6. Humayun, M. Z. and Jacob, T. M., *Biochem. J.*, 1974, **141**, 313.
7. Stumph, W. E., Wu, J. R. and Bonner, J., *Biochemistry*, 1978, **17**, 5791.
8. Rosenberg, B. J., Erlanger, B. F. and Beiser, S. M., *J. Immunol.*, 1972, **108**, 271.
9. Humayun, M. Z. and Jacob, T. M., *Biochim. Biophys. Acta*, 1973, **331**, 41.
10. Cameron, D. J. and Erlanger, B. F., *Immunochemistry*, 1976, **13**, 263.
11. Eichler, D. C. and Glitz, D. G., *Biochim. Biophys. Acta*, 1974, **335**, 303.
12. D'Alisa, R. M. and Erlanger, B. F., *J. Immunol.*, 1976, **116**, 1629.
13. Erlanger, B. F. and Beiser, S. M., *Proc. Natl. Acad. Sci., USA*, 1964, **52**, 68.
14. Ramakrishna, N. and Padayatty, J. D., *Indian J. Biochem. Biophys.*, 1977, **14**, 158.
15. Bovre, K. and Szybalski, W., *Methods in Enzymol.*, 1971, **21**, 350.
16. Vijayaraj Reddy, M. and Jacob, T. M., *Indian J. Biochem. Biophys. Suppl.*, 1978, **15**, 53.
17. March, S. C., Parikh, I. and Cuatrecases, P., *Anal. Biochem.*, 1974, **60**, 149.
18. Schubert, D., Roman, A. and Cohn, M., *Nature (London)*, 1970, **225**, 154.
19. Eilat, D., Steinberg, A. D. and Schechter, A. N., *J. Immunol.*, 1978, **120**, 550.
20. Freifelder, D., *Physical Biochemistry*, W. H. Freeman and Company, San Francisco, 1976, p. 149.
21. Poverenny, A. M., Podgorodnichenko, V. K., Bryksina, L. E., Monastyrskaya, G. S. and Sverdlov, E. D., *Mol. Immunol.*, 1979, **16**, 313.

TISSUE CULTURE OF THE JACK TREE

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ABSTRACT

Shoot tips isolated from the juvenile shoots of jack (*Artocarpus heterophyllus*) cultured on MS basal medium containing an auxin and a cytokinin resulted in multiple shoot induction through stimulation of axillary buds. The shootlets grew only as shoots in culture. Rooting of isolated shootlets occurred rarely. This method, if copious rooting could be induced on a large scale, points to the possibility of clonal propagation supplementing the conventional methods.

INTRODUCTION

IN the study of morphogenesis *in vitro*, most herbaceous forms of plants seem to present no problem to their being grown as de-differentiated tissue and in the manipulation of their callus to re-differentiated shoot buds, roots, or complete plants, which is now a routine[8]. This has implications in the rapid clonal propagation, in larger numbers and in quicker time of many ornamental and other horticultural species. A survey of literature pertaining to the study of organ morphogeresis in aseptic culture of the tree species indicates that apart from members of the Coniferae and a few temperate woody angiosperms such as the aspen, elm, poplar, birches, etc., there have been no serious attempts at clonal propagation of the elite tropical fruit trees through tissue culture. This prompted us to investigate the culture conditions that influenced the growth of explanted organs of the jack (*Artocarpus heterophyllus* Lam.), a tree species belonging to the family Moraceae with particular emphasis on multiple shoot induction *in vitro* and rooting of the isolated shootlets to form whole plants. This report is based on such an attempt.

MATERIALS AND METHODS

Artocarpus sp. is a fairly large-sized tree originally native to India, but now cultivated in Tropical Asia and Africa for its large edible fruits. Propagation is by seed, cuttings or patch buddings, Superior races of the jack tree are known and budlings in general, are difficult to transplant from the nursery row. One of the trees growing at the Indian Institute of Horticultural Research, Bangalore (India) was utilized as a source material for shoot buds and young inflorescence axes for experimentation *in vitro*.

Sprouts from germinating seeds as also slices of young inflorescence axes were used. Shoot tips, cotyledons and hypocotyl fragments were aseptically cultured on nutrient media after sterilization with mercuric chloride (0·2%) for 15 min followed by several rinses in autoclaved distilled water. Murashige and Skoog's[3] basal medium (MS) supplemented with

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FIGS. 1–3. Shoot tip culture : Stages of multiple shoot induction through stimulation of axillary bud growth *in vitro*.

indole acetic acid (IAA), indole butyric acid (IBA), naphthalene acetic acid (NAA), benzylaminopurine (BA), 6 (γ-γ-dimethylallyl amino) purine (2, ip) and gibberellic acid (GA_3) in different concentrations and combinations was used. Sucrose (2%) or glucose (3%) was used as the carbon source and FeEDTA as the source of iron. Autoclaving of media was done in the usual way for tissue culture. Twelve replicates were used for each treatment.

RESULTS

Cotyledons

Small fragments of cotyledons cultured on MS medium contraining BA (2 ppm) and NAA (1 ppm) proliferated to form a callus from the cut ends. The callus could be subcultured and maintained for several months with no apparent sign of organ regeneration even under a wide range of cultural conditions.

Hypocotyl, Primary Root and Inflorescence

Organ segments (1 cm long) isolated from germinating seeds were cultured on MS medium to which BA (2 ppm) and NAA (2 ppm) had been added. Induction of callus occurred from the cut ends. On their transfer to fresh MS, basal medium containing NAA or IBA (1 ppm) and BA (2 ppm), multiple shoot induction was observed unaccompanied by rooting. Rooting, however, was observed only in a couple of instances out of 12 replicates on sequential withdrawal of BA and on prolonged incubation. Fragments of the primary root never callussed even on culture under a wide range of auxin-cytokinin combinations. Good callusing could be obtained from inflorescence primordia in culture originating from pith parenchyma of the axis. Apart from rooting no shoot bud regeneration was observed in the callus.

Shoot tips

Shoot tips, 1 cm long, isolated from fresh juvenile sprouts of a 50 year old tree and cultured on MS basal medium containing IAA (0·1 ppm) alone or with the addition of BA (2 ppm) caused the development of exuberant green callus. However, these failed to give rise to buds or roots. On the other hand, shoot tips excised from uniformly growing branches of the mature tree cultured on MS medium containing BA (30 ppm) + IAA (0·5 to 5 ppm) showed a better response. Callusing from the cut ends was profuse and prolonged incubation for 4–6 weeks, caused the stimulation of growth of buds from meristems axillary to the leaves in all the cultures. Multiple shoot induction unaccompanied by rooting was also characteristic of shoot tips cultured on MS + NAA (1 ppm) + 2 ip (30 ppm). Such regenerated shootlets, however, did not root in culture. On excision and culture of each of the regenerants to the same medium, callusing from basal ends followed by the development of fresh crop of accessory shoots from the nodal regions was observed (Figs. 1–3).

Rooting of the new shoots was, however, very rare and never copious on transfer to a root inducing medium containing IBA and NAA (0·1, 0·5, 1·0, 5·0 and 10 ppm). Addition of GA_3 (1 ppm) caused the abscission of the shoot tip.

DISCUSSION

Over the years, there appears to be no major breakthrough in investigations concerned with the woody

genera *vis-a-vis* clonal propagation through tissue culture. Tropical fruit trees still remain an unplumbed field and are difficult to propagate asexually by conventional methods. Elite trees of economical importance such as mahogany, gulmohur, mango, nutmeg, and others are not easily amenable to tissue culture. However, recent attempts at plantlet regeneration from seedling callus and terminal buds of elite 100 year old teak trees seem to be promising[4]. A beginning has been made in the application of tissue culture methods to successful regeneration in sandalwood tree[8,9] *Eucalyptus*[1,6] and *Tamarix*[5], as also some deciduous trees[11].

Multiple shoot induction *via* callus, although a promising method, cannot guarantee the elite qualities of the parent plant, nor the ones derived from a seedling. Great variations are observed among the different genotypes in their potential for morphogenesis as is evident from investigations on the *Eucalyptus*[3,7] ranging from species that are totally recalcitrant to those that are highly responsive to regeneration. Although jack tissue culture could successfully be raised and organ regeneration in the form of shoot buds could be manipulated with ease, rooting of the shootlets at will, still remains a problem for profitable use in plant propagation.

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1. Aneja, S. and Atal, C. K., *Curr. Sci.*, 1969, 38, 69.
2. Bapat, V. A. and Rao, P. S., *Ann. Bot.*, 1979, 44, 629.
3. Cresswell, R. J. and Fossard, R. A., *Austr. Forestry*, 1974, 37, 55.
4. Gupta, P. K., Nadgir, A. L., Mascarenhas, A. F., and Jagannathan, V., *Plant Sci., Letters*, 1980, 17, 259.
5. Kishore, P. B., Thaker, D. N. and Mehta, A. R., In Proc. *All India Symp.* 3rd Conference, Plant Tissue Culture, M.S. Univ., Baroda, 1978, p. 67.
6. Lakshmi Sita, G., *Plant Sci. Letters*, 1979, 14, 63.
7. Lee, E. C. M. and Fossard, R. A., *New Phytol.*, 1974, 73, 707.
8. Narayanaswamy, S., In *Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culure*, (eds.) S. Reinert and Y. P. S. Bajaj, Springer Verlag, Berlin–Heidelberg, New York, 1977, p. 179.
9. Rao, P. S. and Bapat, V. A., *Can. J. Bot.*, 1978, 56, 1153.
10. Sen, P. K. and Bose, T. K., *Indian Agric.*, 1959, 3, 43.
11. Winton, L. L., *Gen. Physiol. Notes*, Inst. Paper Chem., Appleton, Wisconsin, 1974, 19, 19.

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