Macropropagation of tropical fruit crops and its improvement.

S. MOHAMMED*

MACROPROPAGATION ET AMELIORATION DES ESPECES FRUITIERES TROPICALES.
SHAFAAT MOHAMMED
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RESUME - Des méthodes variées de macropropagation sont utilisées pour la multiplication des espèces fruitières tropicales. Le rendement de ces méthodes tels que bouturage, greffage, marcottage, varie selon les espèces fruitières. Le greffage d'oeil ou de rameau est depuis longtemps parmi les méthodes les plus utilisées malgré le défaut de lenteur et d'encombrement. En général les techniques actuelles de macropropagation manquent d'efficience et sont incapables de répondre à la demande croissante de matériel végétal. Il existe donc un besoin d'amélioration de ces méthodes en insistant sur une utilisation plus intensive du bouturage, une méthode de macropropagation simple, rapide et économique pour diverses productions fruitières tropicales.

INTRODUCTION

Propagation is one of the important aspects of fruit crop cultivation and plays an important role in the development of a fruit production industry. Vegetative or asexual propagation is usually employed for the reproduction or multiplication of fruit trees because various vegetative plant parts viz. stem, leaf and root have the natural ability to regenerate adventitious roots and shoots or, when combined, form a graft union, thus leading to the production of new plants. Vegetative propagation is important for the multiplication of fruit crops because most fruits are highly heterozygous and unique characteristics of such plants lost if they are propagated by seed. In addition, vegetative propagation is essential for cultivars that produce no viable seeds, e.g. some bananas, oranges, figs and grapes. There are several advantages to be gained from asexual propagation such as propagation of species may be easier, rapid and economical, plants come into bearing early and fruit quality and yield are improved considerably.

In recent years, vegetative propagation has been classified into two main groups : (i) macropropagation and (ii) micropropagation (*in vitro* propagation or tissue culture), however, it is macropropagation which is widely used for the reproduction of fruit trees. A large number of fruit species exists in the tropics which can be macropropagated by different methods, but most species still remain difficult to propagate successfully and economically. In addition, the performance of different macropropagation methods varies according to the type of fruit species. For instance, grafting and budding may perform better in certain fruit species than cuttings and *vice versa*. In general, the present use of macropropagation in tropical fruit crops can be considered inefficient and incapable of meeting the growing demand for planting material. Although sporadic attempts have been made in various tropical countries to improve efficiency of macropropagation, the lack of sustained and intensive research seems to have contributed to its overall inefficiency. This paper analyses the current status of macropropagation in tropical

* - Department of Crop Science - The Faculty of Agriculture - The University of the West Indies - St. Augustine, Trinidad.

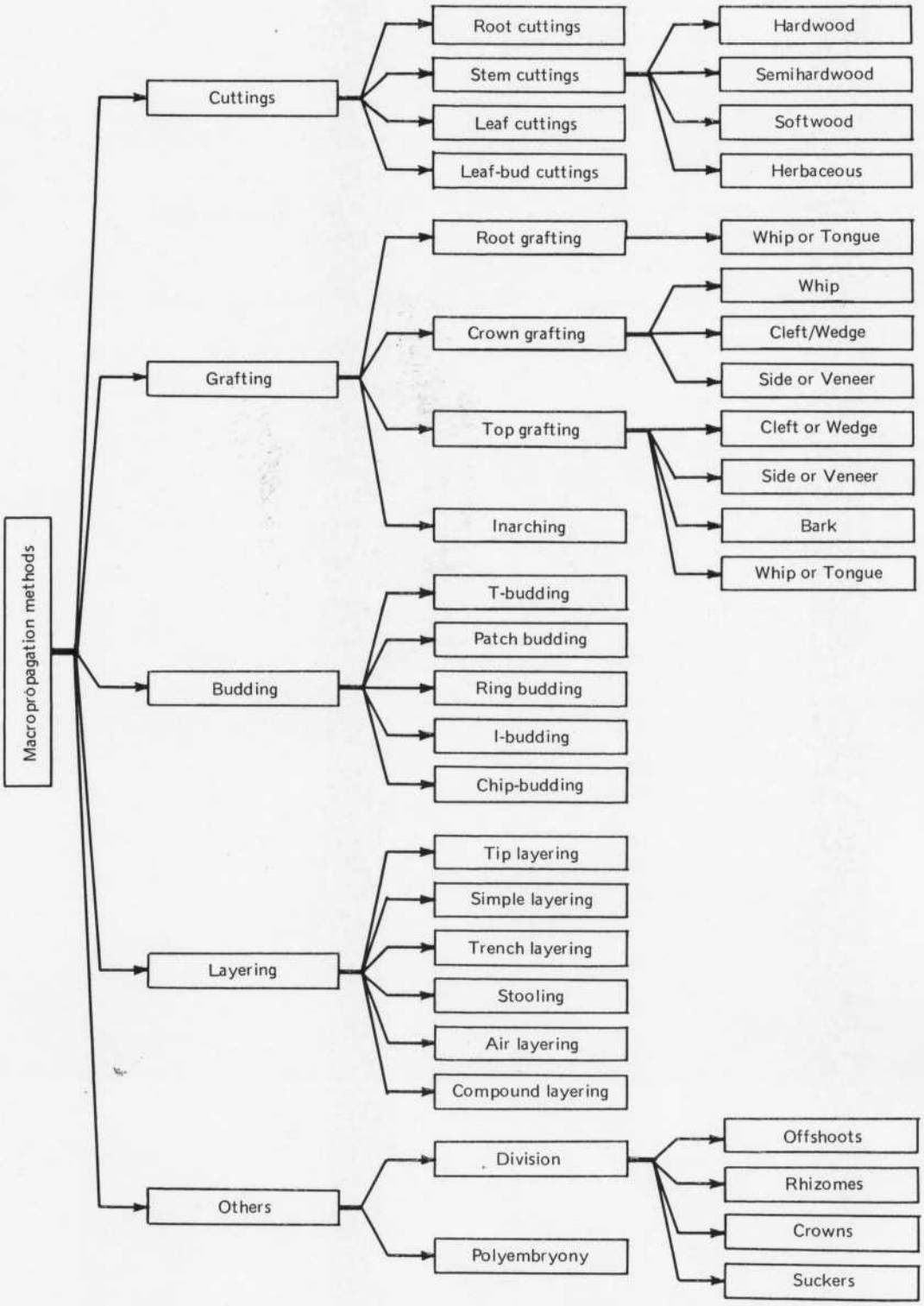

Figure 1 - SCHAMATIC REPRESENTATION OF DIFFERENT METHODS OF MACROPROPAGATION.

fruit crops and emphasizes the need for its improvement.

METHODS

There are four main methods of macropropagation, i.e. cuttings, grafting, budding and layering which are used commercially to propagate fruit plants (Fig. 1). Other minor methods of macropropagation such as division (offshoots, suckers and crowns) and polyembryony are applicable in only those fruit species in which there is a natural provision for such methods to be applied.

Cuttings.

In propagation by cuttings, a portion of stem, root or leaf is cut from the parent plant and is placed under favourable environmental conditions where it is induced to form roots and shoots, thus producing a new plant identical to the parent. Cuttings can be classified according to the plant part from which they are obtained, e.g. stem cuttings (hardwood, semi-hardwood, softwood and herbaceous), leaf cuttings, leaf-bud cuttings and root cuttings (Fig. 1). In tropical fruit species mostly stem and leaf cuttings are used ; leaf-bud and or root cuttings are rarely used.

Grafting and budding.

In grafting and budding, parts of the plant are joined in such a manner that they will unite and continue to form a plant. The part of the graft combination which is to become the upper portion is termed the **scion** and the part which is to become the lower portion is termed the **rootstock**. The main difference between grafting and budding is the length of the scion used. In budding the scion is only a small piece of bark containing bud, whereas in grafting it is a long piece of wood having many buds. There are different types of grafting and budding (Fig. 1) depending on the type of plant parts used and the manner in which two plant parts are actually united. Important types of grafting and budding are the crown (cleft side), top (cleft, side or veneer) and approach grafting and 'T', Patch and Chip budding which are used for the multiplication of many tropical fruit species.

Layering.

This is a method of propagation by which adventitious roots are induced on a stem while it is still attached to the parent plant. The rooted or layered stem is then detached to become a new plant growing on its own roots. There are different forms in which layering can be performed (Fig. 1) but only air layering and or mound (stooling) layering are used commercially for propagation of a few tropical fruit species. The principle advantage is the success with which stems will develop roots by this method. Many clones whose cuttings will not root can be propagated easily by layering.

Others.

In certain tropical fruit species plants produce special parts such as suckers, crowns, offshoots and in still others asexual embryos in addition to a sexual embryo are produced which is known as polyembryony. Such special plant parts and polyembryony can be used to propagate some of the fruit crops.

TABLE 1 - Comparing the performance of different methods of macropropagation.

Performance	Methods				
	Cuttings	Grafting	Budding	Layering	Others
Success	Less successful or difficult	Successful	Successful	Less successful	Successful
Ease	Easy	Difficult	Difficult	Difficult	Easy
Skill	No special skill required	Requires special skill	Requires special skill	Requires special skill	No special skill required
No. of plants obtained	Large	Limited	Limited	Limited	Limited
Time	Takes less time	Takes a long time	Takes a long time	Takes less time	Takes a long time (uncertain)
Economy	Very cheap	Expensive	Expensive	Expensive	Cheap
Rootstocks required	No	Yes	Yes	No	No
Other facilities required	Yes	Yes	Yes	Yes	No
Root system	Shallow	Deep	Deep	Shallow	Deep
Quality	Good	Affected by rootstocks	Affected by rootstocks	Good	Good

COMPARISON

Availability of choices of different methods of macropropagation may enable the propagator to propagate fruit plants efficiently. However, a comparison between methods of macropropagation (Table 1) suggests that certain methods may be superior to the others with regard to their performance. For example, propagation by cuttings is easier and economical and may provide a large number of plants as compared with grafting, budding and layering. Unfortunately, it can be employed successfully only in a few fruit crops. The disadvantage of propagating plants by cuttings is that the rooted cuttings develop shallow (fibrous) root system, which render trees prone to damage by strong winds, however, use of windbreaks can overcome this problem.

Propagation by grafting and budding is slow, cumbersome and requires special skills. Furthermore, the use of seedling rootstocks influences the performance of scion cultivars. Nevertheless, grafting and or budding is beneficial when it is not possible to propagate by cuttings or it is useful if any characteristics of rootstocks, e.g. dwarfing or resistance to pests and diseases is desired. Grafting and budding are also helpful when plant materials of important cultivars are to be transported from one place to another.

The use of layering for the propagation of tropical crops is less favoured and practised only when other methods do not succeed or are difficult to use. The employment of suckers, offshoots and crowns for propagation is confined to the fruit species (banana, pineapple) which produce these specialized plant parts. Similarly, occurrence of polyembryony is a rare phenomenon and identification of nucellar or asexual seedlings is a problem, hence the use of polyembryony for commercial propagation of fruit crops is uncommon. Polyembryony occurs naturally in mango and Citrus but it is not exploited commercially because of the above mentioned problems.

CURRENT STATUS

Although different methods for macropropagation are currently employed on a commercial scale to propagate various tropical fruit species (Table 2), the use of some methods notably grafting and budding in a large number of crops is quite popular. The preferential use of grafting and budding in many fruit species could be due to the poor success or failure of other methods (cuttings, layering). Only a few tropical species (guava, cashew, passion fruit) are commercially propagated either by cuttings or layering. In general, most of the important tropical fruit species (avocado, mango, cashew) are difficult to propagate by cuttings because of inadequate rooting under ordinary conditions. Although some of the fruit species (pomerac, W.I. Cherries) can be easily propagated by cuttings or layerings, they are still propagated by seed because of lack of interest in the cultivation of these as crops. Propagation of most of the tropical fruit species by grafting or budding is successful but these methods are slow and difficult with varying degrees of success. Furthermore, indiscriminate use of seedling rootstocks puts these methods at disadvantage.

NEED FOR IMPROVEMENT

The failure to employ one of the simplest and most economical method of macropropagation (cuttings) in a large number of tropical fruit species and persistent use of problematic grafting, budding and layering in some fruit species suggests that these macropropagation methods should be improved to meet the ever-increasing demand for fruit plants. Availability of large number of asexually propagated plants at low costs is a must for the future development of a tropical fruit production industry, particularly in the wake of development of modern systems of fruit production (MOHAMMED and WILSON, 1983 ; MOHAMMED and WILSON, 1984 a and b). Over the years, production of many tropical fruits, particularly lesser known fruits (guava, sapodilla, annonas, etc.) which are important sources of nutritious food (vitamins, minerals), has remained neglected. Lack of suitable and efficient macropropagation methods among other factors, seems to have contributed to the neglected production.

A need, therefore, exists to develop efficient propagation methods for most of the fruit crops, particularly the crops which are difficult to be propagated by cuttings. There is an equal need to propagate rootstocks by cuttings in order to avoid undesirable influence of seedling rootstocks on scion cultivar. Several modern techniques such as mist systems, root promoting chemicals (indole butyric acid or IBA, napthaleneacetic acid or NAA), etiolation, blanching, improved rooting media (vermiculite, perlite) etc., if used judiciously, could make propagation by cuttings possible in a number of tropical of fruit species. Propagation by cuttings is bound to be an efficient macropropagation method by making available large quantities of planting material at a reduced cost in a short duration. Although propagation by cuttings is preferable, the use of grafting and budding methods may become essentially for reasons explained earlier. Thus, efforts should also be made to improve the efficiency of grafting and budding methods by employing various modern techniques.

Research in various tropical countries has been carried out to improve the methods of macropropagation for fruit crops (GARNER and CHAUDHRI, 1976). Most of the research has gone into the development of efficient methods of macroprogatation for avocado, mango, guava sapodilla, cashew, etc. Some attempts have been made towards understanding the underlying causes for the difficulty of macropropagation methods in different tropical fruit crops. Encouraging results have been obtained as a result of the research carried out in the past, however, there are many crops which still remain difficult to propagate by cuttings and or grafting and budding and reasons

TABLE 2 - A general status of application of various macropropagation methods for the propagation of tropical fruit crops.

Crops	Methods				
	Cuttings	Grafting	Budding	Layering	Others
Citrus (*Citrus* spp.)	Leaf, leaf-bud and stem cuttings (1,5)	Inarching (1,5)	T-budding (1,4)	Air Layering (1,5)	Polyembryony (1,5)
Avocado * (*Persea americana* MILL.)	Stem cuttings (2,5)	Wedge grafting, seedlings (RS) (1,4)	Chip or T-budding, seedling (RS) (1,4)	(2)	(2)
Mango * (*Mangifera indica* L.)	Stem cuttings (2,5)	Veneer grafting, seedlings (RS) (1,4)	Chip or T-budding, seedlings (RS) (1,4)	(1,5)	Polyembryony (1,5)
Guava * (*Psidium guajava* L.)	Stem cuttings (1,4)	Veneer grafting, seedlings (RS) (1,4)	Chip budding, seedlings (RS) (1,4)	Air layering (1,4)	(2)
Sapodilla * (*Manilkara achras*)	(2,5)	Veneer grafting, seedling (RS) (1,4)	Patch budding (1,5)	Air layering (1,4)	(2)
Cashew ** (*Anacardium occidentale* L.)	Stem cuttings (2,5)	Inarching (1,4) (2,5)	Shield budding (1,4)	Air layering (1,4)	(2)
Annona ** (*Annona* spp)	Stem cutting (1,5)	Side/veneer grafting, seedling (RS) (1,5)	Shield budding, seedling RS (1,5)	(1,5)	(2)
Breadfruit (*Artocarpus altilis*)	Root cuttings (1,4)	Inarching (1,5)	Shield budding (1,5)	Air layering (1,4)	Suckers (1,4)
Pomerac ** (*Eugenia malaccensis* L.)	Stem cuttings (1,5)	(3,5)	(1, 3, 5)	(1, 3, 5)	(2)
W.I. Cherries ** (*Malphigia glabra* L.)	Stem cuttings (1,4)	Wedge/veneer grafting (1,5)	Chip budding (1,5)	(1,5)	Polyembryony (1,5)
Passion fruit ** (*Passiflora edulis*)	Stem cuttings (1,4)	(1,3,5)	(1, 3, 5)	(1, 3, 5)	(2)
Banana (*Musa* cvs.)	(2)	(2)	(2)	(2)	Rhizomes and suckers (1,4)
Papaya (*Carica papaya* L.)	Stem cuttings (1,5)	Cleft grafting	(3)	(3)	(2,3)
Pineapple (*Ananas comosus*)	Leaf-bud cuttings (1,4)	(2)	(2)	(2,3)	Suckers, slips crowns (1,4)

1 : possible 2 : not possible/difficult 3 : not tried 4 : used commercially 5 : not used commercially

* : use of seed propagation is common ** : seed propagation is used commercially RS : rootstocks

for difficult use of the methods remain little understood. Therefore, continuous research is required to improve and develop efficient macropropagation techniques. Recent research conducted by MOHAMMED and SORHAINDO (1984) and MOHAMMED (1984) has led to the development of a successful technique to propagate the West Indian avocado race (cvs. Lula and Pollock) by cuttings, previously it has been difficult to be propagated by cuttings under ordinary conditions. Similarly, MUKRED (1984) conducted anatomical investigations in cashew which revealed underlying causes of inefficient use of macropropagation methods. Such research attempts are needed to improve tropical fruit crop propagation.

CONCLUSIONS

Macropropagation is considered still to be an important system of tropical fruit propagation and cuttings, grafting, budding and layering are its major forms. Unfor-

tunately, macropropagation is not being exploited extensively in many crops and seed propagation is resorted to despite its inferiority. One of the reasons for underexploitation of macropropagation, particularly propagation by cuttings is the difficulty in using this method in a number of fruit crops because of failure of rooting. Other methods (grafting, budding and layering), though successful in a large number of fruit crops, are time consuming and require special skills to perform. This situation slows down the rapid multiplication of fruit plants, thus creating a scarcity and increasing the cost of planting material. Hence, increase in the cultivation of many fruit crops is often unduly delayed and affected adversely. Earnest efforts should be made to modernize and improve the techniques of macropropagation used for the propagation of tropical fruit crops.

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