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Influence of Growing Media Characteristics on Water and Nutrient Management of Cutting Plants

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Abstract

Floriculture industry is important sector of horticulture that have high demand in the world. Among this sector cut flower production is the dominant and have great return and attracts investors to invest their money than other sector of agriculture. The sector needs high investment capital since it uses high technology and mostly produced in controlled environment like green house. There are many factors that influence the growth, yield and quality of cut flowers. Among this water, nutrient and growing media are important factors which should be manage properly. Cut flower production needs quality water which are free from disease and contamination of any unwanted materials that are toxic to the plant and environment. Nutrients are also another factor that is responsible for the growth and development of the plant. In cut flower production mineral nutrients are supplied in solution form in most of greenhouse production. Another factor that affect the cut flower production is characteristics of growing media. Different media have different characteristics in terms of nutrient content, EC, pH, aeration capacity etc. before establishing crop the media should characterized and used accordingly. So, the purpose of this review is to assess these factors as it influences cut flower production.

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Cut flowers, greenhouse, growing media, nutrients, nutrient management.

Introduction

Floriculture, or flower farming, is a discipline of horticulture concerned with the cultivation of flowering and ornamental plants for gardens and for floristry, comprising the floral industry. Floriculture crops include bedding plants, houseplants, flowering garden and pot plants, cut cultivated greens, and cut flowers. Cut flowers are usually sold in bunches or as bouquets with cut foliage. The production of cut flowers is specifically known as the cut flower industry. Beyond domestic consumption, many kinds of flowers and ornamental plants are grown for export by various developed and developing countries. Increased awareness about ornamental plants can encourage many growers and entrepreneurs to take up their cultivation as commercial enterprise (Wahome *et al.*, 2011).

Good flower production usually depends upon various factors including the type of growing media used. Growing media is defined as the mean where the roots of cultivated plants grow (Kampf, 2000). Their primordial function is to give support for plant growing (Kampf, 2000; Robert, 2000). Nutrients availability plays a pivotal role in good flower production and thus provision of proper growing media is the pre-requisite for better growth and production of floriculture crops. The plant growing medium must be porous for root aeration and drainage and also capable of water and nutrient retention.

According to some studies suitable growing media are necessary for gas exchange between plant roots and atmosphere, supply of nutrients and water quality flower production as well as sufficient anchorage of plant (Awang *et al.*, 2009). Porosity of growing media is an index for root media aeration. When root media aeration is suitable, supplement of nutrient elements and water for growth of plant is easily (Mohamadi-Ghehsareh *et al.*, 2012). Nutrient availability is one of the important factors influencing the suitability of organic substrates for plant growth and development (Caballero *et al.*, 2007). However, different growing substrates have several materials which could have effects on plant production. Thus, selecting the best substrate among the various materials is imperative to the plant productivity (Olympios, 1992).

Recently particular emphasis was laid on protected cultivation and more specific on cultivation of vegetables and flowers on substrates and soilless cultures (closed systems and open with minimum drainage). New unites with soilless cultivation (mainly perlite, coconut and rockwool) have been established applying modern greenhouse technology and fully computerized irrigation-fertigation methods (Chimonidou, 2003a).

The demand for increased production and better yield quality, the lack of good quality water for irrigation and the need for protection and conservation of the environment require the implementation of new technologies in greenhouse cultivation. In this respect, the first measures to be taken are improvement of greenhouse structures and automation of the systems. Moreover, modern techniques have to be applied such as cultivation on artificial substrates, hydroponic cultures, re-circulation of irrigation water and nutrient solution in closed systems and control of the climatic conditions in the greenhouse (temperature, air humidity, CO2, etc.).

Apart from higher production of good quality (10 %- 25 % yield increase in vegetables and up to 30 % in flowers), such technology would result in efficient and effective use of water and fertilizers and in minimizing the use of chemicals for pest and disease control, especially after the prohibition in using Methyl Bromide for soil sterilization (Polycarpou *et al.*, 2007). Moreover, some cultural practices, like soil cultivation and weed control are avoided, and land not suitable for soil cultivation can be used (Polycarpou and Hadjiantonis 2004).

Water use in the greenhouse production of flowering plants has been the focus of much concern and research over the last decade (Beirnbaum, 1992). With the advent of nutrient management regulations for nurseries and greenhouses, the timing and the amount of water and nutrients that plants receive has become a high priority. Irrigation and fertilization practices that reduce water and nutrient loss and ensure nutrient availability in the media promote environmentally sound cultural practices (Ku and Hershey, 1992). Yet, it is economically important to the grower to maximize growing area and production cycles while producing high quality plants. Most horticulturists develop nutrient management plans for ornamental plants based on three main factors: water quality, container media status and nutrient concentrations of recently matured plant tissue. Nutrient availability, deficiencies, and toxicities are determined from laboratory analyses of plant tissue and growing media. Research involving careful monitoring of the media pH and increased understanding of how pH can cause gradients of nutrient uptake would improve nutrient management recommendations and practices.

Characteristics of growing media for cut flower production

Agriculture production needs sustainable and environmentally fertilizer management practices. Soil fertility is the most substantial and controlled factor affecting the nutritional content of plant. The production of organic food has been demonstrated to inhibit chemical fertilizers, herbicides, and pesticides and centralize on natural material and methods of controlling the plant growth, crop yield and plant diseases. The organic fertilizers may serve as alternative practice to chemical fertilizers for improving soil microbial activity and soil structure (Dauda *et al.*, 2008). With attention to rapid development of greenhouse cultivations for production of cut flowers such as carnation, the selection of a suitable substrate for cultivation and growth of carnation is required.

The implementation of fully automated irrigation systems required changes in the growing media for most container-grown plants to add materials that allowed for fast and thorough draining in order to avoid over-watering and high moisture levels (Biernbaum, 1992). Media used as a growing substrate for horticultural crops that is composed of some materials that are not soil is termed “soilless” media. Yet technically, this media can be classified within the Histisol soil taxonomic group because it is mainly (50% or greater) composed of peat and bark-based materials. These “man-made Histisols” are largely organic based and participate in pH dependent cation exchange reactions. Depending on the pH of the media, the materials can vary widely in nutrient holding and nutrient exchange capacities

Soil-less as plant growing media

Soilless culture is the modern cultivation system of plants that use either inert organic or inorganic substrate through nutrient solution nourishment. Possibly it is the most intensive culture system utilizing all the resources efficiently for maximizing yield of crops and the most intense form of agricultural enterprises for commercial production of greenhouse vegetables (Grillas *et al.*, 2001). This protected cultivation system can control the growing environment through management of weather factors, amount and composition of nutrient solution and also the growing medium. Therefore, quality of horticultural crops grown through soilless culture improves significantly compared to conventional soil culture (Massantini *et al.*, 1988). This artificial growing system provides plants with mechanical support, water and mineral nutrient for higher growth and development. Over the years, hydroponics has been used sporadically throughout the world as a commercial means of growing both food and ornamental plants. Primarily, gravel or sand was used in soilless culture system to provide plant support and retain mineral nutrient and water. Afterward, several substrates have been evolved due to their unique properties for holding moisture, aeration, leaching or capillary action, and reuse potentiality. Soilless growing media are easier to handle and it may provide better growing environment (in terms of one or more aspects of plant growth) compared to soil culture (Mastouri *et al.*, 2005). Organic substrates include sawdust, coco peat, peat moss, woodchips, fleece, marc, bark etc. whereas, inorganic substrate of natural origin are perlite, vermiculite, zeolite, gravel, rockwool, sand, glass wool, pumice, sepiolite, expanded clay, volcanic tuff and synthetically produced substrates are hydrogel, foam mates (polyurethane), oasis (plastic foam) etc. (Olle *et al.*, 2012).

Soil is usually the most available growing medium for plants. It provides anchorage, nutrients, air, water, etc. for plant growth (Ellis *et al.*, 1974). However, soils do pose serious limitations for plant growth too, at times. Some of them are presence of disease-causing organisms and nematodes, unsuitable soil reaction, unfavorable soil compaction, poor drainage, degradation due to erosion etc. (Beibel, 1960). Soilless culture is the technique of growing plants in soil-less condition with their roots immersed in nutrient solution (Maharana & Koul, 2004). Soilless culture systems of cultivation can be classified according to the techniques employed. Soilless culture could be applied to growing some popular local crops with the application of food safety standards and at a reasonable price (Paul, 2000). This system will also help to face the challenges of climate change and also helps in production system management for efficient utilization of natural resources and mitigating malnutrition (Butler & Oebker, 2006).

Various soilless substrates have successfully been used for several decades to intensify production and reduce cost (Maloupa *et al.,* 1992). These substrates have marked influence on plant’s health and vigor by dint of their role as a basic medium. A light, rich, porous and well drained medium is considered ideal for roses. Higher yield of best quality stems is entirely based on physico-chemical characteristics of growing substrates. Moreover, the fact that roses, unlike most other crops, are being constantly harvested and thereby exhibiting large fluctuation of the transpiring area must be taken into consideration when attempting to select a growing medium. Fascella & Zizzo (2005) studied that soilless cultivation of roses grown in perlite/coconut coir dust increased yield and stem quality which might be related to the higher water holding capacity and cation exchange capacity of coconut coir, suggesting this organic material as one of the alternatives to peat for hydroponic culture. In recent years, coco coir is increasingly used as substrate, because it not only has many characteristics in common with peat (Lennartson, 1997) but also acceptable pH, EC and other chemical properties (Abad *et al.*, 2002). A growing trend among growers is to identify alternative substrate components. Rice hulls have been identified as an alternative substrate component and are an agricultural byproduct which can be a suitable substrate component (Buck & Evans, 2010).

Soilless culture and Nutrient solution Management

All essential nutrients are supplied to soilless culture plants in the form of nutrient solution, which consists of fertilizers salts dissolved in water. The soilless culture grower must have a good knowledge of the plant nutrients, as management of plant nutrition through management of nutrient solution is the key to success in soilless culture gardening. The soilless culture methods enable growers to control the availability of essential elements by adjusting or changing the nutrient solution to suit the plant growth stage and to provide them in balanced amounts. As the nutrients are present in ionic forms in the nutrient solution and also, not needing to search or compete for available nutrients as they do in soil, soilless culture plants reach maturity much sooner. Optimization of plant nutrition is easily achieved in soilless culture than in soil.

While optimum nutrition is easy to achieve in soilless culture, incorrect management of the nutrient solution can damage the plants and lead to complete failure. The success or failure of a soilless culture garden therefore, depends primarily on the strict nutrient management programme. Carefully manipulating the nutrient solution pH level, temperature and electrical conductivity and replacing the solution whenever necessary, will lead to a successful soilless culture garden.

Influence of water and nutrients on cut flower production

It is essential to have a good knowledge of plant mineral requirements in order to formulate optimum nutrient solutions. The ideal solution would provide the plant with the precise elements for producing the highest yield and/or quality and reduce the susceptibility to biotic and abiotic stresses. However, fertilization is often empirically based. Commercial greenhouse growers generally use high nutrient concentrations in an attempt to maximize crop yield (Rouphael and Colla, 2009), but this relationship is not necessarily straightforward. In general, crop yield responds positively to increasing concentrations until a level after which further increases often lead to no further increases in yield (luxury consumption). When concentrations are too high, yields may be even decreased (toxicity) (Salisbury and Ross, 1991).

Concerns about nutrient runoff from greenhouses have promoted a surge of research related to reducing nutrient losses during the production of container grown plants. In commercial plant production, the earliest methods for providing water and nutrients to plants were accomplished by “top irrigation”. This method was very labor intensive and resulted in widespread inconsistency in growth rate and heterogeneity in plant quality (Baas *et al.*, 1995). Thin plastic drip tubes and overhead sprayers provided water on demand and were used as the first irrigation systems for greenhouses. These systems are very inefficient and in the case of overhead irrigation often resulted in over 50% of the water and nutrients applied lost as runoff. Even though these systems have been improved over the years to provide a more uniform application of water and soluble fertilizer, nutrient loss is still an important concern (Biernbaum, 1992). The introduction of the ebb-and flow irrigation system added greater control to avoid nutrient losses from commercial bedding plant and pot plant production. The optimum leaching fraction should be the smallest leaching fraction needed to maintain proper plant health (Biernbaum and Fonteno, 1989). By adjusting the rate of fertilizer along with the amount of water applied to each pot, the amount of nutrients lost and overall runoff from the facility are decreased. Ku and Hershey (1992) found that geraniums preferred a leaching fraction greater than 0.4. Lower leaching fractions resulted in a reduction of overall plant yield possibly due to the geranium’s inability to tolerate salts accumulating in the media over time.

Several studies have documented the advantage of using lower concentrations than the standard. Locascio *et al.*, (1992) showed that the quality of chipping potatoes decreased with excessive potassium. Zheng *et al.*, (2005) and Rouphael *et al.*, (2008) proved that nutrient solution concentration used by growers can be reduced by 50% without any adverse effect on biomass and quality parameters in geranium and gerbera, respectively. Dufour and Guerin (2005) demonstrated that more than 60% of the nutrients supplied in the cultivation of *Anthurium andreanun* were lost in the leachate. This results in contamination of groundwater and is no longer permissible. Efforts should be made, from an environmental standpoint, in order to find out and use the less concentrated but optimum nutrient solution possible.

The relationship of water and growing media

In soilless culture, an accurate and dynamic control of the water supply is needed to meet plant water requirements due to the low water-holding capacity of the system (De Boodt and Verdonck, 1972). Optimum water supply should fulfill plant demand and also prevent salt accumulation in the substrate area surrounding the root. However, under conditions of high transpiration (e.g. at midday in summertime), supply of water may be often insufficient leading to temporal water stress in the plant. In order to avoid it, sometimes too much supply is given. This results in excessive ion lixiviation within the root environment and in loss of unabsorbed water, which should be avoided from an environmental standpoint because water is a scarce resource.

In order to carry out an effective management of irrigation, precise information of water status of the group substrate-plant-environment is needed. Different methods try to approach this objective through measurements in the plant, in the substrate or by means of climatic sensors. Currently, most soilless systems rely on the measurement of a single sensor, normally a radiometer to determine solar radiation or a tensiometer to determine substrate water potential. When the level of water potential or cumulated radiation reaches a threshold, an irrigation event is activated. A higher level of precision, though, may be obtained through the integration of a more complex model in the irrigation control system, which estimates water demand according to several parameters. Many models have been developed with different levels of complexity (Medrano, 1999) but currently, most of them are based on Penman-Monteith equation, which include radiation, VPD and leaf area, among other parameters (Monteith and Unsworth, 2007).

The relationship of nutrient and growing media in cut flower production

Nutrients availability plays a pivotal role in good flower production and thus provision of proper growing media is the pre-requisite for better growth and production of floriculture crops. The plant growing medium must be porous for root aeration and drainage and also capable of water and nutrient retention. Oxygen, of course, is required for all living cells. The coarse-textured media often meet these requirements. Mushroom compost, leaf mold, farmyard manure and other amendments may fulfill these requirements. Mushroom compost, leaf mold, farmyard manure and other amendments may fulfill these requirements. Brundert and Schmidt (1982) stated that plants with higher water requirements grew more vigorously in leaf mold medium. Maldonado (1984) observed that the plant height and leaf development of foliage plants were best in leaf mold medium. Khan and Khan (1991) reported that the bulb of *Dahlia* was best developed in the leaf mold. Aquila and Pasini (1989) observed maximum plant height and number of leaves in plants grown in leaf mold medium. Shah *et al.,* (2006) got maximum leaves (7.0 mean), with maximum length (20 cm), maximum leaf area (84.7 cm2) and maximum roots (15 mean) in *Ficus binnendijki* cutting, when leaf mold was used as potting media A good growing medium would provide sufficient anchorage or support to the plant, serves as reservoir for nutrients and water, allow oxygen diffusion to the roots and permit gaseous exchange between the roots and atmosphere outside the root substrate (Argo, 1998 and Abad *et al.,* 2002). This important factor is usually under estimated while working on commercial flower production. Only few studies deal with growing media and their effect in various flowering ornamentals like *Lilium* (Kapoor *et al.,* 2000), *Gladiolus* (Khan *et al.,* 2002), *Crocus* (Wazir, 2005), *Phlox* (Naz *et al.,* 2006), *Dahlia* (Kiran *et al.,* 2007), *Freesia* (Ali *et al.,* 2011) and tuberose (Ikram *et al.,* 2012).

Different growing media can be used to grow cut flower while physical and chemical properties of media like structure, texture, pH as well as nitrogen phosphorus and potassium are the dominant factors for growth and development of plants (Larson, 1998). These properties determine the availability of nutrients to plants, mobility of water into or through soli and penetration of roots in the soil. Soil mixes play an important role in pot plant production. Their chemical and physical properties determine the nutritional status of potting media to sustain better plant growth (Gabriels *et al., 1986)*. Composition and nutritional status of the media reported by Khasa *et al.,* (2005) to be helpful for the production of good quality flowering plants with a greater number of flowers and greater size

Cut flowers *like Zinnia* is grown in many types of soils, soil mixtures, or mixtures of organic matter and materials without soil that may include sand, peat, perlite, bark and wood chips, sludge, or composted leaves. The growing media should be porous, uniform in texture, hold sufficient moisture and should be well drained. Commercial mixtures are often used because they are sterilized, ready to use and may even contain some fertilizer (Hochmuth *et al.,* 1996). Different growing media can be used to grow *Zinnia* 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 Composition and nutritional status of the medium is considered to be helpful for the production of good quality flowering plants with more number of flowers and greater size.

Good flower production usually depends upon various factors including the type of growing media used. Recently particular emphasis was laid on protected cultivation and more specific on cultivation of vegetables and flowers on substrates and soilless cultures (closed systems and open with minimum drainage). Soilless culture is the modern cultivation system of plants that use either inert organic or inorganic substrate through nutrient solution nourishment. This artificial growing system provides plants with mechanical support, water and mineral nutrient for higher growth and development. On the other hand, it is essential to have a good knowledge of plant mineral requirements in order to formulate optimum nutrient solutions. The ideal solution would provide the plant with the precise elements for producing the highest yield and/or quality and reduce the susceptibility to biotic and abiotic stresses. So, it is very important to know the relationship between nutrient, water and growing media to gain high return from the investment in cut flower production. Concerning this topic there is limitation of research to support growers by providing profitable technology to encourage and expand cut flower production investment in our country to increase foreign income to contribute for the national economy.

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