | |
| Osakro | 12.0 | 407 | 72.0 | 301 | 93.0 | 10.6 | 1.0 | 12.0 |
| Asamiensa | 11.6 | 371 | 69.3 | 322 | 84.3 | 15.3 | 3.0 | 36.0 |
| LSD | 1.6 | 12.0 | 10.0 | 20.0 | 11.0 | 3.0 | 1.0 | 5.0 |

tion, using serological methods and electron microscopy.

## Results and discussion

Table 1 shows the vegetative growth, yield and yield components of the tissue culture derived plantain cultivars studied. Adequate moisture (Table 2) and fertility during the entire growing period enabled the plants to grow and mature within 12 months, much earlier than what was obtained in previous years for field-derived suckers grown under upland conditions (Hemeng, 1993). This shows that by providing adequate drainage, the lowland areas in the forest zone can be rendered very suitable for plantain cultivation. There was no difference in growth, mean bunch weight and the mean number of hands per bunch of the tissue culture-derived and field-derived Apantu suckers. The tissue culture procedures were, therefore, satisfactory for Apantu cultivar. The yield of the tissue culture-derived Oniaba was very outstanding. Compared with the yield of field-derived suckers grown under upland conditions in previous years (Hemeng, 1993), there was about 100 per cent increase in bunch weight and 50 per cent increase in the number of fingers per fruit bunch in the tissue culture-derived Oniaba plants. There was, however, no difference in the number of hands per fruit bunch. The good yield obtained for tissue culture-derived Oniaba plants was largely due to adequate moisture and fertility, and indicates that the culture procedures were satisfactory for the Oniaba cultivar.

TABLE 2

*1993 and 1994 Monthly Rainfall Distribution (mm) at the Agricultural Research Station, Kade*

| *Month* | *1993* | *1994* |
|---|---|---|
| January | 0.0 | 1.3 |
| February | 142.1 | 65.1 |
| March | 130.9 | 72.6 |
| April | 167.7 | 116.8 |
| May | 109.3 | 184.5 |
| June | 438.2 | 142.3 |
| July | 43.7 | 72.9 |
| August | 46.8 | 92.7 |
| September | 101.6 | 154.7 |
| October | 247.0 | 276.9 |
| November | 103.2 | 91.8 |
| December | 21.6 | 0.0 |
| Total | 1552.1 | 1271.6 |

The regular number of hands per fruit bunch produced by Asamienu cultivar is two, for which the name of the cultivar is derived (Osa = hand, Mienu = 2). Other variants from the same ex-plant were noted in this study. The other variants, Osakro (one hand) and Asamiensa (3 hands) occur naturally at a much lower frequency. Karikari (1973) attributed the variation to soil fertility. This study has revealed that it is an inflorescence type variation that is inducible by tissue culture, consistent with observations made by Vuylsteke & Swennen (1992) on other plantain cultivars. There was about 33 per cent reduction in bunch weight and 50 per cent frequency of occurrence of the variants. For these reasons, the current culture techniques were unsuitable for the Asamienu cultivar. Furthermore, the fruit fingers of the tissue culture-derived Asamienu were curved upwards (negatively geotropic) and separated compared with the more compact hands of the field-derived Asamienu plants.

High concentrations of the cucumber mosaic virus (CMV) were found in the leaf samples of two of the tissue culture-derived Apantu and two of the field-derived Apantu plants. The affected plants died within 5 months after planting. This shows that the current shoot-tip culture techniques using over 1 mm long ex-plants do not eliminate plantain viruses. Culture procedures that eliminate plantain viruses are needed to produce virus-free plants. Shoot-tip and meristem cultures are more certain to produce virus-free plants when the mother-plants have been exposed to elevated temperatures of 35-40 °C and high relative humidity of 80-90 per cent for a few days before obtaining ex-plants from them (Waithaka, 1992). Generally, the smaller the ex-plant, the higher the percentage of virus-free plants obtained (Ng, Thottapilly & Russel, 1992).

Pending the development of the culture techniques that eliminate plantain viruses, there is the need to use virus-free ex-plants for *in vitro* multiplication of local plantains to avoid spreading the disease through tissue culture (Osei, 1995). After comparing several different CMV antisera, Lockhart (Personal communication) has found one which is able to detect all isolates of CMV in banana and plantain from different locations in Africa. This antiserum can be used to identify CMV-free materials for mass propagation of local plantain cultivars by tissue culture.

*Acknowledgement*

Dr Elizabeth Acheampong, Department of Botany, University of Ghana, Legon, supplied the tissue culture-derived plantain suckers. The help of Dr E. E. Lockhart, Department of Plant Pathology, University of Minnesota, USA in the identification of the CMV is duly acknowledged. The technical assistance of Mr Eric Asare, University of Ghana Agricultural Research Station, Kade, is also acknowledged. This paper is published with the permission of the Dean of the Faculty of Agriculture, University of Ghana, Legon.

REFERENCES

**Afreh-Nuamah, K.** (1994) Factors responsible for the lodging of plantains at the University of Ghana Agricultural Research Station, Okumaning-Kade. *Musa Africa* No.5. Ibadan, Nigeria: IITA.

**Anon.** (1993) *National Agricultural Research Project Newsletter* 2, No. 1 (ed. K. Fosu). Accra: CSIR-NARP.

**Hemeng, O. B., Oduro, K. A., Ofori, I. & Banful, B.** (1995) *Plantain production in Ghana. (Final report offield survey, submitted to the National Agricultural Research Project (NARP), Council for Scientific and Industrial Research (CSIR), Accra, Ghana).*

**Hemeng, O. B.** (1993) *Plantain development project: One and half years progress report.* Accra: CSIR, Ghana.

**Jarret, R. L.** (1986) *In-vitro* propagation and genetic conservation of bananas and plantains. In *Report, Third Meeting, IBPGR Advisory Committee on* in vitro *Storage*, pp. 15-33. Rome, Italy, IBPGR.

**Karikari, S. K.** (1971) A note on plantain (*Musa paradisiaca* Lin.) production in Ghana. *Ghana Farmer* **14** (2), 29-34.

**Karikari, S. K.** (1971) Origins of plantain and bananas in Ghana. *Ghana Jnl agric. Sci.* **6,** 9-10.

**Ng, S. Y. C., Thottapilly, G. & Russel, H. W.** (1992) Tissue culture in disease elimination and micropropagation. In *Biotechnology: Enhancing research on tropical crops in Africa* (ed. G. Thottapilly, L. M. Monti, D. R. Mohan Raj and A.W. More). Ibadan, Nigeria: IITA.

**Osei, J. K.** (1995) The cucumber mosaic virus infect plantain in Ghana. *Musa Africa* No. 6. Ibadan, Nigeria: IITA.

**Vuylsteke, D. & Swennen** (1992) Biotechnological approaches to plantain and banana improvement at IITA. In *Biotechnology: Enhancing research on tropical crops in Africa* (ed. G. Thottapilly, L. M. Monti, D.R. Mohan Raj and A.W. More). Ibadan, Nigeria: IITA.

**Vuylsteke, D.** (1989) *Shoot-tip culture for propagation, conservation and exchange of Musa Germplasm. Practical Manual for Handling Crop Germplasm* in vitro. **2.** Rome, Italy, IBPGR.

**Waithaka, K.** (1992) Micropropagation techniques and the production of pathogen-free plants. In *Biotechnology: Enhancing research on tropical crops in Africa* (ed. G. Thottapilly, L. M. Monti, D. R. Mohan Raj and A. W. More). Ibadan, Nigeria: IITA.