REVIEW ARTICLE

A REVIEW ON VEGETATIVE PROPAGATION AND APPLICATIONS IN FORESTRY

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Received-18.01.2022, Revised-03.02.2022, Accepted-07.03.2022

Abstract: Vegetative propagation is a remarkable tool for improving the quality of forest tree planting stock. It is widely used as a means of genotype preservation in clone banks and seed orchards. Low quality seed and poor germination rates affect the availability of planting stock in such case vegetative propagation is the best alternative. This review paper describes about the various techniques of vegetative propagation which includes macropropagation with cuttings, grafting, layering and Micropropagation via tissue culture. The technological advancement laid forth a road map for improving traditional propagation techniques and developing new ones such as condensed node proliferation technique, excised bud technique, hydroponics and somatic embryogenesis. but despite this, the possibility of vegetative propagation using hormones is not clear for many indigenous tree species. So, this review also includes role of plant growth regulators in improving success of reproducing species. Lack of knowledge and skill is the major hurdle to use vegetative propagation. So, an attempt was made to discuss various techniques with their advancement and significance.

Keywords: Vegetative propagation, Macro propagation, Micro propagation, Plant growth regulators

INTRODUCTION

Vegetative propagation of plants is essentially the reproduction of plant material from vegetative organs so that the offspring will contain the exact characteristics of the parent plant with regards to genotypes and health status.Vegetative regeneration is a natural as well as a man-made process (Leakey, 1985). It is now widely recognized as ways to dramatically improve the output and quality of forest products from commercial plantings in the sub-tropics and tropics for producing quality planting material and capturing genetic variation (Leakey, 1987; Leakey et al. 1990; Ezekiel, 2010). An important reason for vegetative propagation is the shortening of the reproductive cycle of a tree. It can play a key role in tree improvement programmes as a means of large-scale multiplication of superior clones or tested plus trees(K. Palanisamy and K. Subramanian 2000; P Prabakaran *et al*., 2017).The benefits of vegetative propagation in forestry are widely established, with plants that are "true to type" and easy flowering and fruiting in tree species (Venkateshwarlu and Mukhopadhaya, 1999), uniform raised stock, rapid growth rate, and better clone-site matching, resulting in higher wood volume production (Ooyama and Toyoshima, 1965; Fielding 1969), thus becoming the preferred method of propagation (Oliveira, 1989).Vegetative techniques are used as indispensable tool for mass multiplication of superior phenotypes/genotypes and producing uniform plants (Leakey *et al*., 1982).Techniques have already been used for maintaining genetic superiority and increasing productivity of many economically important tree species (Rafiqul, 2008). Adoption of vegetative propagation in tree spices has increased substantially in recent years and all the major tree spices have been propagated by this method with varying degrees of success (J Rema *et al*., 1997). The Vegetative propagation is possible by the following two methods (K T Parthiban *et al*., 2016). Macropropagation through cuttings, grafting, layering and Micropropagation (Krishan Kumar Singh 2018; Leakey R.R.B 2017).

Macro propagation:

Vegetative methods of propagation are undoubtedly the most evolved and expanded method Macro-propagation technique was conceived as a means of rapid multiplication of the plant can be vegetatively propagated (Agbo and Omaliko, 2005). The potential of greater genetic gain and greater uniformity can be achieved which is not possible through sexual propagation. Macro-propagation in tree breeding programmes has been emerging as a strong attraction to the traditional seed orchard breeding system (Prabakaran, P *et al*., 2017). It is relatively easy technique carried out in a shed or even in the field (Elida michelleT. Sangma and Hemant kumar 2015). Macro propagation through different types of cuttings is generally considered as an important tool for rapid multiplication of true-totype genotypes with the highest genetic quality materials (Chauhan *et al*., 2015).

Cuttings: The term cutting refers to any portion removed from the parent plant which is meant for regeneration (K T Parthiban *et al*., 2016). Rooting of cuttings is a complex process involving ecophysiological, biochemical as well as anatomical factors controlling root initiation and development (Uniyal et al. 1993). Cutting position was the most

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important variable influencing rooting success (Diego Wassner and Damia´nRavetta 2000). The application of auxin to attract assimilates to the cutting base and to the stimulate meristematic differentiation is probably the best-known means of promoting rooting in all kinds of cuttings. IBA has an important role in the development of adventitious roots, increasing rooting percentage, improving quality of roots and uniformity in rooting of cuttings (Nagesh, 2002; Teklehaimanot *et al*., 2004; Husen and Pal, 2007a; Opuni-Frimpong *et al*.,2008) Major types of cuttings are stem cuttings, root cuttings, leaf cuttings and leaf bud cuttings (K T Parthiban *et al*., 2016).

Vegetative propagation via **stem cuttings** offers production of true-to-type plants in a short period of time and availability of superior individuals for large scale commercial plantation with quick productive gains (Pratap Chandra Panda *et al*., 2019). Rooting of stem cuttings is easiest and economical methods of vegetative propagation usually exploited in many tree species (B H babu *et al*., 2018). Macro propagation through induction of rooting in stem cuttings is a preferred practical option for establishing industrial plantations, seed orchards, nutritional trials etc., thereby augmenting forest productivity (Aslam and Rather 2008). Stem cuttings are classified into hardwood, semi-hardwood and soft wood cuttings (Evans, 1999). Hardwood cuttings are taken from dormant, mature stems of more than one year old. The semi-hardwood cuttings are usually prepared from partially mature wood of the current season's growth while softwood cuttings are prepared from soft, succulent new growth of woody plants (Evans, 1999; Leakey *et al*., 1982).

Root cutting is a semi-artificial, vegetative plant propagation technique. Cuttings taken from roots may also be used but only a few species can be propagated this way (Rosie Lerner and Mary Welch-Keesey 2002).**Leaf cuttings** are prepared by taking a single leaf from the plant (Rosie Lerner and Mary Welch-Keesey 2002). Leaf cuttings of most plants will not generate a new plant; they usually produce only a few roots or just decay. Because leaf cuttings do not include an axillary bud, they can be used only for plants that are capable of forming adventitious buds (Ervin Evans and Frank Blazich1999). **Leaf-bud cuttings** are used for many trailing vines and when space or cutting material is limited. Each node on a stem can be treated as a cutting. This type of cutting consists of a leaf blade, petiole, and a short piece of stem with an attached axillary bud (Ervin Evans and Frank Blazich 1999).

Grafting:

Grafting is an ancient, vegetative, asexual plant propagation technique (Eliezer E. Goldschmidt 2014).Grafting commonly influences the phenotype of the grafted plants (Warschefsky *et al*., 2015).It is accomplished most commonly by connecting two plant segments, the shoot piece known as'scion' and the root piece called 'rootstock'(stock) (Eliezer E. Goldschmidt 2014; K T Parthiban *et al*.,2016).The success of the graft depends on the compatibility between the rootstock and scion (Jing Wang *et al*.,2016).There are a number of grafting techniques which include slice grafting, tongue grafting, saddle grafting, cleft or wedge grafting, side grafting, veneer grafting, approach grafting, bark grafting, root grafting and bridge grafting (K T Parthiban et al; Deependra Yadav *et al*., 2018; leaky RRB 2014).

Layering:

This method is practiced in a wide range of tree species due to its simplicity (K T Parthiban *et al*.,2016). Layering is done by bringing a culm or branch in contact with a moist rooting medium while attached to the mother plant. It is a technique by which adventitious roots are formed on a stem while still attached to the plant. There are four types of layering: ground or simple layering, compound layering, air layering or marcotting and mound layering (K.K. Seethalakshmi; K T Parthiban *et al*., 2016; Ervin Evans and Frank Blazich 1999; Leaky RRB 2017; Pratap Chandra Panda *et al*., 2019). The success of layering is dependent on early root initiation and formation of sufficient fibrous roots (Krishan Kumar Singh 2018).

Micropropagation:

Plant micropropagation has been reviewed in the literature with special mention of its applications to forest trees (Bonga and Durzan 1982; 1987; Haines 1994) that were successfully cultured in vitro as early as the 1950's (Bonga and von Aderkas 1992).This is one of the methods of propagation wherein micro-shoots viz; explants (shoot tip, node, internode, meristem, infloresoence, leaf and leaf bits) are cultures in vitro conditions leading to mass multiplication of single plant (K T Parthiban *et al*.,2016).Micropropagation continues to play a role in the conservation of native plants and is included here as a viable propagation option when other methods fail. The micropropagation technology has a vast potential to produce plants of superior quality, isolation of useful variants in well-adapted high yielding genotypes with better disease resistance and stress tolerance capacities (Brown and Thorpe, 1995). Plant tissue culture is a modern method of propagation and conservation of plant species (OjoMichael Oseni *et al*., 2018). Tissue culture is the procedure for maintaining and growing plant tissues and organs in an aseptic culture in which the environment, nutrient, and hormone levels are tightly controlled (Thorpe, 2007). Plant tissue culture technology is being widely used for large-scale plant multiplication (B.S. Ahloowalia *et al*., 2004).

Role ofPlant growth regulator in vegetative propagation:

Some chemicals occurring naturally within plant tissues (i.e. endogenously), have a regulatory, rather than a nutritional role in growth and development. These compounds, which are generally active at very

low concentrations, are known as plant hormones (or plant growth substances (George *et al*., 2008, Santner *et al*., 2009; Davies, 2010). Many cuttings do not root easily and their rooting ability is increased by using these plant growth hormones (Kumar 2015).

Types of Plant growth regulators:

Five major kinds of natural plant growth substances are present in plants. They are auxins, gibberellins, cytokinin, abscisic acid and ethylene with the exception of ABA and ethylene which are represented by single molecules in plants, others are multiple forms of natural plant growth substances (Leakey, 1985). Among the above-mentioned plant growth regulators, auxins are widely used in vegetative propagation through cuttings.

Auxins:

An auxin thus, be defined as an organic substance which promotes growth (i.e., irreversible increase in growth) along the longitudinal axis when applied in low concentrations to shoots of the plants freed as far as practicable from their own inherit growth promoting substances (Thimann, 1963). Since the discovery fifty years ago that auxins greatly increased the capacity of cuttings to produce roots in most plant species, auxins have become universally used alone, or in combination with other chemicals, as an aid to propagation in horticulture and forestry (Leakey, 1985). Synthetic auxins are now usually preferred to endogenous indoleacetic acid (IAA). Indole-3-butyric acid (IBA) is the most commonly used, often combined with a-napthalene acetic acid (NAA) or one of the phenoxy acetic acids. Recently, equimolar concentrations of aryl- and phenyl-esters of IAA and IBA have been reported to outperform the unmodified acids in *Pinus banksiana* (Haissig 1979; Leakey, 1985). The effects of auxins on rooting capacity may depend on the method of application (Howard 1972, Leakey, 1985). Common forms of treatment include (a) a quick dip in relatively concentrated solution, and (b) a soak in relatively weak aqueous (Bowen et al., 1975; Leakey *et al*. I982a; James 1983a). The primary physiological effects of auxin are cell division and cell elongation in the shoots. It is important in the secondary growth of stem and differentiation of xylem and phloem tissues. Besides cell elongation, auxin may also be active in cell division. In many tissue cultures, where the callus growth is quite normal, the continued growth of such callus takes place only after the addition of auxin (Bisht et al 2018).

Gibberellin:

The most pronounced effect of gibberellins on the plant growth is the elongation of the internodes (Bisht *et al*., 2018). The role of GAs in the regulation of adventitious root development is poorly understood. GAs issignaling molecules that exert their effect by triggering signal transduction cascades, which activate or repress downstream genes responsible for carrying out particular developmental and growth processes (Busov *et al*., 2006, Zhao *et al*., 2014). Exogenous GAs inhibited initiation of the first cell divisions of root primordia in the roots of aspen, but they subsequently stimulate the elongation of adventitious shoots (Zhao *et al*., 2014). The length of *Melissa officinalis* L. seedlings receiving the 5000 mg/L GA3 application is 2.71 times greater than that of the control group in terms of stem length without branches and 74% greater in total length (Sevik & Guney 2013).

Cytokinin: The word for cytokinin is a generic name for all naturally occurring substances that are known to promote cell division. CTKs are a class of plant hormones that play important roles in many aspects of plant growth and development, e.g., the formation of shoot and root meristems, and seed germination. CTKs are mainly synthesized in the root system and are transferred via the xylem to other parts of the plant (Werner *et al*., 2003; Werner and Schmulling 2009). Many studies of the biological activities of CTK are based on experiments that focus on the consequences of exogenous CTK application or the endogenous enhancement of CTK content (Faiss *et al*., 1997). CTK and auxin act antagonistically during root development (Fukaki and Tasaka 2009; Laplaze *et al*., 2007). In particular, CTK inhibits root elongation and branching (Cary et al., 1995). More recently, CTK treatment was found to delay cell division in the pericycle and perturb the first anticlinal division, thereby disrupting lateral root development (Mahonen *et al*., 2006, Zhao *et al*., 2014).

Abscisic acid (ABA):

This hormone is widespread in higher plants and is found in many different organs and tissues (both old and young) of plants. ABA induces abscission of the leaves of a wide variety of plants and fruits of some plant species (Bisht *et al*., 2018). ABA also regulate many complex plant processes, including the inhibition of root growth and development (Davies 1995; Chen *et al*., 2002; Sharp 2002). ABA is usually regarded as a stress hormone in higher plants (Mauch and Mauch 2005; Verslues and Zhu 2005). Blake and Atkinson (1986) found that low concentrations of ABA promote rooting in poplar cuttings, but higher concentrations have the opposite effect (Zhao *et al*., 2014).

Ethylene:

Ethylene, another important regulator, regulates the differentiation of the root meristem. Ethylene induces cell division in the quiescent center, leading to the expression of specific genes in these cells; ethylene can also inhibit the differentiation of peripheral primitive cells (Ortega *et al*., 2007, Zhao *et al*., 2014). The increase in ethylene levels that occurs early in the poplar rooting process may be the first biochemical event associated with the rooting of poplar (Hausman 1993, Zhao *et al*., 2014).

Recent advances

Vegetative propagation techniques can be used in the wide area of clonal forestry, conservation, genetic engineering, and the utilization of tropical-forest trees (Haines 1994). some of the advance technologies have also been introduced for effective results which includes Condensed node proliferation technique, Excise Bud Technique, Hydroponics and Somatic embryogenesis

Condensed node proliferation technique (CNPT):

It is an approach by proliferating condensed nodes present at the base of tender shoot branches (TSBs) of plant. CNP technique was successful with comparatively very less injury and minimum loss of potential branches from mother plant (Atul Tripathi *et al*., 2016). CNP technique utilizes the inherent potential of lateral meristem (Fabbri *et al*., 2011). A study was conducted by utilizing the condensed nodes of TSBs, which can be used for large scale production of *C. wightii* plantlets/saplings with minimal input, labor and at very low cost. The CNPT is a better solution to the limitations of air-layering (Atul Tripathi *et al*., 2016). This technique is most successful compared to cuttings and tissue culture of *C. wightii* (Atul Tripathi *et al*., 2016).

Excised bud technique

EBT was introduced (Lopez 1994) to spare the mother plants. Upper bud development is stimulated in the field of healthy, vigorous plants by exposure and earthing up of the corms. Peepers which consequently develop to a height of 3-5 cm are carefully excised and raised in nursery bags in fertile soil or well decomposed organic substrate (K P Baiyeri and S C Aba 2007). This is a type of budding technique which improved the propagation of banana (K P Baiyeri and S C Aba 2007).

Hydroponics

Soil is usually the most available growing medium for plants. It provides anchorage, nutrients, air, water, etc. for successful plant growth (Ellis, N.K et al., 1974).With the advent of civilization, open field/soil-based agriculture is facing some major challenges of land degradation and urbanization (Mamta D. Sardare and Shraddha V. Admane 2019) where soil quality and availability is decreasing. Under such circumstances, soil-less culture can be introduced successfully (Butler, J.D. and Oebker, N.F 2006). Soil-less culture mainly refers to the techniques of Hydroponics and Aeroponics (Mamta D. Sardare and Shraddha V. Admane 2019). It is a method of growing plants using mineral nutrient solutions, without soil (Beibel, J.P. 1970). This system helps to face the challenges of climate change and also helps in production system management for efficient utilization of natural resources and mitigating malnutrition (Butler, J.D. and Oebker, N.F 2006). Aeroponics is another technique, more or less similar to hydroponics with only difference that under aeroponics plants are grown with fine drops of nutrient solution (Ellis, N.K et al., 1974)

Somatic embryogenesis

cells or callus cultures on solid media or in suspension cultures form embryo-like structures called somatic embryos, which on germination produce complete plants. The primary somatic embryos are also capable of producing more embryos through secondary somatic embryogenesis. Although, somatic embryogenesis has been demonstrated in a very large number of plants and trees, the use of somatic embryos in large-scale commercial production has been restricted to only a few plants, such as carrot, date palm, and a few forest trees (Joint, F. A. O. 2004). Somatic embryos are produced as adventitious structures directly on explants of zygotic embryos, from callus and suspension cultures. Somatic embryos and synthetic seeds (embryos encapsulated in artificial endosperm) hold potential for large-scale clonal propagation of superior genotypes of heterogeneous plants (Redenbaugh *et al*., 1993; Mamiya and Sakamoto, 2001). They have also been used in commercial plant production and for the multiplication of parental genotypes in large-scale hybrid seed production (Bajaj, 1995; Cyr, 2000).

FUTURE PROSPECTS

Future perspectives for the use and application of plant growth regulators in forestry are promising for stimulating rooting and shooting of stem cuttings. The need for further research in this aspect is increasing gradually due to lack of potential seed every year which creating immense problems for providing quality planting stock. Vegetative propagation through stem cuttings is quite easier when we have an idea to induce rooting and shooting which can be conquered using rooting hormones in appropriate concentrations. A lot of research work have already been carried on effects of different plant growth regulators on stem cuttings in many forestry species. Furthermore, research needs to be conducted tostandardize the treatments for different environmental conditions.

CONCLUSION

Vegetative propagation has a great potential to produce quality planting stock with superior phenotypic as well as genotypic characters in a very little span of time. This review acts as a guide for various vegetative propagation techniques and also describes about the role of plant growth regulators in speeding of propagation techniques. Advances in vegetative propagation will refine existing technique strategies. Recent advances provide a nutshell on the emerging techniques like Condensed node proliferation technique, excised bud technique, Hydroponics and somatic embryogenesis. Future research should focus on recent advances in a wide

range to promote seed enhancement in different species.

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