Asian Journal of Research in Botany

2(4): 1-9, 2019; Article no.AJRIB.52684

Efficacy of Excised-Bud (EB) and Half-Corm (HC) at Four Physiological Growth Stages on Plantlet Regeneration of *Musa genotypes*

Victoria Wilson[1*] and Abdou Tenkouano[2]

[1]Department of Plant Science and Biotechnology, Rivers State University, Port Harcourt, Rivers State, Nigeria.
[2]CORAF /West and Central African Council for Agricultural Research and Development, Dakar, Senegal.

Authors' contributions

This work was carried out in collaboration between both authors. Author AT designed the study. Author VW carried out the field work, collected and analyzed data and developed the manuscript. Both authors read and approved the final manuscript.

Article Information

Editor(s):
(1) Dr. Ogbonna, Abigail Ifemelunma, Lecturer, Department of Plant Science and Technology, Faculty of Natural Sciences, University of Jos. P.M.B.2084 Jos, Nigeria.
Reviewers:
(1) Mary-Louise Mhazo, Mananga Centre for Regional Integration and Management Development, Eswatini.
(2) Grace O. Tona, Ladoke Akintola University of Technology, Nigeria.
(3) Dwi Susanto, UMK Kampus Kota (Universiti Malaysia Kelantan), Malaysia.
Complete Peer review History: http://www.sdiarticle4.com/review-history/52684

Original Research Article

Received 12 Septembner 2019
Accepted 17 November 2019
Published 22 November 2019

ABSTRACT

Aims: This study was conducted to determine whether excised buds (EB) or half corms (HC) from 3 *Musa* genotypes at four growth stages of mother plants would produce the most plantlets and to find out the effects of scarification on number of plantlets regenerated.
Study Design: Treatments comprised three *Musa* genotypes at four growth stages and two macro-propagation methods – excised bud and half-corm in a randomized complete block design with 4 replications.
Place and Duration of Study: International Institute of Tropical Agriculture (IITA) High Rainfall Station, Onne (4°51'N, 7° 03'E, 10 m above sea level), Rivers State, Nigeria for eighteen months.
Methodology: Propagules, excised buds and half corms from a tetraploid cooking banana hybrid BITA 3; tetraploid plantain hybrid PITA 14, and a cooking banana landrace Cardaba, at 6-month

**Corresponding author: E-mail: victoriawilson.2005@gmail.com, victoria.wilson@ust.edu.ng;*

vegetative, pre-flowering, post-flowering and bunch harvest stages were planted to regenerate plantlets. At bunch harvest growth stage, additional excised buds and half corms were scarified to find out the effect on regeneration of plantlets.

Results: Excised buds and half corms did not differ significantly (P = .05) in number of plantlets produced in PITA 14 irrespective of growth stage but bunch harvest stage was best. In BITA 3, excised buds produced significantly more plantlets than half corms at the 6-month vegetative and bunch harvest stages. However, at the pre-flowering stage, half corms produced significantly more plantlets than excised buds. In Cardaba, half corms were significantly better at all growth stages especially bunch harvest stage. In all *Musa* genotypes, scarification increased significantly the number of plantlets.

Conclusion: This study found that PITA 14 is best propagated by excised buds or half corms irrespective of growth stage. For BITA 3, excised buds either at 6-month vegetative or bunch harvest stage; or use of half corm at pre-flowering stage was best. Half corm at any stage is best for Cardaba.

Keywords: Musa genotype; macro-propagation; scarification; excised bud; half corm; plantlet regeneration.

1. INTRODUCTION

Bananas and plantains are monocotyledonous plants in the genus Musa (*Musaceae*, *Zingiberales*). They are giant herbs, commonly up to 3m in height, with no lignifications or secondary thickening of stems that is characteristic of trees. The banana plant is a tree-like perennial herb. It is an herb because it does not have woody tissues and the aerial parts of the parent plant die down to the ground after the growing season. It is a perennial because one of the offshoots growing at the base of the plant, the sucker, then takes over. The parent plant and its suckers form what is commonly called a mat, or stool. What looks like a trunk is not a woody stem but a pseudostem, a compact mass of overlapping and spirally arranged leaf sheaths. Most of the 'true' stem is inside the pseudostem. In a fruiting plant, it starts on the rhizome and ends with the meristem in the male bud (if present). The variability observed in morphological traits is used to characterize banana plants. The roots are produced by the underground structure called a rhizome. The primary roots originate from the surface of the central cylinder whereas secondary and tertiary roots originate from the primary roots. The rhizome is commonly referred to as a corm, and occasionally as a bulb, but the botanically preferred term is rhizome, characterized by horizontal underground growth; production of roots from multiple nodes; and production of clonal plants. Detailed morphological descriptions are widely published [1,2,3]. *Musa* is vegetatively propagated and planting materials can be produced either by micro-propagation or by macro-propagation. Farmers prefer natural replacement of suckers through regeneration of landraces, hybrids or clones [4,5]. Regeneration is very slow because apical dominance causes “shy suckering” which prevents buds from developing into suckers until the reproductive phase of the “mother plant.” [6]. Apical dominance is controlled by a growth hormone that is produced in the terminal bud and inhibits growth of the lateral shoots (side shoots originating from lateral buds at the base of the main plant) [7]. Besides being slow, natural suckering does not yield enough suckers of the desired varieties and when such suckers are infested by pests or infected by disease, pest and disease susceptibility can be quite high in the event of outbreaks [4,8,9] which can easily wipe-out whole plantations. The result is a serious shortage of clean planting materials and this shortage of planting materials is considered a serious constraint for rapid *Musa* production [10]. While micro-propagation methods can provide large quantities and high quality planting materials [11], but the tender plantlets require great care in the first 2 months of planting. Also the equipment, technical skills, cost and highly controlled environment required are beyond the reach of resource poor farmers [12]. Therefore, macro-propagation has remained an effective alternative method which requires less capital and skills to produce large numbers of better-quality *Musa* planting material by farmers. However, some problems associated with macro-propagation include use of large numbers of parent materials, large space required for multiplication, and lack of uniform size of plantlets. Macro-propagation techniques include traditional methods that use whole suckers or relatively large pieces of the parent plants to

produce planting materials; these are usually bulky and difficult to transport. Common methods of macro-propagation include decapitation and false decapitation. Decapitation is the destruction of the terminal bud to increase the sprouting and development of suckers [13]. False decapitation also destroys the main apex in order to remove apical dominance, but it maintains the entire plant [14]. The rate of suckering using the above methods range from nine to fourteen suckers per annum [10,15]. Stripping of older sheaths to expose buds as well as mulching and earthing of the exposed buds have also been used to increase the number of suckers obtained from a mother plant [16,17,18]. Whole plants (peepers or sword) have also been used to produce planting materials [19,20]. The whole corm and corm-bits are used to produce few plantlets of uniform size [21]. The study [22] showed that the corm method could produce about five hundred suckers within eight months. More recent macro-propagation techniques involve methods that employ whole suckers or relatively large pieces of corm tissue to produce planting material in a propagator [23]. Other methods of macro-propagation utilize the whole corm, split-corm, split-bud and corm-bit techniques [24,25]. Depending on variety, one corm can yield an average of 10 seedlings, which can be increased by a factor of 3–4 by removal of the apical meristem of emerging lateral buds [26]. Hence, alternative methods based on bud excision are being investigated. Bud excision requires buds to be removed from the mother corm, and incubated in a pre-nursery to generate shoots. Prior to transplanting, the shoots obtained could be further multiplied by making incisions-scarification, which could yield a higher number of uniform size plantlets. Different banana propagation techniques can give different number of shoots [27]; while number of shoots produced is also influenced by the banana's genotype [28,29]. To the best of our knowledge no studies have investigated the use of excised buds (EB) and half corms (HC) obtained at four physiological growth stages of different *Musa* species as propagules for production of planting material. It is important that such a study be conducted in order to provide critical information on the ideal physiological growth stage that can provide the maximum number of propagules for rapid multiplication of each *Musa* spp. This study was therefore conducted specifically to:

1. Assess and compare the rate of regeneration of excised buds (EB) and half corms (HC) obtained at four physiological growth stages as viable macro-propagation materials in 3 *Musa* genotypes
2. Find out how scarification of excised buds and half corms affect the rate of regeneration of plantlets of 3 *Musa* genotypes.

2. MATERIALS AND METHODS

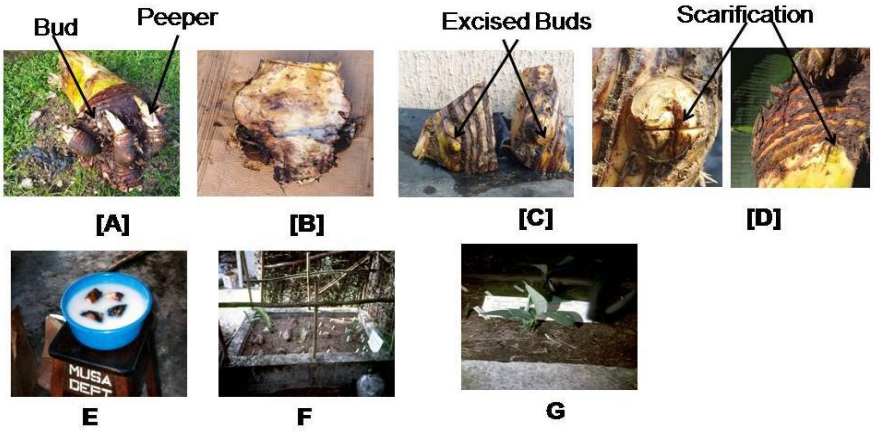
This study was carried out at the International Institute of Tropical Agriculture (IITA) High Rainfall Station, Onne (4°51'N, 7° 03'E, 10m above sea level), in Rivers State, south-eastern Nigeria. The rainfall pattern is monomodal, distributed over a 10 month period from February through December, with an annual average of 2400 mm. Relative humidity remains high all year round with mean values of 78% in February, increasing to 89% in the months of July and September. The mean annual minimum and maximum temperatures are 25°C and 27°C, respectively, while solar radiation / sunshine lasts an average of 4hours daily [30]. The soil is derived from coastal sediments of the Niger Delta, freely drained and acidic (pH 4.3), and made up of mainly Kaolinite. Onne soils are also high in phosphorus 60 mg kg^{-1}, manganese 0.2 mmol kg^{-1}, but low in nitrogen [31,32].

2.1 Preparation of Macro-propagation Materials

Three *Musa* genotypes comprising one tetraploid cooking banana hybrid BITA-3 (TMBx 5295-1) that is resistant to black Sigatoka disease; one tetraploid plantain hybrid PITA 14 (TMPx 7152-2) which is high yielding, short cycling, and resistant to black Sigatoka and to Banana streak virus diseases; and a cooking banana landrace (Cardaba) resistant to black Sigatoka disease were the source of the macro-propagation materials. Corms were harvested from 5 field-grown plants of each of these genotype source materials at each of the four physiological stages of growth as follows:

(i) At 6-month vegetative growth stage,
(ii) At onset of flowering growth stage,
(iii) At end of flowering growth stage, and
(iv) At bunch harvest growth stage

The harvested corms were immediately washed under a running tap. Roots were trimmed off and plant debris was removed to expose all buds on the corm, after which each corm was split into two equal halves. One part was used as half-corm while buds (swellings on the corm consisting of immature corms and leaves



[A]. Whole corm from mother plant at harvest stage showing buds & peepers
[B]. Half Corm [C] Excised buds [D] Scarified buds with 2 incisions each
[E]. Excised buds & Half corms being treated [F] Excised buds & Half corms in pre-nursery [G] Multiple shoots of excised bud ready for transplanting

Fig. 1. Illustration showing experimental processes

enclosed by scales) were excised from the other half. Buds of about 150 g each were excised from the corms with a locally fabricated mechanical extractor to ensure uniformity in size of buds. These two macro-propagation methods, excised-bud (EB) and half-corm (HC) were used in multiplication of plantlets in order to determine which technique produced the highest number of healthy plantlets.

2.2 Treatment Applications and Experimental Design

Treatments were the three *Musa* genotypes and four physiological stages described earlier and two macro-propagation methods – excised bud (EB) and half-corm (HC) giving a 3 X 4 X 2 factorial combination in a randomized complete block design with 4 replications. The excised buds were initially surface sterilized with 20% solution of Sodium hypochlorite, and allowed to stand for 5minutes in a solution of 6 g copper-oxychloride in one litre of water to prevent decay, after which they were allowed to air-dry for 4hours. The treated materials were planted at a spacing of 20 cm by 20 cm in a germination chamber consisting of a concrete basin filled with a mixture of sawdust and poultry manure at a ratio of 3:1 and watering was done as required. At the bunch harvest stage, an additional set of excised buds and half corms were scarified. Scarification was by making 2 incisions on the excised buds and on the growing point of the half corms.

2.3 Data Collection and Statistical Analyses

Sprouting was considered to have occurred when the buds grew about 5 cm above the soil level. The final number of regenerated plantlets was recorded. The data were subjected to square-root transformation, prior to analysis of variance (anova) to test treatment effects. All data were analysed using the general linear model procedure of statistical analyses software [33]. The values used in Figs. 1, 2, 3, 4 and 5 are means ± sd and any effects found to be significant have been tested at a significance level of 5% while means were compared using the least significant difference (lsd) at $p = .05$.

3. RESULTS

3.1 Plantlet Regeneration at 6-month Vegetative Growth Stage

At the 6-month vegetative stage of growth, excised buds (EB) from the cooking banana hybrid (BITA 3) had significantly ($P = .05$) more (333% more) plantlets than its half corm (HC) (Fig. 2). However, there was no significant difference ($P = .05$) in the number of plantlets produced by the excised buds and the half corms in the plantain hybrid (PITA 14). In the cooking banana (Cardaba) the half corms produced significantly ($P = .05$) more (600% more) plantlets. In fact, excised buds did not produce any plantlets in Cardaba.

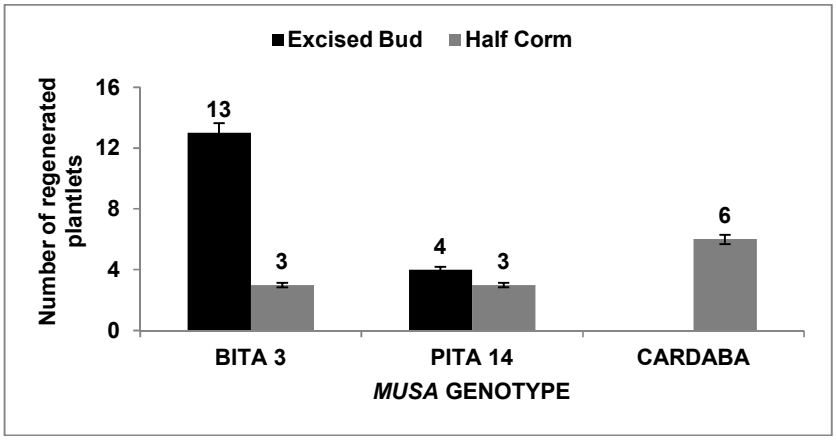


Fig. 2. Number of regenerated plantlets from excised buds and half corms obtained at the 6-month vegetative stage of growth in 3 *Musa* genotypes

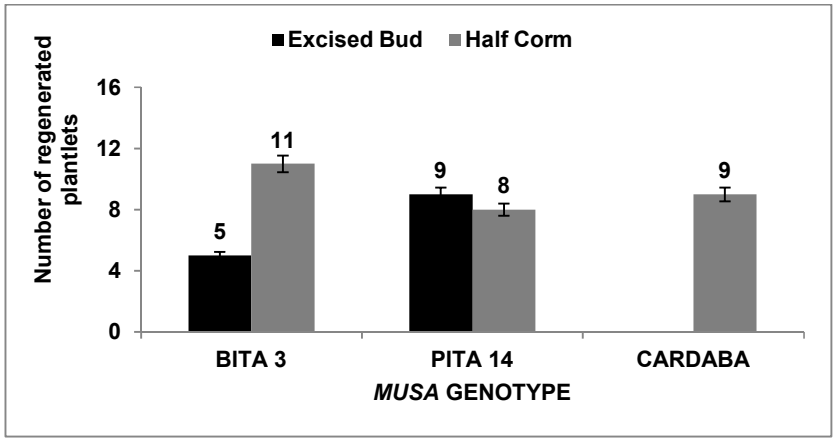


Fig. 3. Number of regenerated plantlets from excised buds and half corms obtained at the pre-flowering stage of growth in 3 *Musa* genotypes

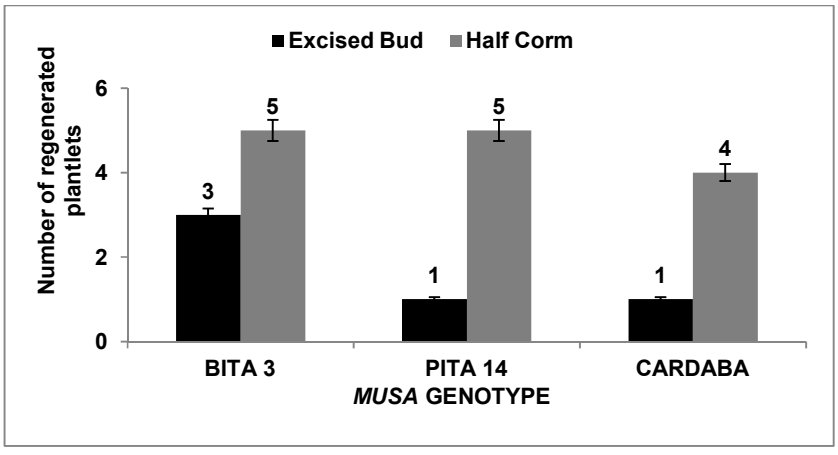


Fig. 4. Number of regenerated plantlets from excised buds and half corms obtained at the post-flowering stage of growth in 3 *Musa* genotypes

3.2 Plantlet Regeneration at Pre-Flowering Growth Stage

At the pre-flowering growth stage, half corms (HC) produced significantly (*P* = .05) more (120% more) plantlets than the excised buds (EB) in the cooking banana hybrid (BITA 3) (Fig. 3). There was no significant difference (*P* = .05) in the number of plantlets produced by the half corms and the excised buds in the plantain hybrid (PITA 14). Again at this stage of growth, half corms produced significantly (*P* = .05) more (900% more) plantlets than excised buds which did not produce any plantlets in the cooking banana landrace Cardaba.

3.3 Plantlet Regeneration at Post Flowering Growth Stage

At post flowering growth stage, there was no significant difference (P = .05) in the number of plantlets produced by the excised buds and the half corms in the cooking banana hybrid (BITA 3) (Fig. 4) as well as in the plantain hybrid (PITA 14). However, there was a significant difference (P = .05) in the number of plantlets produced by the excised buds and the half corms in the cooking banana Cardaba.

3.4 Plantlet Regeneration at Bunch Harvest Growth Stage

Excised buds (EB) obtained at bunch harvest stage in the cooking banana hybrid (BITA 3) produced significantly (P = .05) more (86% more) plantlets than its half corm (HC) counterpart (Fig.5). There was no significant difference (P = .05) in the number of plantlets produced by excised buds and half corm at this stage of growth in the plantain hybrid (PITA 14). The half corms produced significantly (P = .05) more (550% more) plantlets than excised buds in the cooking banana landrace Cardaba.

3.5 Effects of Scarification on Excised Buds (EB) and Half Corms (HC)

Excised Buds: Scarification increased significantly (*P* = .05) by more than 4 times, the number of plantlets produced by excised buds (EB) in the cooking banana hybrid (BITA 3) and by approximately 3 times in the plantain hybrid (PITA 14) (Fig. 5). In the cooking banana Cardaba, scarification resulted in a significant (*P* = .05) increase by doubling the number of plantlets produced compared to non scarified buds.

Half Corms: Scarification increased significantly (*P* = .05) by more than double, the number of plantlets produced by half corms (HC) in the cooking banana hybrid (BITA 3) and by 50% in the plantain hybrid (PITA 14) compared to non scarified half corms (Fig 6). In the cooking banana Cardaba, scarification increased significantly (*P* = .05) the number of plantlets by 91% compared to non scarified half corms.

4. DISCUSSION

4.1 *Musa* genotypes and Macro-propagation methods/ propagules

Generally, hybrid cooking banana (BITA 3) produced significantly the highest number of plantlets from excised buds (EB) at both 6-month vegetative and bunch harvest stages of growth. However, at the pre-flowering stage, half corm

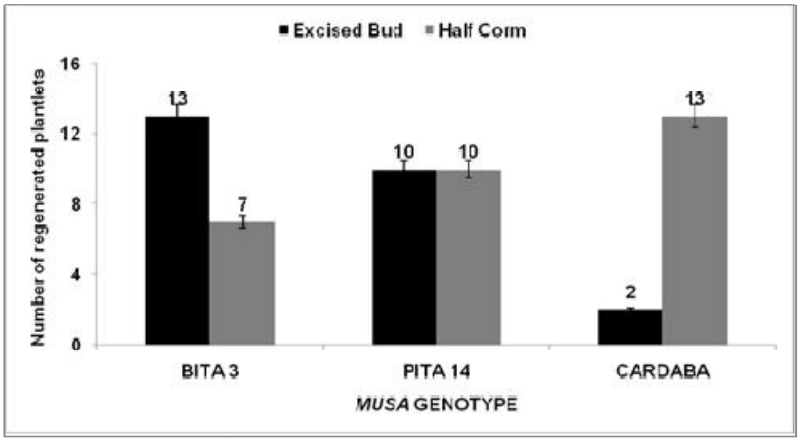


Fig. 5. Number of regenerated plantlets from excised buds and half corms obtainedat the bunch harvest stage of growth in 3 *Musa* genotypes

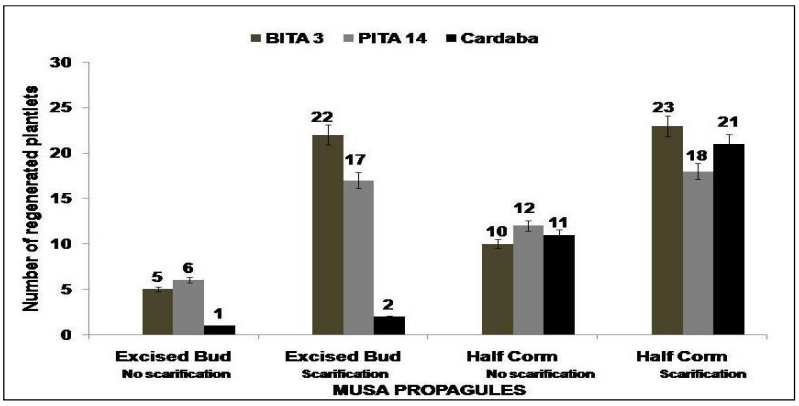


Fig. 6. Number of regenerated plantlets from scarified and non scarified excised buds and half corms obtained at the bunch harvest stage of growth in 3 *Musa* genotypes

produced the highest number of plantlets indicating at which stage to use each propagation method/ propagule. For hybrid plantain (PITA 14), excised buds and half corms produced the highest number of plantlets at bunch harvest stage of growth. Cooking banana, Cardaba, produced the highest number of plantlets from half corms obtained at harvest. This was the most productive physiological stage for using the half corm propagule in the cooking banana Cardaba. This was followed by those obtained at pre-flowering and 6-month vegetative stages in that order. Of the 3 genotypes, significantly higher numbers of plantlets were obtained from the hybrids than from the cooking banana Cardaba. Generally excised buds were best for the hybrid cooking banana and half corm for cooking banana Cardaba while either of the propagules could be used for hybrid plantain. The higher number of plantlets obtained from hybrids suggests genetic improvement of the hybrids over the banana landrace Cardaba. Higher suckering of the hybrids over their plantain parents has been attributed to their ability to overcome apical dominance [34]. According to [14] sucker production and development are influenced by growth hormones produced by the mother plant, which is regulated by the Ad gene [34]. It could also be from hormonal changes which occur during the lifespan of any plant [35]. Besides the action of hormones, apical dominance may be influenced by the physiological stage of the plant which depends upon the source-sink relationship. The rate of regeneration is determined by the amount of assimilates from leaves to sink which in turn depend upon age and vigour of the plant [36]. Thus the higher regeneration of the hybrids over the cooking banana landrace may also be due to the higher ploidy level of the hybrids. This would explain the higher vigour arising from a higher sink accumulation and consequently result in a higher number of plantlets regenerated than the cooking banana [37,38].

Scarification of excised buds and half corms may have (a) triggered hormones that induced cell division, callus formation and elongation, (b) increased efficiency of uptake and translocation within the propagules and accumulation at the active sites and (c) may have removed any anatomical barrier limiting formation of plantlets causing higher regeneration of plantlets in both propagules [25,39,40,41].

5. CONCLUSION

The study results showed that macro-propagation of the hybrid plantain PITA 14 could be done using either excised buds or half corms at any physiological growth stage but ideally at bunch harvest stage for best results. In the cooking banana hybrid BITA 3, excised buds at the 6-month vegetative or bunch harvest stage proved optimal, while use of half corms is best at pre-flowering stage. In the cooking banana Cardaba, half corms at all physiological growth stages could be used although bunch harvest stage was the most productive. Scarification of excised buds and half corms increased number of plantlets in all genotypes.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. *Musa* Germplasm Information System, MGIS; IPGRI–INIBAP/CIRAD, Descriptors

for banana (*Musa* spp.) IPGRI, Rome (ITA). 1996;55.

2. Australian Government, Department of Health and Ageing, Office of the Gene Technology Regulator. The biology of *Musa* L (banana). 2008;80.
3. Robinson JC, Galán Saúco, V. Bananas and plantains. Crop production science in horticulture. CABI, Wallingford (GBR). 2010;297.
4. Kasyoka MR, Mwangi M, Kori N, Gitonga N, Muasya R. Evaluating the macropropagation efficiency of banana varieties preferred by farmers in eastern and central Kenya. Second RUFORUM Biennial Meeting, Entebbe. Uganda. 2010: 449–503.
5. Ocimati W, Karamura D, Rutikanga A, Sivirihauma C, Ndung V, Ntamwira J, Kamira M, Kanyaruguru JP, Blomme G. Agronomic practices used by farmers in the management of *Musa* across different agro-ecological zones in Burundi, Eastern Democratic Republic of Congo and Rwanda. In: Blomme G, Van Asten P, Vanlauwe B. (eds.). Banana Systems in the Humid Highlands of Sub-Saharan Africa: Enhancing Resilience and Productivity, (Wallingford, UK: CAB International). 2013:175–190. Available:https://doi.org/10.1079/9781780642314.0175
6. Braide J, Wilson GF. Plantain decline: A look at possible causes. *Paradisiaca.* 1980;4:3-7.
7. De Langhe EA, Swennen R, Wilson G. Aspects hormonaux du rejetonnage des bananiers plantains. Fruits. 1983;38:318-325.
8. Manzur MD. *In situ* mass propagation of the FHIA-20 banana hybrid using benzylaminopurine. *Infomusa.* 2001;10(1): 3–4.
9. Butler D. Fungus threatens top banana, Nature. 2013;504:195-196
10. Wilson GF, Vuylsteke D, Swennen R. Rapid multiplication of plantain: an improved field technique. In: International Cooperation for Effective Plantain and Banana Research, Proceedings, 3rd IARPB/INIBAPA, Montpellier, France. 1987;24-26.
11. Singh TD, Singh CH, Nongalleima K, Moirangthem S, Devi HS. Analysis of growth, yield potential and horticultural performance of conventional vs. micropropagated plants of *Curcuma longa* var. Lakadong. Afr. J. Biotech. 2013;12: 1604-1608.
12. George P, Manuel J. Low cost tissue technology for the regeneration of some economically important plants for developing countries. Inter. J. Agric, Environ. Biotec. 2013;6:703-711.
13. Green-Ortiz JJ, Fierro C. Removal of the apex as a means of propagating plantains. In: Proceedings of the 24th Annual Congress of the American Society for Horticultural Science. Tropical Region University of Mayaguez, Puerto Rico. 1976;223-225.
14. Swennen RA. Physiological Study of the Suckering Behaviour in Plantain (*Musa* cv. AAB). Faculty of Agriculture, Catholic Uni. Louv., Belgium. Ph.D. Thesis. 1984;132: 80.
15. Noupadja P. Study of three field multiplication techniques for generating planting material of *in vitro* propagated plantain (*Musa* cv. AAB). MUSAFRICA. ISSN 1995;117-2266.
16. Barker GW. A system of maximum multiplication of banana plants. Tropical Agriculture, Trinidad. 1959;36:275-284.
17. De Langhe EA. Multiplication végétative accélée, en plantation, du bananier plantain (Bosua). Bulletin Information l'INEAC. 1961;10(2):69-90.
18. Charpentier JM. La remontée du meristéme central du bananier. Fruits. 1966;21(3):103-119.
19. Strivastava RP. Selection of planting materials for banana. Allahabad Farm-Management. 1963;37:18-20.
20. Baiyeri KP, Aba SC. A review of protocols for macro propagation in *Musa* species. Fruit, Veg. Cereal Sci. Biotech. 2007;1: 110-15.
21. Shanmugavelu KG, Aravindakshan K, Sathiamoorthy S. Banana, Taxonomy, Breeding and Production Technology. Metropolitan Book Co. PVT. LTD. New Delhi. 1992:459.
22. Adelaja BA. Rapid on-farm multiplication technique for plantain and banana. Annual Reports. National Horticultural Research Institute; 1983. ISSN 0795-4115
23. Tenkouano A, Hauser S, Coyne D, Coulibaly O. Clean planting materials and management practices for sustained production of banana and plantain in Africa. Chronica Horticulturae. 2006;46: 14–18

24. Faturoti B, Tenkouano A, Lemchi J, Nnaji N. Rapid Multiplication of plantain and banana: Macropropagation techniques, IITA Report; 2002.
25. Tumuhimbise R, Talengera D. Improved Propagation Techniques to Enhance the Productivity of Banana (*Musa* spp.). Open Agriculture. 2018;3:138–145. Available:https://doi.org/10.1515/opag-2018-0014
26. Njeri N, Mwangi M, Gathu R, Mbaka J, Kori N, Muasya R. Assessing effectiveness of macro-propagation technology to produce healthy seedlings of banana varieties with high market demand in eastern and central provinces, Kenya. Second RUFORUM Biennial Meeting 20–24 September 2010, Entebbe, Uganda. Research Application Summary. 2010:531–533;
27. Karamura E, Staver C. Strategies for improving bananas and plantains seed systems in Africa. BMGF Technical Report; 2010.
28. Vuylsteke D, Swennen R, Wilson GF, De Langhe E. Phenotypic variation among *in vitro* propagated plantain (*Musa* sp. Cultivar 'AAB'), Sceintia Hort. 1998;36:79-88.
29. Singh HP, Uma S, Selvarajan R, Karihaloo J.L. Micro-propagation for production of quality banana planting material in Asia-Pacific, Asia-Pacific Consort. Agric. Biotec. New Delhi, India; 2011.
30. Ortiz R, Austin PD, Vuylsteke D. IITA High Rainfall Station African humid forest. American Journal of Horticultural Science. 1997;32:969-972.
31. Winslow MD. Silicon disease resistance and yield of rice genotypes under upland cultural conditions. Crop Science. 1992;32: 1208-1213. Available:http://www.nal.usda.gov/
32. Swennen R, Vuylsteke D, Ortiz R. Phenotypic diversity and patterns of variation in West and Central African Plantains (*Musa* spp., AAB group *Musaceae*). Economic Botany. 1995;49: 320-327.
33. SAS Institute Inc. SAS User's Guide. Statistical Analysis Institute Inc. Cary, NC; 1992.
34. Ortiz R, Vuylsteke DR. Genetics of apical dominance in plantain (*Musa*, AAB group) and improvement of suckering behaviour. Journal of American Society of Horticultural Science. 1994;119(5):1050-1053.
35. Peñarrubia L, Moreno J. Senescence in plants and crops. In: Pessarakli M. (ed.). Handbook of plant and crop physiology. Marcel Dekker, Inc. New York. 1995;461-481.
36. Eckstein K, Robinson JC, Davie SJ. Physiological responses of banana (*Musa* AAA; Cavendish sub-group) in the subtropics 111. Gas exchange, growth analysis and source-sink interaction over a complete crop cycle. American Journal of Horticultural Science. 1995;70 (1):169-180.
37. Craenen K, Ortiz R. Effect of black Sigatoka resistance locus bs_1 and ploidy level on fruit and bunch traits of plantain-banana hybrids. Euphytica. 1996;87:97-101.
38. Ortiz R. Secondary polyploids heterosis and evolutionary crop breeding for further improvement of the plantain and banana (*Musa* spp., L.) genome. Theoretical and Applied Genetics. 1997; 94:113-120.
39. Naqvi SSM. Plant growth hormones: Growth promotors and inhibitors. In: Pessarakli M. (ed.). Handbook of plant and crop physiology. Marcel Dekker, Inc. New York. 1995;527-556.
40. Mok DW, Mok MC. Cytokinin metabolism and action. Ann. Rev. Plant Physiol. Plant Mol. Biol. 2001;52:89-118.
41. Kim EK, Hahn EJ, Murthy HN, Pack KY. High frequency of shoot multiplication and bulbet formation of garlic in liquid cultures. Plant cell tiss. Org. Cult. 2003;73:231-236.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/52684