Sustainability in Plant and Crop Protection 16

Imran Ul Haq
Siddra Ijaz *Editors*

Etiology and Integrated Management of Economically Important Fungal Diseases of Ornamental Palms

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Preface

Ornamental palms are common in tropical regions, where they dominate the landscape. All palms belong to the family Arecaceae (syn. Palmae) comprising of thousands of species distributed throughout the tropical and sub-tropical ecological zones. The family ranks third globally after the grass and legume families. About 200 palm genera are currently recognized. The species richness is much less precise because of conflicting concepts by taxonomists as to what constitutes a distinct species, and the need to revise a number of large genera. Actually, the number of species recognized in the literature is more than 2400, which shows the taxonomic complexity of Palmae. Scientists have brought some ornamental palms under the category of "False Palm", which are cultivated as ornamental or for aesthetic purposes, but they are not true palms. As the horticultural industry is flourishing rapidly, ornamental palms occupy a key status for landscape purposes. Their great demand in landscape as well as for products makes ornamental palms perfect candidates for the horticultural industry. Nevertheless, they are prone to different biotic stresses including fungal diseases, which are a major threat. However, there is little and scattered information available along few reports on fungal diseases, although reality is otherwise. We came to know about this fact while conducting a survey to document the different diseases of ornamental plants under project (#2762) "Etiology and integrated management of perennial declining evergreen ornamental plants in Pakistan", funded by the Higher Education Commission (HEC) of Pakistan. The ornamental palms are exposed to stress by a variety of fungal pathogens and their associated diseases. With this perspective, we decided to compile information in the form of a compendium, which will serve as a reference for scientists and researchers dealing either directly or indirectly with ornamental horticultural research. The volume is organized into three distinct parts, comprised of 16 chapters in total. Part I consists of three chapters. The first one provides information about the economic importance of ornamental horticulture, describing the current scenario and future prospects. Chapter 2 focuses on molecular taxonomy, ecology and distribution of ornamental palms, whereas the third chapter deals with cultivation and growth constraints. Part II includes eleven chapters on the etiology and management strategies of economically important fungal diseases. Part III comprises of two

chapters, which describe the etiology and management of “False Palms”. The production of this book gave us great pleasure with the hope that it will provide essential information on biology, diversity, taxonomy and, majorly, fungal diseases of ornamental palms. At the end we acknowledge Higher Education Commission, Pakistan, for providing funds under HEC project # 2762, titled; “Etiology and integrated managment of perennial ornamental plants”. that became ignition for aspiration to edit this book based on the information gathered while working on this project.

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Part I
Biology and Horticultural Aspects of Ornamental Palms

Chapter 1
Ornamental Horticulture: Economic Importance, Current Scenario and Future Prospects

Iftikhar Ahmad, Hafiz Atta-ur-Rehman Saeed, and Muhammad Abdul Salam Khan

Abstract Ornamental horticulture comprises production of cut flowers, potted plants and cut foliage crops, which is highly competitive on account of advances in infrastructure availability, improved varieties development, postharvest handling and marketing options. With rise in production costs, floriculture production is shifting from the three most important global producers, The Netherlands, USA and Japan to some Latin American, African and Asian countries, where growing conditions are favorable and resources are cheaper. Among ornamental plant production for landscape and interioscapes, ornamental palm production is a high demanding segment, which has high value all over the world. In this chapter, ornamental palm types, economic importance, and future prospects are described along with their basic characteristics and growing requirements.

Keywords Horticulture · Economic importance · Ornamental palms · Interioscapes

1.1 Introduction

Floriculture consists of four major components, viz. cut flowers, potted plants (including potted flowers and potted greens), cut foliage, and bedding/garden plants. Compared to fruits and vegetables, floricultural products require higher initial investment, efficient management and a high-tech production technology. Therefore, their profitability per unit area is much higher than other agricultural commodities. According to a report, value per ha in The Netherlands has reached to $138,000

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followed by Colombia having $100,000 (BIOX 2005). Floricultural production ranks among top four export earning commodities, that include petroleum, coffee, and bananas (BCMAFF 2003). The Netherlands, Japan, and USA are global leaders in floriculture production with approximately $44 billion value (Marques and Caixeta Filho 2003). Moreover, per capita consumption of floriculture products varies greatly in different countries with developed countries generally having a higher consumption, such as Switzerland €136, which ranked first in all countries, followed by Norway at €14 per capita (IFTS 2004). Presently, the Netherlands, the US and Japan are the leading floricultural producers in the world followed by Colombia, Kenya, Equador, Ethiopia and Zimbabwe, which are emerging floricultural economies during last two decades (Wijk 1994; Kenya Flower Council 2005).

There are more than 120 countries in the world which are actively involved in floriculture production. Japan, leading with a production value worth $3.7 billion, whereas The Netherlands, with $3.6 billion and the USA, with $3.3 billion accounted for more than half of the world total (Papademetriou and Dadlani 1998). In 2004, the total production value was around $75 billion, of which The Netherlands had a €3.6 billion share (FCH 2004), USA had $5.18 billion (USDA 2005), while Japan had $3.47 billion (MAFFJ 2002–2006). In terms of areas under floriculture crops, China and India are leading with more than 75,000 ha in China and 65,000 ha in India (Yang et al. 1998; CMA 2005). The proportion of different floriculture products varies greatly among countries (IFTS 2004; USDA 2004; 2005). The main floriculture products are cut flowers (45.3% in Germany, 48.5% in The Netherlands, 15.7% in USA, 31.6% in China and 99.3% in Colombia), potted flowers (34.8% in The Netherlands and 39.1% in China), and bedding and garden plants (51.8% in USA) (MAFFJ 2002–2006). Among these, cut flowers are the leading product in world floriculture trade. In 2001, fresh cut flowers shared 50.5% of the world trade value of floriculture (Laws 2004), the top four crops, in decreasing order, being roses, chrysanthemums, carnations and lilies. Production of huge amounts of high quality flowers all year around, with lower labor and other production costs, induced some floriculture production shifts towards Southern Hemisphere countries. The Global production of floriculture products will likely continue to expand, especially in developing countries in Africa, Latin America and Asia, whose productivity is expected to increase further. Traditional large producing countries such as The Netherlands, Japan and the USA continue to lead global production, increasing productivity per worker and unit area. Total area under production will remain stable or drop slightly in these three countries. Production of highly labor-intensive cut flowers will shift in areas with lower labor and other production costs.

During last two decades, floriculture production has shifted to many developing countries having favorable climatic conditions and fertile soils, with cheap labor and friendly export/import policies. These countries include Kenya, Colombia, Ecuador, Ethiopia, Zimbabwe, Malaysia etc., whose exports are rising day by day to European countries. Around the globe, there are three significant floriculture consumption regions, viz. Europe (66.7%), USA (19.3%) and Japan (10.7%). From a country perspective, USA is the biggest consumer at $6.99 billion, sharing 19.3% of the world total value. Germany is second largest (18.8%), followed by Japan

(10.7%), France (8.5%), United Kingdom (8.5%), Italy (6.8%), The Netherlands (4.1%), Spain (4.1%), Switzerland (2.6%), and Poland (2.6%). These ten countries account for 85% of the world total floriculture consumption. On a per capita basis, generally European countries have a higher floriculture consumption with Switzerland ($136), Norway ($114), The Netherlands ($93), Denmark ($83), Germany ($83), Austria ($78), Sweden ($77), and Belgium ($69) having higher per capita consumption. Outside Europe, Japan ($31) and the USA ($51) have relatively lower consumption per capita (Xia et al. 2006). Cut flower use is expected to still rise in coming years, particularly in Asian countries, where floriculture markets will experience increasingly global competition. A number of traditional markets are showing signs of saturation, while new countries are trying to get their place on the market. At the same time, with increased living standards, new markets will develop in some regions of the world such as Eastern Europe and Asia.

Floriculture, now a visible and growing section of Horticulture, encompasses production, propagation and marketing of ornamentally important trees, shrubs, palms, indoor plants as well as flowers that address the demand of cut flowers and potted plants in market. As the greenhouse technology developed, a positive competition in three big centers of floriculture market (Europe-Africa, America and Asia-Pacific) increased globally, especially in three big producers as well as consumers of floriculture items (The Netherlands, Japan and America). World floriculture trade has been exceeded up to 50 billion US $ while increasing daily. The Netherlands is the biggest exporter as well as importer of floriculture products, due to their distinctive way of trade. After Netherlands, Kenya, Ethiopia and Colombia are next biggest exporters (Ogawa 2004).

Pakistan is a country whose GDP depends up to 21% on agriculture. However, floriculture is a developing industry in the country but still occupies only 0.5% of arable land. Floriculture includes a vast range of commercially grown crops in all climatic regions of the country, whereas agronomic crops such as wheat, rice, maize and cereals are limited to specific regions of country. Floriculture in Pakistan is still limited to developed cities such as Karachi, Lahore, Islamabad, Peshawar and Faisalabad, while Pattoki (Kasur district) is biggest producing region as well as national market hub for floricultural crops. In Pakistan most of farmers are small land owners, they grow agronomic crops and depend on yields. Conventional crops are economical for larger areas but a solution for small land owners may be represented by floriculture.

On the other hand, floriculture products generate high cash value as well as aesthetic food for soul. Inexpensive labor, favorable climatic conditions and easiest availability of land are key benefits for local producers. Most common constraints to producers include lack of irrigation sources, expensive hybrid seeds and corms, lack of knowledge about fertilizers, high post-harvest losses, lack of cold store facilities, no greenhouse technology, low quality of products and lack of knowledge about packaging. Unfortunately, Pakistani farmers are not producing export quality products due to the above mentioned constraints and lack of cooperation with research and business officials. Moreover, producers are not aware about export standards of world floriculture markets. Pakistan has opportunities in nearest

Chinese, Japanese, Gulf and other Asian markets, but due to continuous negligence towards floriculture, national products have negligible shares in these markets. Pakistan needs to create awareness among farmers about standards of export quality products, providing greenhouse technology, managing continuous flights, and adopting postharvest treatments and packaging, according to the world trade demand. Most of evergreen plants also require less water and fertilizer. In floriculture products, demand of cut flowers is continuously emerging and contributes a big share in Pakistan floriculture market. The requirement of evergreen plants was low until the development of housing societies while nowadays a huge number of dracaenas, dieffenbachias, colorful shrubs, exotic trees and most graceful species of ornamental palms are in the demand of every developing and developed housing scheme. Among green plants, palms have their own aesthetic, historic and economic value.

1.2 Trends and Prospects

1.2.1 New Style and High Quality

In order to fulfil the trends set by the market for fresh cut flowers, bedding plants, ornamental palms, and potted flowering plants, and to compete with low-cost production and labor countries, production systems often have to be optimized, especially in large greenhouse areas in localities around the world where climate is less than optimal. Computer systems that monitor and regulate the growth environment, movable tables for enhancing production area, supplemental lighting and mechanization (for reduced labor costs), and re-use of irrigation water are all means of achieving these production goals.

1.2.2 Transition of the Producing and Consuming Center

Traditionally wholesalers play several roles (product sourcing, brokering and handling, providing product information, credit source, identifying emerging market trends, tracking of difficult-to-find material) for retail florist customers, and have served as middle-men for a long time, providing a bulk source (local or imported) from which redistribution occurs in smaller lots to retailers. These will continue to play a major part of global cut flower markets. However, distribution centers and grower-direct-auctions are becoming increasingly popular due to greater demands to reduce costs, cuts of the middle-men and speed up purchases in a more efficient way, allowing thus for a superior quality product (longer vase life). High-tech driven markets (USA, EU, Japan, S. Korea and increasingly China) are starting to move towards online grower auctions. This tends to cut the wholesale agent and the

importer out of the picture, altogether. Retailers are also getting smarter, avoiding middle steps, and increasing purchases/sales by both traditional retailers (including large floral chains), street and special locality vendors such as supermarkets, stores, warehouses and internet sites. Retailers can be broadly categorized into three sectors: (a) specialty i.e. florist shops, garden centers, mail catalogues, craft/art specialty, toll-free numbers, farmer's markets, street vendors (accounting for 59.5% of the cut-flower market), (b) mass merchandisers i.e. supermarkets, discount chain stores, warehouse clubs, convenience stores (accounting for 36% of the cut-flower market), (c) others (4.5% of market) (van den Broek et al. 2003). This balance is definitely going to change, with a greater tendency towards (b), but this depends strongly on the national consumer market.

1.2.3 Use of the New Technologies and Advanced Facilities

A greater understanding of the physiological, genetic and ecological mechanisms underlying plant growth, flower initiation and development, and subsequent post-harvest conditions will lead to the launch of much more superior quality products onto the market, which is increasingly demanding, and reliant on novel ideas for its growth and expansion. At the same time, mass production units (either *in vitro* systems or bioreactors for mass production of micropropagules) will be essential to satisfy growing demands, which might otherwise, through conventional propagation practices, could not be fulfilled. Moreover, a greater ease, consistency and reliability of genetic transformation methods will allow the introduction of novel characters such as new colors, manipulated growth patterns and development, and also strengthen plants' responses to environmental (biotic and abiotic) stresses. There is no single factor that determines the efficiency of a production site or unit, and several aspects must be considered simultaneously: sufficient working capital, availability of suitable plant material, green or shade housing, location, ease of cultivation, well drained or suitable soil, species selection, flowering period, planting density, irrigation design, drainage, shelter or windbreaks, insects, diseases, climate, supply of labor, access to the market, weed control, spray equipment, mechanical equipment, cool room storage, and packaging facilities.

1.2.4 New Marketing System

Successful marketing and profitable exports depend on different factors such as: understanding and meeting market and customers' demands; understanding specific cultural and social customs, fashion and trends affecting buying patterns, quality of the product on arrival, product presentation and promotion. Successful marketing goes hand-in-hand with assured supply, quality product, packaging, cool chain transport and cool storage facilities, pre- and post-harvest treatments and

IPM. Marketers must be aware of color preference, stem length, bunch weights, bunching, sleeving, box size, product description sales as a consignment or as a fixed price basis. Moreover, knowledge of the export logistics (freight forwarder services, domestic transport, direct flights, customs clearance system, export documentation, packaging, pressure cooling, cool storage, distance from international airport, fumigation services), and legislative requirements (permits and authorities, quarantine, inspection, and phytosanitary certification for specified markets, import permits, duties, tariffs and customs requirements, and plant quarantine clearances of arrival in some export markets) will all ensure a sound marketing strategy.

1.3 Ornamental Palms

After cut flowers, second major segment of floriculture industry is the production of live potted plants, which accounts for around 43% of total trade. Among these, there are ornamental trees and shrubs, climbers, bedding and house plants. In this chapter, we will focus on ornamental palms. Symbolically, palm trees depicted victory, peace and productivity in many cultures in the past, while nowadays the palm is considered as a symbol of tropics and tourism.

Palms (Arecales), members of family Palmae (Arecaceae), are quite popular ornamentals in tropics and subtropics. They are placed in six subfamilies with approximately 4000 species and more than 200 genera. Palm trees have great diversity in morphology and ecology, and are commonly found in tropical, subtropical and Mediterranean climatic regions. These also have high economic value being source of food and oil, fiber, wine and other beverages, active compounds, rattan—used in furniture production—and thatch—used as roofing material—, tannins, and lumber. Moreover, palms are integral part of modern landscapes, interiorscapes, and are grown in many national and international tropical gardens, such as The Palm House at the Royal Botanical Gardens, Kew Gardens (England). In USA, primarily in California, Florida and Hawaii, palms are produced for the ornamental industry as potted, greenhouse-grown plants for interior use, or container- and field-grown plants for landscape use. While in other parts of the world, they are grown in fields for food, oil and other commercial uses.

Generally, palms are naturally distributed in tropical regions, but now the majority of them has been transported to new locations, different from their native habitats. For example, *Phoenix dactylifera*, commonly grown for its edible dates, probably originated in the Persian Gulf, but now it is commonly found throughout subtropical Florida, employed as landscape centerpieces. However, new cultivars of ornamental palms have not been bred for new environments but are transported to new locations in which they often fail to survive. This movement of palms to new environments poses great challenges to ornamental palm growers. Palms are basically monocots and their anatomical structure has important implications for their health. Each stem of a palm has a single apical meristem (bud or heart). Once the meristem is damaged—due to any pathogen, nutritional deficiency, herbicide,

mechanical or environmental factors—the plant may die. This vulnerability is particularly known in single-stem palms. Since palm stems have no vascular cambium, they are essentially devoid of secondary growth. Therefore, palms cannot repair injuries to their stems, and diligent effort must be made to prevent lesions that provide opportunities for insect and/or pathogen invasions of the trunk.

Palms are integral part of the green vegetation in many developed countries. There are almost 4000 species of palms in the world, most of which are native to warm tropical regions. However, there are a number of species native to subtropical and lower hilly areas e.g., the Chinese windmil palm (*Trachycarpus fortunei*) which is outstandingly cold-resistant and hardy. Nowadays, species of palms are available for all landscape attributes such as indoor, outdoor, potted, green belts, group plantation and corner plantation as well.

People from old age era were directly dependent on many palm trees for several important products, such as natural waxes, oils, kernels, wood, fibers, leaves and fruits etc. Nowadays, there are few economically important species, for commercial purposes. History of palm trees is as old as man itself. Although controversial, it is thought that palms were first cultivated by Mesopotamians and other Middle East civilizations around 5000 years ago. History also guides us about useful benefits and distinctive traits of palms, i.e. the date palm (*Phoenix dactylifera*), that produces high yields of energy rich fruit, the coconut palm (*Cocos nucifera*) that produces delicious fruit coconuts (while its outer covering is used as organic substrate for raising of plant seedlings), the traveler's palm (*Ravenala madgascariensis*), which is a false palm that stores water in its branches during rain that later is useful for water supply, the rattan (climbing palms) that were broadly used to make furniture chairs and handicrafts, and many others. Many palm species bear edible fruit that remained as a survival food during famines, i.e. the Southern Paitue, or the California *Washingtonia filifera* that provides fruit to feed people in starvation.

As a testimony of the historical value of palms, the word "dates" is cited 26 times in the Holy Quran.

> Does any of you wish that he should have a garden with date-palms and vines and streams flowing underneath, and all kinds of fruit, while he is stricken with old age, and his children are not strong (enough to look after themselves)—that it should be caught in a whirlwind, with fire therein, and be burnt up? Thus doth Allah make clear to you (His) Signs; that ye may consider. (**Surah Al-Baqara, 266**)

Dates were also mentioned 30 times in the Bible. Palms remain as an important part of every civilization in old and middle ages, and even nowadays for many religion such as Islam, Christianity etc.

1.4 Biology of Palms

Palms are flowering angiosperms, and appeared almost 80 million years ago. Being monocots they have only a single cotyledon produced by each seed after germination. This character of palms relates very closely to bamboos and grass plants. Palms

are now growing all around the world. Even if they attain the size of trees, in relation with their growth and basic structure, palms are more relevant to other monocots such as corn, grasses, bamboos and rice etc. rather than tropical trees such as maple, oak and others (Broschat et al. 2014). In monocots there are very rare species which attain the size of a palm, i.e. a date palm that may reach up to 40 m. One of the main characteristics of monocots is the lack of a distinctive and useful layer of productive cells known as vascular cambium, which in dicots appears between the xylem (that transfers water) and the phloem (that transfers carbohydrates). It also makes new phloem towards the inside of the stem, while the xylem is opposite to it.

As in palms there is no vascular cambium, water and carbohydrate conducting tissues become dispersed in whole internal stem. Woody dicots are able to expand their stem diameter and produce new vascular tissues, which is known as secondary growth. Horticulturists perform successful grafting and budding in closely related varieties and species of dicots due to the regenerative ability of cambium that also makes it able to fix injuries. On the other hand, palms lack cambium and therefore grafting and budding cannot be performed, as well as secondary growth. This means that once a palm tree reaches its maximum girth size it cannot raise stem size or diameter. Scattered xylem and phloem in palms stem last for the whole plant life. For this reason palms are also unable to fix their injuries. Most of the palms have only a single growing bud/node on the apical meristem. This apical meristem is hence vital for palms because it has only one single growing point. If it is damaged then the plant dies (Broschat et al. 2014).

Propagation of palms for commercial agricultural and ornamental objectives is achieved through seeds. However, there are certain species (*Phoenix dactylifera* and *Rhapis* spp.), which can be propagated through suckers (baby plants produced at the base of the mother plant) and tissue culture (Corley 1980). Seed propagation has certain serious problems such as the very low seed germination percentage and the long time needed for growth of seedlings. This is a challenge to produce uniform seedlings, with higher germination percentages.

Palm seeds usually take 90–120 days to germinate with only a 15–20% germination rate, which represent a great loss to producers. Palm seeds vary greatly in size, with the smallest seed measuring only 5 mm, while the biggest weighs up to 20 kg (this is the coco-de-mer Will Apse (Biologist from UK) palms *Lodoicea maldivica*). Germination in palms usually occurs in two ways: one is called remote germination, while the second is known as adjacent germination. In remote germination, a shoot from the cotyledon grows away from the seed, seedling shoot and radicle root develop, while the main cotyledon remains inside to provide food from endosperm in the form of nutrients. *Phoenix dactylifera*, *Livistona chinensis* and *Chamaerops humilis* are true examples of remote germination. On the other hand, if we see the adjacent procedure, a round button-like cotyledon grows, root develops from radicle and shoot emergence starts. *Syagrus romanzoffiana* and *Butia capitata* are best examples of this process.

Considering problems in palm seeds, the maturity of seeds stands on top. Most of the time seeds are immature, with an embryo that is not fully mature, causing a poor germination percentage. Also happens that all seeds are not synchronous, and

do not mature at a single time, originating a mixed germination frequency. There is an exception where maturity does not matter, as in *Dypsis lutescens*. The second major problem is the collection of fallen seeds. It is observed that fallen seeds always carry spores of disease causing agents, that do not let the seed to emerge. Thirdly, usually farmers treat seeds with higher concentrations of fungicides that cause low germination percentages and even a delay in the process. Suitable substrate selection is another problem in nursery raising, requiring good sanitation and disease-free growing media.

There are some easy tests to check the viability of seeds including float test, tetrazolium chloride test and the physical cut method. To perform float test, seeds must be placed in a container filled with water. Dead seeds will float while viable ones will soak. However, this method is old and scientists do not recommend it any more. In the tetrazolium chloride test, a selected population of seeds are cut in half and the embryos are coated with 1% or 10 g L^{-1} of tetrazolium chloride (TTC), before being placed in the dark for 2–24 h. If the embryos become pink or red, they are viable otherwise they can be considered as non-viable. In the third test, the seeds are cut in half and the embryo and endosperm are observed. If the embryo is firm and colored and the endosperm fills all of its space in the seed coat, the seed may be considered as viable. If the embryo is discolored and the endosperm is dis-shaped, it is non-viable.

After seed selection, pre sowing treatments of palm seeds should be finalized. Growers and nurserymen commonly use scarification, stratification, soaking in water, removal of fruit remnants and application of chemical boosters such as gibberellic acid (GA) as pre sowing, or priming techniques (Nagao et al. 1980; Broschat and Donselman 1987).

Scarification-mechanical treatments to seeds are highly risky and require an experienced skill. Hard seed coat is a common problem in almost all palm species, and scarification is recommended for the hardest ones. In *Hyphaene* spp., only the upper husk, that is of a leathery type, should be removed mechanically. Mechanical treatments are harmful for the embryo, because a minute damage to the embryo turns the seed into waste. However, hammer hit, cutting of upper side to allow water access to endosperm, and levigation with stones are used which are being helpful to improve germination (Nagao et al. 1980).

Stratification-storage of seeds at a specific low temperature may help to break their dormancy. However, in case of palms, dormancy is usually not a problem. The main problem is instead with the hard seed coats, and suitable temperature during the germination period. It is recommended not to store palm seeds for years. If storage is necessary, then first remove fleshy fruits from seeds and wash with water to ensure the total removal of fruit residues. Secondly dry them, at temperatures higher than 15 °C, avoiding storage for more than 6 months (Broschat and Donselman 1987).

Soaking in water for a few days gives better germination rates. But if seeds are soaked in water and heated from below, the germination rates will be much higher. This procedure is even more effective than the use of chemical boosters/enhancers. Gibberellic acid, sulphuric acid and other chemical enhancers show good results, while hot water treatment showed the best results (Broschat and Donselman 1987).

Removal of flesh/fibrous fruit residue from the seed is necessary to boost up the germination rate. This procedure enhances the germination speed while the final germination percentage remains the same for both practices. However, fruits should be removed immediately because they may contain spores of different pathogens (Marcus and Banks 1999).

1.5 Pruning of Palms

Pruning is a judicious removal of plant parts performed to get specific objectives and goals, based on clear objective for each cut. In Pakistan, pruning is often limited to just cutting off branches, while this operation should be a totally scientific, experienced and skill-required job. Generally, it is thought that palms are slow growing plants and they do not require any pruning. Although they are slow growing, they need pruning to remain attractive and avoid diseases. As pruning requires certain goals, there are some objectives to achieve for members of this family. Palms are pruned to remove old dried fronds, collect fruits and remove suckers to maintain a solitary, main trunk. Old dried fronds are not a burden on plants, but when their cluster get wet by rain, they produce a conducive environment for fungal diseases (Pfalzgraf 2000). Insects are also observed in the skirt (old dried fronds that remain attached) of *Washingtonia robusta* that are lethal to the palm. It is also observed that when palms are planted on green belts, their old dried fronds often fall on vehicles that cause a severe damage. Approximately, all palm species produce fruits but few of them are edible, with a very little amount of commercial importance.

Date and coconut palms are two important commercial species in the world, and throughout history. Their fruits contribute a big cash value in the Horticulture sector of world trade. When we use these palms in landscapes, fallen dates produce a debris that cause hazards and may incubate insects as well as spores of pathogens. On the other hand, coconut palms produce a drupe of almost 2–3 lbs in weight that may cause serious injury to people. Fruit pruning of these palms is then also a necessary practice. Palms often produce basal suckers on their main trunk that affect the palm's look as well as snatching its single straight stem look. These suckers develop initially on the root system of palm, to later produce their own. Furthermore, these suckers are removed to maintain solitary straight trunk and to propagate more palms (Robinson 2004).

There are some important do's and do not's of pruning palms:

- Do not injure the living part of main trunk while pruning its frond or removing the sucker. This is advised because this damage cannot be healed up.
- Do avoid to damage the root ball of palm while pruning basal suckers because most of the nutrients available to palms are from upper surface of soil.
- Do not allow the flowers as well as fruits to develop because they use energy, cause mineral deficiency and create a messy debris when falling around the tree.

- Do pruning in the correct season, preferably in spring or summer months because it will differentiate growing and stagnant growth branches.
- Do not let the brown or paled leaves remain attached to trees because they cause certain mineral deficiency and induce this deficiency to newly growing leaves.
- Do pruning on newly growing parts, only if necessary, i.e. if planted indoor and/or space becomes limited.
- Do not over prune the palms. You must keep a desired and suitable shape that creates an attention in landscapes.
- Do pruning of 3 to 4 year older fronds. Palm's fronds may take 3–5 years to become mature, if you observe the new growth of current year, you must leave the last two growth of fronds and prune older than these. This helps palm to remain attractive until new growth becomes mature and protects new growth from heavy winds.
- Do pruning close to the main trunk but take care of living green part.

1.6 Common Ornamental Palms

*1.6.1 Areca Palm (*Areca catechu*)*

Origin This palm is also known as Areca palm, betel palm, or Indian nut. It is indigenous to Philippines. However, it now expanded over Asia and some islands of the Pacific Ocean and West Indies.

Growth and Botany *Areca catechu* is a small to medium sized species that grows almost up to 6–7 m height. Main trunk expands only 5-10 cm in diameter and leaves are medium green and assembled leaflets are attached. Areca palm also produce flowers which make a small, round fruit.

Propagation Seeds are the main source to propagate these palms, while suckers are also used for propagation. Seeds are sown in spring and seedlings are ready for transplant within 6–8 months. A low germination rate is a common problem of almost all species of palms especially in the case of Areca palms with rates lower than 25%, even after 100 days of sowing. Seed priming with bio-membrane and solvents is the best solution.

Economic Importance Suitable for symmetric gardening and for open indoor areas, i.e. super stores, malls and hotels. Fresh fruit is also used for some addictive beverages while its fruit is famous in Chinese people for chewing. Its fronds and trunks are used in local construction, in the making of weapons, and as sources of wax. *Areca* seeds are also widely used in traditional Chinese medicine as an anti-parasitic agent and antihypertensive agent. Its leaves and nuts are also used to cure

diarrhea, throat inflammations, dropsy, sunstroke, beriberi, edema, bronchial catarrh, and urinary disorders (Badet 2011).

Future Prospects Areca palms contain polyphenols, fibre, fat polysaccharides, protein, and alkaloids. Moreover, their content may reach 8–12% in fats, which may be used in preparation of confectionery. There are bright prospects of using Areca palm fruits in pharmaceutical industry, as a digestive and carminative anti-diabetic, against certain skin diseases, relieving asthma and low blood pressure. Its husk may also be used for preparing paperboards, hard boards, cushions and non-woven fabrics besides being a good source of furfural. Its leaf sheath has the potential to be used for preparation of single use cups, plates, plyboards, tea chest, packing cases and suitcases, which can be commercially exploited.

*1.6.2 Toddy Palm (*Borassus flabellifer*)*

Origin Toddy palm, also known with the common name Palmyra palm, is used to make wine, from flower sap sugar and other local products. Areng (*Arenga pinnata*), nipa palm (*Nypa fruticans*) and coconut (*Cocos nucifera*) are other palm species known as toddy palms. *Borassus flabellifer* originated from subcontinent India and Pakistan and other Asian countries.

Growth and Botany Grey trunk, rounded signs of leaf scars and a straight upright single stem growth increase its beauty, as it attains more than 30 m height. Leaves look like fans, with reasonable difference in two leaves. They remain attached to the trunk for several years. Growth in earlier stages is very slow, while in later stages it grows rapidly. Toddy is a dioecious palm in which male flowers are very short (only 1 cm long) while female florescence is long and round like a golf ball. After pollination these flowers produce edible fruits.

Propagation Off shoots and seed are the right way of propagation. Seeds are present in jelly type sockets of fruit. They have a slow growth and low germination rates, while offshoots grow smoothly with high survival rate. Seeds are sown in garden soil and become able to transplant after 5–6 month. First year of plant from germination to forward should be under semi shade, later growth needs sunlight for further metabolism.

Economic Importance Toddy palm is one of the best choice among flowering shrubs, lawn sides and other formal and informal landscapes. Older leaves of toddy remain attached to the palm for long time, where the dry and green leaves combination gives a different look in garden. In ancient times its fruit were stored unripen and roasted later. The fruit was used in the past as raw, cooked or pickled, with a taste like the coconut, so that it was usually offered to guests. The soft juicy part of the fruit (toddy) is used to make sweet dishes.

Future Prospects Toddy palm has several medicinal uses and may be used commercially in the pharmaceutical industry. Moreover, its leaves have potential to be used as thatching for house floor and walls, weaving into baskets, mats and many other items. A number of fibers can also be obtained which can be used for making hats, boxes, baskets, fans, etc.

*1.6.3 Coconut Palm (*Cocos nucifera*)*

Origin Most common known nut but actually it is a drupe fruit. The word coconut was derived from "coco" (Spanish and Portuguese) which means "skull" or "head". *Cocos nucifera* is native to America. Old Sri Lankan, Indian and Malayan civilizations have great evidence of this palm in their history and religions. Its fruit, water, juices, milk, husk, oil, and coir are the main products being used for centuries.

Growth and Botany Coconut palm is one of the long and heighted palm trees. They are mainly of two types: dwarf and tall. Leaves are long up to 6 m. They do not leave any scar on stem when become old and fall. Fruit is mainly a round drupe almost 18–20 cm inches in diameter. The fruit contains a medicinally and economically important juice when harvested. Coconut palms need warm, humid areas to produce an economical crop, otherwise they have an ornamental use. Peak produce from a coconut palm tree is 70–80 fruits per year, from plants that need 10–12 years to reach this stage.

Propagation Coconut palms are conventionally propagated through seed. Recent research has shown that a coconut itself when having husk on it can be used to propagate further. Moreover, in recent days keeping in view the importance and demand of coconut trees they are being tissue cultured. Edible seeds or coconut with husk and water are placed in well drained media that finally raise seedlings. Seedlings need warm humid environment for better growth.

Economic Importance Coconut is used as food and oil as well as for ornamental purposes, in suitable coastal and warm humid areas. Landscapes in coastal areas are incomplete without coconut palms. It produces fruit and a list of by products which are important for their economic and medicinal value. Fruit itself is one of most demanded drupe in the world. Water in fruit has great medicinal value for stomach and renal care. Husk on fruit has a distinctive role in handicraft industry while hairy coir on husk is a very nutritive substrate for nursery production (Rajan and Abraham 2007).

Future Prospects As a cash crop, major components of coco palm include crude coconut oil (CNO) and copra (dried coconut kernel) (Mittaine and Mielke 2012). As a food crop, it is a source of coconut milk, sugar, coconut water, fibers, fuels, raw or virgin oil for cooking and cosmetics, while some varieties are also used in popular

medicines (Batugal et al. 1998). However, with value addition, new non-traditional products have entered into global markets, which include but not limited to virgin coconut oil (VCO), cold pressed from the fresh kernel, coconut water extracted from mature or immature nuts, or coconut sugar, taken from the sap flowing out of the flower, which have great prospects for future developments in the coco industry (Prades et al. 2016).

***Areca catechu* (Areca palm)**

***Borassus flabellifer* (Toddy palm)**

***Cocos nucifera* (Coconut palm)**

***Cycas revoluta* (Sago palm)**

*1.6.4 Sago Palm (*Cycas revoluta*)*

Origin This palm is also known as Japanese sago, king sago, kanghi and cycad palm. The species belongs to the Cycadaceae family, therefore it is considered as false palm, but its growth resembles to the palms, originated from Ryukyu Island of Japan. There are several species that are known as sago. Cycads are also drought tolerant. They shed their leaves in winter in temperate areas.

Growth and Botany Very symmetrical, straight and deep dark brown trunk of palm makes graceful old look. Trunk, when reaching 45–50 cm in diameter does not expand more in later ages. Height may reach up to 5 m, after 15–20 years of growth. Leaves are deep to semi dark green in color, emerge from main trunk and remain attached to plants for 3 years after emergence. Leaf petiole is covered with thorns and leaflets have very sharp head, that may punch a human hand while caring them. Cycads are dioecious, where male inflorescence have cones and female produces mega sporophylls. Insects, wind and men are carrier of pollens. Small orange round non-edible fruits are formed, that contain seeds.

Propagation Cycads produce suckers in their base, a most suitable, fast and easy way to propagate them as compared to seeds. Although, seeds are also being used in commercial propagation. Seeds need special priming strategies before sowing. Soaking in distilled water for a week before sowing lifts germination rates from 30% to 80%. Seedlings become ready for transplant within 120–150 days after sowing.

Economic Importance Formal landscapes always contain cycads as accent plant. Corner plantation and indoor gardening has cycads as prime plant. Horticulturists must know before planting that cycads may shed their leaves in temperate winter and a permanent indoor conditions. They need bright light in indoor conditions. Their leaves are **highly toxic** to pets and children. High amount of alkaloids extracted from their leaves are used in pharmaceutical industry. In some cultures, cycas leaves are used after cooking and their seed kernels are used in cakes.

Future Prospects Cycas has a potential as food and in medicine, and also as oil, fiber, and gum source. However, all plant parts are toxic. Cycas is one of most demanding cut foliage crop being used worldwide for its decorative leaves, which further has scope to expand its market demand. Some cycads also help in nitrogen fixing, which may be used for improving soil health and lowering fertilizers requirements for crop production. Metroxylon sago is real sago palm from family Arecaceae which is used to make sago daana, used to cure several digestive system ailments.

*1.6.5 Fish Tail Palm (*Caryota mitis*)*

Origin *Caryota* is a genus of almost 13 species of palm trees. They are commonly popular as fish tail palm just because of their leaves look like the tail of a fish. All are originated from India, China and Indonesian forests from where they spread to Florida and the Americas. *Caryota furfracea*, *Caryota griffithii*, *Caryota urens* and *Caryota javanica* are the most famous species in this genus. *Caryota mitis* grows well in hilly areas. On the other hand, adaptation to subtropical areas is very good than to tropical one.

Growth and Botany *Caryota mitis* has a cluster type habit created by multiple stems. Bipinnate leaves are long up to 1–2 m, while leaflets, less than a 30 cm, end in a shape reminiscent of a fish tail. Main trunk does not exceed than 15 cm in diameter while in height may reach up to 15 m. The purple flowers of *Caryota* grow below the leaves and produce a dark red to purplish, non-edible fruit.

Propagation By seeds, which show first germination after 90–120 days. Seedlings become ready after 60 days from germination. They need a 25–30 °C temperature with 60–70% humidity to grow quick. A bright light is good for initial years while full sun in tropical areas is sufficient to dry the leaves.

Economic Importance It is suitable for sub-tropical and tropical climates and will do well in containers or indoors. It is also used as accent plant in parks, is a very nice choice in group plantations and performs well in semi shaded areas. Its purple inflorescence is graceful while fruits are non-edible. However, it is rich in carbohydrates and proteins. Inflorescence is tapped for toddy and the pith of the trunk is extracted for a kind of sago flour (Burkill 1993; Whitmore 1998). The fruit wall and sap contains irritant, needle-like crystals.

Future Prospects Being rich in carbohydrates and proteins, it might be used as replacement of vegetable oil. Moreover, it has great demand in modern landscapes for its unique plant structure and is popular in Indo-Pakistan and other Asian countries.

*1.6.6 Chinese Fan Palm (*Livistonia chinensis*)*

Origin Chinese Fan Palm is one of the purely subtropical species of palm trees. It is also known as fountain palm. It originated to China and Japanese islands. Furthermore, they are now naturalized in Indo-Pakistan region, America, Middle East, Bermuda and Dominican Republic.

Growth and Botany Trunk has light wooden colored, non-even but clean surface and does not cross 30 cm in diameter while in height it reaches up to 8 m. Fresh and lush green leaves look like Chinese traditional hand fan, and may lengthen up to