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Role of different rooting media and auxins for rooting in floricultural crops: A review

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Abstract
The production of floricultural crops involves a number of cultural inputs. Among these, perhaps the most important factor which plays a major role in quality production and rooting of herbaceous cuttings of plants is rooting media. Due to the relatively shallow depth and limited volume of a container, rooting media must be amended to provide the appropriate physical and chemical properties necessary for plant growth. Application of auxin-based, commercially available rooting hormones contribute significant role to the process of regeneration of roots in the cuttings and their survival. Plant growth regulators like auxins play an important role in improvement of rooting of cuttings. This review article discusses the role of different type of rooting media and auxins for rooting in flower crops and highlights the gaps in our knowledge that need further research.

Keywords: rooting media, auxins, floriculture, IBA, growth regulators

Introduction

Economic importance of ornamental plants: Ornamental plants provides a great diversity of beautiful plants, including cut foliage, cut flowers, bedding plants, indoor plants, potted plants, bulbous plants, outdoor plants, which may be annuals, biennials or perennials in their growth habit. Hence ornamentals bring aesthetic feelings to our surroundings (Riaz *et al*., 2002; Memon *et al*., 2013) [41, 28] and also economically vital in horticultural trade, all over the world. Floriculture is a conventional farming activity in India having immense potential for providing gainful self-employment among small and marginal farmers. The demand for ornamental flowers is ever increasing in international and domestic market with the improvement in standard of living and quality of life. Floriculture has blossomed into commercial activity with a considerable growth and a useful crop diversification option, particularly for small farmers over the past three decades. Europe, the USA and Japan are the main markets with almost three-quarters of global floriculture consumption accounting for a total of about 60 billion EUR. Europe's share of the global market is estimated between 40 and 50% with Germany, UK, France and Italy as the largest markets (Van Rijswick, 2008) [50].

In India floriculture as an industry has tremendous potential for generation of gainful employment in rural as well as urban areas. Leading cut flower producing states of India are West Bengal (33%), Jharkhand (12%), Himachal Pradesh (10%), Andhra Pradesh (9%), Orissa (8%) and Assam (5%). Leading loose flower producing states in India are Tamil Nadu (18%), Andhra Pradesh (13%), Maharashtra (13%), Karnataka (12%) and Chhatishgarh (11%). India occupies 51st position in terms of exports and contributes Rs. 455 crores which is 0.06% of global trade.

Top ten importing countries for Indian flowers are USA, Netherlands, Germany, UK, UAE, Japan, Canada, Italy, Australia and China (DE *et al.,* 2016) [16]. The ornamental plants (flowering and potted) having value of 32 billion euro were produced in the world in 2014 and Europe contributed 34.3% followed by China (15.9%) (AIPH, 2015) [2]. Since the global demand of floricultural products is increasing tremendously, India can effectively use this opportunity to solve the problem of unemployment & poverty through achieving a consistent growth in production and export of floricultural commodity as well earn valuable foreign exchange. In comparison to the developed countries and also to some developing countries floriculture in India is still in a nascent stage.

Efficiency of vegetative propagated ornamental crops: Vegetatively propagated floriculture crops continue to increase in popularity because of tremendous production, marketing and

garden success. However, vegetative propagation of some species is more costly compared to generative propagation, but in many ornamental species it is the only way of propagating that ensures the preservation of all characteristics of the parent plant (Hartmann *et al.,* 2011). The efficiency of vegetative propagation is significantly affected by the environment in the propagation house, such as temperature, quality of the used substrate, rooting hormone and the air humidity. Other important aspects include the care for mother plants, selection of appropriate term for taking the cuttings, and quality of storage of the plant material before the cuttings are taken (Walter, 1997; Hartmann *et al.,* 2011) [51].

Role of rooting media: The growth and development of plants is affected by the different types of factors. Among these different factors, the most vital factor which plays a major role in quality production and rooting of herbaceous cuttings of plants is rooting media. Different growing media can be used to grow plants while the physical and chemical properties of media like structure, texture, pH as well as nitrogen, phosphorus and potassium are the dominant factors for the growth and development of plant (Larson 1980; Riaz *et al.,* 2008; Younis *et al.,* 2007) [42]. For proper growth, a root medium must provide four functions: supply nutrients, provide water, permit gas exchange to and from the roots and should also provide support to the plants. In general, approximately a moisture content of 20-35 per cent, 60 per cent porosity, 30-40 per cent aeration and a pH range of 6.0 - 6.8 are the most optimum physical conditions of the rooting medium. The type of rooting medium also determines the nature of roots which are produced on the cutting (Nanda, 1985) [32]. Composition and nutritional status of the media is reported by Khasa *et al.,* (2005) [23] and Carlile (2008) [11] to be helpful for the production of good quality flowering plants with more number of flowers and greater size.

Types of rooting media:

Water: Commonly used for easily rooting species. Its great disadvantage is the lack of aeration. Artificial aeration promotes rooting and impedes rottening.

Sand: It should be fine enough to retain some moisture around the cutting and coarse enough to allow free draining. The sand should be washed and sterilized before use.

Soil: Well aerated sandy loam is preferable. Due to the possible presence of root-borne disease, soil may need to be sterilized or treated with pesticides.

Peat moss: Used in combination with other materials in order to increase the water holding capacity.

Coconut husk: Widely used in humid tropical environments where it has the same use as peat moss.

Industrial manufactured material such as Vermiculite, Perlite and Pumice are used separately or in combination with some other rooting media. Their advantage is their lightness, cleanness and high water holding capacity.

Role of growth regulators: Ornamental crops find wide use of growth regulators for modifying their developmental processes. The major areas where growth regulators have successfully played their roles in ornamental plants are in vegetative propagation, inhibition of abscission, prevention of bud dormancy, growth control, promotion of flowering, prolonging the vase life of flowers and retarding their senescence (Murti and Upreti, 1995) [30]. Among the various external factors, growth regulators also play an important role in developmental process of the ornamental plants. The auxins have been of considerable use for growth promotion. The cases in which growth promotion by growth regulators would be helpful are those where environmental factors delay or inhibit growth or where problems are encountered due to excessive application of retardants.

(1) Effect of media on rooting of cuttings

Media is a substrate that helps to provide moisture, support, nutrients and aeration to the growing plant and helps in proper growth and development of plants. Rooting medium is essential in increasing rooting percentage, as the selection and combination of medium components are of important in the rooting success of any vegetative propagation.

The combination of suitable rooting components is essential in providing adequate aeration and drainage to ensure faster and better quality of root development. Soil texture is also an important physical property of the soil that plays a key role in deciding seed germination and rooting of cutting. The choice of the growing media can be made best by using detailed study of the physical and hydraulic characteristics of the growing media (Raviv, 2005) [39].

1.1 Properties of cocopeat and its effect on rooting of cuttings:

Cocopeat is a multipurpose growing medium made out of coconut husk. The fibrous coconut husk is pre washed, machine dried, sieved and made free from sand and other contaminations such as animal and plant residue. Increasing demand and mounting costs for peat as a growing media in horticulture have led to the search for high quality and low cost substrates as an alternative (Chong 2005, Wilson *et al.,* 2006, Ostos *et al.,* 2008, Gil *et al.,* 2008 and Moral *et al.,* 2009) [63- 67].

Cocopeat is considered as a good growing media component with acceptable pH, electrical conductivity and other chemical attributes (Abad *et al.,* 2002) [1]. It is also rich source of nutrients and can easily be mixed with other growing media as reported by Bhattacharjee (2006) [10]. The combination of peat and compost in a growing substrate is synergistic; peat often enhances aeration and water retention and compost improves the fertilizing capacity of a substrate (Zaller, 2007) [68].

Coir has been tested as a horticultural medium for several ornamental and agronomic crops with acceptable results (Creswell 1992, Evans *et al.,* 1996, Meerow 1994, Pill and Ridley 1998) [69-72]. Due to these properties, use of cocopeat as a rooting media in carnation crop was effective for minimum number of days for root initiation, maximum percentage of rooting, cumulative root length and number of roots (Renuka and Sekhar 2015; Khewale *et al.,* 2005) [40, 24]. Similarly coco peat + perlite as substrate in hibiscus also recorded maximum root diameter, root length, no. of root, rooting percentage (Torkashvand and Shadparvar, 2011) [29].

1.2 Properties of vermicompost and its effect on rooting of cuttings:

Vermicompost is stable, fine granular organic manure, which enriches soil quality by improving its physicochemical and biological properties. It is highly useful in raising seedlings and for crop production. Vermicompost is becoming popular

as a major component of organic farming system. It is produced by the fragmentation of organic wastes by earthworms. It is rich in micronutrients which are ideal for plant growth.

This medium in combination with other rooting media is suitable for improving vegetative and flowering characters in pot mum chrysanthemum (Nair and Bharthi 2015; Bala and Singh 2013) [29, 6]. Under poly house conditions, highest percentage of establishment of rooted cuttings was recorded with red earth + cocopeat (87.72%) followed by cocopeat + vermicompost (83.32%) and vermicompost alone (81.15%) as studied by Renuka and Sekhar, 2015 [40]. Vermicompost with other medium is also beneficial for improving flowering characters like flower diameter, maximum plant height, flower stalk length and vase life in gerbera and marigold crop (Chauhan *et al.*,2014, Gupta *et al.,* 2014) [12, 20].

1.3 Properties of vermiculite and its effect on rooting of cuttings:

Vermiculite is a hydrous phyllosilicate mineral. It undergoes significant expansion when heated. Vermiculite is combined with other materials such as peat or composted pine bark to produce soilless growing medium for the professional horticulturalist and for the home gardener. These mixes promote faster root growth and give quick anchorage to young roots. The mixture helps retain air, plant food, and moisture, releasing them as the plant requires them and initiates the rooting process.

1.4 Properties of perlite and its effect on rooting of cuttings:

Perlite is an amorphous volcanic glass that has relatively high water content, typically formed by the hydration of obsidian. It occurs naturally and has the unusual property of greatly expanding when heated sufficiently. It is an industrial mineral and a commercial product useful for its low density after processing.

In horticulture, perlite can be used as a soil amendment or alone as a medium for hydroponics or for starting cuttings. When used as an amendment it has high permeability and low water retention and helps prevent soil compaction. Due to these properties it alone or when mixed with other rooting media had pronounced effect on rooting, vegetative and flowering characters of floricultural crops like carnation, lilium, hibiscus and bougainvillea (Wei *et al.*,2017, Asghari *et al.*,2014, Seyedi *et al.*,2012, Babashpour *et al.*,2012) [52, 4, 45, 5].

1.5 Effect of sand on rooting of cuttings:

Sand is a natural and mostly used rooting medium for the most of the vegetatively propagated plants. Possessing different physical and chemical properties it is when mixed with other media effectively improves the rooting, plant height, length of branches/plant, number of leaves/plant, leaf area, number of branches/plant, number of flowers/plant and flower diameter of carnation plant (Wei *et al.*,2017, Yasmeen *et al.*,2012) [52, 53]. Hardwood cutting placed in coarse sand gave highest number of roots per rooted cutting (15.02), percentage of sprouted cutting (81.67), fresh weight of roots per rooted cutting (1680.33 mg), dry weight of roots per rooted cutting (560.11 mg) and percentage of survival of rooted cutting (38.5) of Rose cv. Local red (Aklade *et al.*,2010). Sand with coir dust (1:1) medium with 150mg/l NAA level was best for root growth performances in soft wood cuttings of *C. moonii* (Rubasinghe *et al.,* 2009) [43].

(2) Effect of plant growth regulators on rooting of cuttings:

Plant growth regulators are the natural or synthetic compounds that modify the growth and development of plant by influencing their physiological processes and thereby increasing the productivity of crops (Kakimoto, 2003) [62]. For successful propagation; adventitious root formation is required. The rooting capacity varies with genotypes and, frequently, depends on the age of the plant used as source of cuttings. For years, many efforts have been made to improve adventitious rooting, not only by testing the combined effect of different plant growth regulators (Da Silva, 2008). In addition, authors reported that the presence of cytokinins could enhance the root formation (Pijut *et al.,* 2011) [36].

2.1 Role of auxin

Auxin is well known to stimulate the rooting of cuttings (Hartmann *et al*., 2002) [22]. The most widely used auxin for commercial rooting is IBA (Nickel, 1990) [33]. Today, IBA and NAA are still the most widely used auxins for rooting stem cuttings and for rooting tissue-culture-produced micro cuttings (Zimmerman and Wilcoxon, 1935) [55]. Auxins play an important role in controlling the growth and development of the plants; besides other things they also influence the production of primary, secondary and adventitious roots (Šebánek, 2008) [44].

Indole acetic acid (IAA) is the naturally occurring auxin found in plants. The most commonly used auxin is synthetic 3-indolylbutyric acid (IBA), which proves to be the most effective hormone promoting the production of adventitious roots compared to natural indolyl-3- acetic acid (IAA) (Pop *et al.,* 2011) [37]. Some of the processes regulated by IBA include formation of embryo in development, induction of cell division, stem and coleoptile elongation, apical dominance, induction of rooting, vascular tissue differentiation, fruit development, and tropic movements such as bending toward light. Synthetic forms of auxin are available commercially in the form of Indolebutyric acid (IBA) and naphthaleneacetic acid (NAA).

2.1.1 Effect of auxin on rooting of cuttings

Exogenous auxins application plays an important role in enhancing rooting efficiency and also quality of stem cuttings, while IBA and NAA helps to stimulate adventitious rooting in cuttings (Copes and Mandel, 2000) [13]. Using rooting hormones increases the overall percentage of rooting, facilitate initiation of adventitious roots, and enhance the number and quality of adventitious roots (Dirr and Heuser, 2006) [17] The promoting effect of IBA on rooting is because of its conversion to IAA in plant tissue. When treated with IBA, there was significant improvement in rooting percentage and other rooting parameters in carnation cuttings among different cultivars (Gowda *et al.,* 2017, Prince *et al.,* 2017, Kumar *et al.,* 2014, Ghofrani 2013) [19, 38, 25, 18]. Auxins were also effective regulators in the induction of rooting and less number of days taken for rooting in carnation cuttings (Singh *et al.,* 2006, Bharathy *et al.,* 2003) [48, 8]. Different auxins and their level on rooting parameters of marigold resulted in improved rooting percentage, root lrngth, number of roots and dry weight of roots (Bhatt *et al.,* 2012 [9], Sharma 2014 [57], Majumder *et al.,* (2014) [56]

Hardwood cuttings of hibiscus and Mussaenda Pink when treated with the IBA resulted in maximum number of primary roots per cutting (27), longest root (25 cm) and maximum leaf size (7 cm) and rooting percentage (Shiva and Nair 2009,

Bhandari 2014, Patel 2009) [46, 7, 35]. The cuttings of poinsettia treated with IBA obtained the significantly maximum number of primary and secondary roots per cutting, longest root length, maximum fresh weight of roots per cutting, highest number of leaves per cutting (Singh and Singh, 2005). The positive results regarding rooting parameters was also observed in bougainvillea with different concentrations of IBA and NAA and IBA @ 4000 ppm proved superior with respect to rooting percentage (%) of rooted cutting, survival percentage and took minimum number of days for sprouting (Parmar *et al.,* 2010 and Maurya *et al.,* 1974) [34, 27]. Ullah *et al.,* (2013) [49] reported that the maximum (82.4) number of roots was found in 400 ppm of IBA whereas; maximum root length was recorded (6.5 cm) in 100 ppm of IBA but increasing concentration of IBA up to 400 ppm.

Commercial cut flower cultivar of rose viz., 'First Red' when treated with indole butyric acid (IBA) and naphthalene acetic acid (NAA) resulted in early root appearance (22.55 day) with maximum rooting (76.67%), highest primary root number (12.57), longest root (5.87 cm) and field survival (73.13%) in cuttings treated with IBA @ 1500 ppm (Dawa *et al.,* 2013) [15]. Application of auxins in rose significantly improved rooting parameters (Nasri *et al.,* 2015, Akhtar *et al.,* 2015, Yeshiwas *et al.,* 2015 and Abbas *et al.,* 2015) [58, 59, 61, 60]. In tip cuttings of marigold application of IBA + NAA 150 ppm significantly increased no. of roots (58.79) and highest length of root/cutting (Bhatt *et al.,* 2012) [9].

Future challenges for rooting media and auxins

Although the use of different rooting media and auxins is encouraged in the modern production system of ornamentals and also helpful in altering various growth characteristics but their unjudicial use can threaten the environment and also effect the consumer acceptability. The standardization and specification of rooting media, suitable auxin type and their usage in optimum dosage for specific crop will enhance their acceptability by the growers as well as consumers.

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