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Date Palm in Pakistan, Current Status and Prospective

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Data Page

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Abstract

Date Palm in Pakistan, Current Status and Prospective discusses the current situation of Date palm farms and farming practices in different date-producing areas of Pakistan. The booklet discusses the much-unknown dates in the Balochistan province and compares its practices to that of the date palm farming cluster in Sindh province i.e. Dates' City, Khairpur. There is a lot of information provided for flood-affected date palm farms and how the farmers can protect their farms from monsoon rains. For this purpose, a comprehensive flood-affected date palm farm mitigation plan is outlined in the text. A detailed discussion has been given on constraints facing the development of date palm farming and processing in Pakistan along with remedial measures. A detailed account of modern date palm farming and processing techniques used in other date-producing countries is provided for reference to date palm farmers, processors and researchers in Pakistan.

Acronyms

CDRI	Crop Disease Research Institute
D.I. Khan	Dera Ismail Khan
DPRI	Date Palm Research Institute
EU	European Union
Euro-GAP	European Good Agricultural Practices
FAO	Food and Agriculture Organization
FDA	Food and Drug Administration
HACCP	Hazard analysis and critical control points
[redacted]	[redacted]
IPM	Integrated Pest Management
Kg	Kilogram
N-P-K	Nitrogen Phosphorous Potassium (Fertilizer)
PARC	Pakistan Agriculture Research Council
PVC	Polyvinyl Chloride
RPW	Red Palm Weevil
SALU	Shah Abdul Latif University
TIS	Transport Information Services
UAE	United Arab Emirates
USA	United States of America
UK	United Kingdom
USD	United States Dollar
WTO-SPS	World Trade Organization-Sanitary and Phytosanitary measures

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Executive Summary

This booklet is an attempt to provide basic information on the description of date palm cultivation in Pakistan, major flood-affected date palms and fruit, protection from monsoon rains, major date palm problems in Pakistan including diseases and pests with an emphasis on the Khairpur area, in addition to instances of some successful date palm countries like Egypt, USA and UAE. It should serve as a brief reference and a source of information for date palm farmers, specialists and anyone interested in the date palm. Date Palm (Phoenix dactylifera L.) or “Khajoor” in the Urdu language, is dubbed the “tree of divine providence” by many people who depend on it in their life. The date palm tree provides communities in the desert oases and rural areas with many benefits. For thousands of years people travelling across the desert have carried dates with them as high-energy food. Wood from its tree was used to build homes, to make artifacts and burned for fuel. During Ramadan, Muslims break their fast each day by eating dates. Palm fronds are used by Christians of their celebration of Palm Sunday and in Jews in their celebration of the Feast of the Tabernacles (Booths).

Date flesh of all cultivars showed high level of total sugars (62.60-83.32%) and small amounts of protein (2.3-3.85%), ash (2.15-3.46%) and fat (0.1-0.46%) on dry matter basis. Although the mineral contents varied widely, all cultivars could be an important source of potassium [2]. Pakistan is the fifth largest producer of dates with 680,107 tons in 2007/08 and is rated among the largest producers of the date palm in the world with different cultivars. The major countries importing both fresh and dried dates from Pakistan are India, USA, UK, Canada, Germany, Denmark, Malaysia and Indonesia. The major cultivars are Begum Jangi of Balochistan, Aseel of Sindh and Dhakki of Dera Ismail Khan. Dates are growing in all four provinces of Pakistan. The main dates producing areas of Pakistan are Turbat and Panjgoor (Baluchistan), Khairpur and Sukkur (Sindh), Muzaffar Garh, Jhang, Multan and D.G Khan (Punjab) and D.I. Khan (KPK). Date Palm is an important crop of Sindh, mainly growing in the Khairpur and Sukkur districts. Almost 85% of the Sindh dates are produced only in Khairpur.

1. Introduction

This booklet is an attempt to provide basic information on the description of date palm cultivation in Pakistan, major flood affected date palms and fruit, protection from monsoon rains, major date palm problems in Pakistan including diseases and pests with emphasis on Khairpur area, in addition to some successful instances of date palm countries like Egypt, USA and UAE. It should serve as a brief reference and a source of information for date palm farmers, specialists and anyone interested in the date palm. Date Palm (Phoenix dactylifera L.) or "Khajoor" in Urdu language dubbed the "tree of divine providence" by many people who depend on it in their life.

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Table 1: Area, Production, Yield and Ranking of Dates in Pakistan (2007-08)

Area	Area (Hectare)	Production (Metric Ton)	Yield per Hectare (kg)	% Area	% Production
Balochistan	50800	249700	4915	56.4	44.8
Sindh	32000	253100	7909	35.5	45.4
Punjab	5900	44300	7525	6.6	7.9
Khyber Pakhtunkhwa	1400	10400	7429	1.5	1.9
Pakistan	90100	557500	6189		

Date Palm is an important crop of Sindh, mainly growing in Khairpur and Sukkur districts. Almost 85% of the Sindh dates are produced only in Khairpur. In Khairpur, maximum benefit was achieved through intercropping of other crops under the shade of the trees (temperature exceeds 50°C in summer). Date palms allow other species such as maize, banana, wheat, rice and vegetables to thrive in terms of growth (Fig. 1). Some of these species needs full sun light such as rice, wheat, etc. and frequent irrigation. Subsequently the distance among adult date palms was increased to reach 30 feet to allow light penetration to those cereals crops (Fig. 1).

The productivity of adult trees none significantly decreased. Newly established date palms of 3-4 years have dramatically influenced. Flood irrigation has caused water entrance to the heart of young trees and fungal infection with Diplodia disease.

There is no contradiction between the date palm tree and intercropped species regarding fertilizer applications. Growers used to ignore any application for palm tree while they apply for other intercropped species. Date palm can positively respond to the lateral addition of organic and inorganic fertilizer but, best system for irrigation is long intervals with huge irrigation.

Furthermore, a suspicion that short intervals of frequent irrigation and water logging could be one of the reasons that cause date palm decline disease at Khairpur where the intercropping is a common practice. Persisted water could enhance the soil borne pathogen of Fusarium solani to infect the trees.

Intercropping with fruit crops such as Banana, Citrus etc., is preferable than cereals and maize crops which require frequent water supplement.

Figure 1: Intercropping Banana and Rice Crops under the Shade of Date Palm at Khairpur.

Date palm at D.I. Khan is widely cultivated crop and there is rapidly growing demand for the offshoots of local cultivars such as “Dhakki”. On the other side, date palm cultivation is narrow at Jhang and “Halawy”, “Hellawi” or “Halawi” is the common cultivar at this area (Fig. 2). Tissue culture is a good means to provide the initial disease and pest free plants.

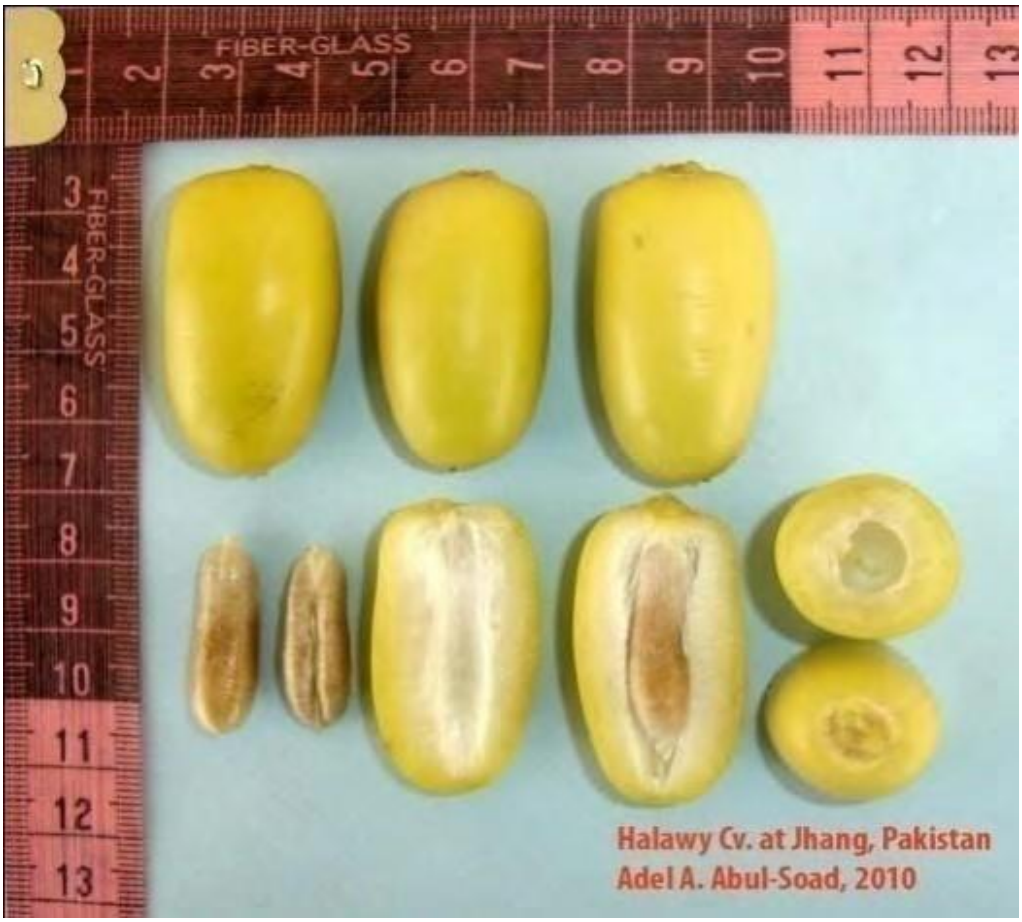

Figure 2: Fruit at Khalal stage of the Predominant Cultivar "Halawi" at Jhang in Punjab

1.1 Dates in Balochistan

The Balochistan area has a dry hot weather during the season. Annual rainfall is below 100 mm and the wind speed is mostly high and charged with dust. Date palm plantations are spread in the areas where the groundwater is shallow (15 feet), mainly around the Hamun-e-Mashkhel and the belt along the border with Iran where the Tahlab river basin joins the Hamun-e-Mashkhel. Sand Dunes, drought periods, poor management and labor are current problems in such areas (Fig. 3).

Figure 3: Date Palm Plantations Are Threatened by Sand Dunes at Desert Area of Hamun-e-Mushkale in Baluchistan.

The predominant cultivars are “Begum Jangi”, “Muzafati” or “Mazafati” and “Rabie” which account for more than 90% percent of the population, followed by the 10% of other cultivars that are “Carba”, “Drage Trownge”, “Shandishkand” (Fig. 4), and “Ringno” etc. The state of the art is “Shandishkand” which is a crisp and tasty fruit; however, its population is limited and no attached offshoots. The average annual production of the preferred cultivars is 50-70 kg/tree. Most of the cultivars are semi-dry.

Figure 4: Edible Fruit of the "handishkand" Cultivar in the West Northern Area of Balochistan

Farmers utilize "Baat" or "Sondh" (Fig. 5), i.e. baskets made from the leaflets of date palm fronds to protect the developing fruit from strong wind waves loaded with sand particles and getting wasted. Every 1-3 fruit bunches were covered with "Baat". At the time of harvest, the practice is to cut the "Baat" along with upper leaf to which the Baat is tied to.

Figure 5: Growing "Muzafati" Tree at Yak Mach with Covering Bag "Baat" Placed on the Fruit Bunch(s)

1.2 Dates City, Khairpur

During the harvest season in Khairpur, a new city is developed with different activities of date palm having age of not more than two months. Many people earn their livelihood from Date Palm. It is like a big festival which can be seen everywhere in the area. The farmers are picking the "Rutab" fruit of different cultivars, harvesting the "Khalal" fruit for making "Chohara1" by boiling then curing them on mats made from the fronds of palm tree, and trucks transferring the crop within the area. The settlements of temporary immigrants from surrounded areas who are coming to earn some money are the common sign of Khairpur. In addition, the smell of "Chohara" can be easily determined from the air during these months at Khairpur. The city of dates becomes the cynosure of date's exporters to look for a business chance to export Khairpur dates abroad while the international demand is increasing.

Near to the end of the festival, another activity based on "dates processing" has to be started. There are few plants working on dates processing at the date's city; however, the standards of the processed dates in these processing units need to be improved. It is one of the challenges in front of the industry to increase the price of Pakistani dates to resist the competent prices of the international market. But, fund is still the main hindrance facing the research institutes to

[1] The local name that has given to the boiled date fruit at Khalal stage (before ripening) in order to harvest early to avoid the monsoon rain threat in July and August

continue in this sector and conduct the required research whether on the product of current plants or establish a world-model small processing plant.

Prices of early season dates are always expensive than the mid season dates. In UAE, price differs according to the cultivar also. One kg of “Naghal” dates equals 200 UAE Dirham whereas the price has decreased to 20 Dirham (US Dollar equals 3.7 UAE Dirham). For the farm prices, “Medjool”, “Khalas” and “Barhee” were on the top and price reached 11-13 thousand UAE Dirham per tonfor the fresh dates. In Karachi market the price of 400 grams box of packed Medjool equals 350 Pak Rupees while the one kg of Aseel reached 80 Rupees for cured dates in October. Sometimes price of Aseel reached to 120 at the maximum in Sukker Market in December. The range of dried dates is 2000-7000 per 40 kgs in the Sukker Market which is the biggest market in Pakistan for dried dates in terms of boiled dates which is called Chuhara or Shohara (Fig. 6). Keeping in consideration US Dollars equals 85 Pak Rs at that time.

There are more than 300 cultivars of dates in Khairpur, Sindh, Pakistan and this is the biodiversity center of dates. Province wise elite date cultivars of Sindh include: Aseel, Karbalian, Fasli, Dedhi, Kupro, Gajjar, Kachoo wari, Began, Mithri, Bhedir, Khar, Autaqin and Asul khurmo. Only Aseel and Karbaline are good enough to be promoted as international cultivars.

Figure 6: Curing Boiled Date Fruit at “Khalal’ Stage on Mats under Sun and Open Air for 5-6 Days

1.3 Flood Affected Date Palms

Flood hit Pakistan in August 2010. A torrent of water has threatened date palm trees mostly at Khairpur. Floodwater covered 1-3 meters of tree’s trunk at some areas of Khairpur (Fig. 7). The impact on the tree and fruit was recorded. Some of young trees (offshoots) of new plantations were died while attached offshoots to adult trees had less impact. However, adult date palm tree has the ability to continue growth while its base was entirely covered with water.

The large air pockets in the tissue of roots are apparently playing a role in the respiratory system of the date palm tree.

Figure 7: Flooded Date Palm Orchards at Khairpur during Monsoon Rain in 2010

As date palm is the corner stone for livelihood of people at Khairpur, while flood has hindered the whole life over there during and after the monsoon rain. Water has covered date palms at houses vicinity as well (Fig. 8). Moreover, crop of short trees bearing fruit bunches wasted due to increasing the water level to immerse completely bunches. As well as, it stopped all activities of harvesting and dates curing under sun heat.

Figure 8: Flood Disturbs People's Lives as Water Reaches Palms Inside Houses.

At the time of flood, significant number of people who were living at unprotected areas was settled by the Government and other relief agencies in the date palm orchards (Fig. 9). Date trees provided them a shelter to live under. Some of those people were the seasonal labor was working in date palm industry at Khairpur during harvesting season to harvest, transfer crop on trucks, making “Chohara” and cure the dates on mats.

Figure 9: The Settlements of Affected Flood Migrants beneath the Shade of Date Palms

Moreover, rain had deleterious impact on boiled fruit on mats which were near to be proportionally dried “Chuhara” and caused fermentation (Fig. 10). These fruit were collected and used as fodder to the grazing animals.

Figure 10: Deleterious Impact of Rain on Cured Dates on Mats which Used as Animal Fodder

Some areas of Khairpur were protected by mud belts made from the soil mixed with the stones to avoid the water overflow during the flood. Date palms confronted heavy rainfall for many days during flood. A positive impact occurred and trees appeared flush green through the photosynthesis process of green fronds which expectedly has enhanced after showering by rain water. Furthermore, soil conditions were expectedly improved after flood waters receded through leaching of excess salt. In addition, river bed silt sedimentation after flood mostly is good sources of nutrients particularly trace elements. Crop of the next season in 2011 is optimistically going to be fruitful. No disease symptoms exceptionally emerged, particularly the wilt disease (or as known here in Pakistan, sudden decline disease of date palm). After 1-2 months of flood waters receded, the regular agricultural activities have started for intercropping under the shade of date palm trees (Fig. 11).

Figure 11: Palm Trees after Flood Waters Receded at Protected Areas in October 2010

Date fruits take 180-210 days approximately from fruit set until maturity. The sensitive stage to rainfall is from full maturity (Khalal stage) up to ripening (Rutab and Tamer stages). Summer monsoon rains cause always a problem for date palm crop particularly during July and August, whether fruit still on the tree or during curing process on the mats. Alternative ways are to cure date fruit artificially in controlled champers or dehydrators. It is necessary in order to dehydrate Rutab fruit to reach Tamar stage (dates) where the fruit moisture content less than 24%. Nevertheless, the used dehydrators units are not enough to dry considerable amounts of dates during the season (Fig. 12).

Figure 12: Dates Dehydrators Installed by Pakistan Agriculture Research Council (PARC) project at Khairpur using Solar Energy

1.4 Protection from Monsoon Rains

Date palm is usually growing in the dry land and arid zone where the hot dry summer and little rainy winter climate prevails. However, few countries are facing the monsoon rains during the fruit ripening season in July, August and September, such as Pakistan, Oman, Sahara Desert (Sahel) in Africa and USA (California and Arizona). Rainfall deteriorates the fruit within 1-2 days only. Rain fall for intermittent few hours caused crakes in the epicarp at late “Khalal” stage of “Otakin” cultivar at Khairpur (Fig. 13), whereas other cultivars which were at early green ‚Khalal‟ stage showed more resistance to such condition.

Figure 13: Cracks of Date Fruit Epicarp Caused by Rainfall for Intermittent Few Hours Accompanied Ambient Humid Climate

The major damage caused by rain occurs when either the rain is early, or the dates are late in ripening. In fact, rain does not seriously damage the dates when they are still at the early Khalal stage, but rather has a beneficial effect by washing away all dust and sand particles from the fruits. Rain can however cause severe checking and cracking in the Kimri and late Khalal stages. It is worth mentioning that the amount of any particular rain is of less importance than the conditions under which it occurs. A light shower accompanied by prolonged periods of cloudy weather and high relative humidity may cause more damage than heavy rain followed by clear weather and dry winds.

In many dates growing areas rainfall right after the pollination which may cause reduce the fruit setting or rain during fruit ripening will cause the fruit to crack and ferment then mold will develop. In order to protect the date fruit from monsoon rains, few types of covering material have been used like Bituminized paper, nylon bags, Punched paper etc. Rain fall near

harvesting lowers the temperature which delays the ripening [6]. No significant difference in chemical composition was recorded between covered and un-covered fruit bunches with Bituminized paper (Fig. 14).

Bunch covering is, however not only practiced against rain damage, but traditionally is also used in the form of coarsely woven well ventilated baskets “Sund” to protect the maturing fruit from birds and prevent early ripening fruit from falling to the ground. Bunch covering against rain or sun burn increasing the temperature may benefit maturation. In Balochistan, „Baat‟, covering basket made from the date palm leaflets has been used to cover the date fruit bunches and protect them from the hot and dry winds bearing sand particles to fall on the ground or to fail reaching maturity (Fig. 5).

Figure 14: Aseel Dates Covered with Bituminized Brown Papers to Protect Fruit from Monsoon Rains at Khairpur

A unique type of bags[2] (Tyvek®) recently has appeared in the Pakistani market which is been used on other fruit crops for similar purposes. This type of bags could be feasible to cover date‟s fruit bunches. However, the optimal usage of such bags to protect the date‟s fruit against monsoon rains mainly, the appropriate time to cover fruit bunches at different places in Khairpur was investigated [redacted] by the aid of Date Palm Research Institute, Shah Abdul Latif University, Khairpur (DPRI). The preliminary results of the first year evaluation of 2010 were reported [9]. It was observed that the climate varies within Khairpur area itself, which may affect covered fruit, bunches, where the covered fruit of date palm near to mountain area is matured earlier than other areas due to the dry weather and hot air. Early ripening cultivars of dates always get the advantage to gain higher revenue as they reach to the market first. The miss use of Tyvek bags by farmers may produce unexpected results. The usual harvesting time of a cultivar must be taken in consideration while farmer is going to harvest the covered fruit bunches (Fig. 15). The covered fruit bunches of Fasli cultivar must be harvested one week at least earlier than the traditional harvest time. Otherwise, moisture and molds is subsequently going to increase inside the bag and wasted fruit rates will increase.

[2] DU PONT Company, Pakistan.

Figure 15: Protection of the Fruit Bunches form Monsoon Rains by DuPont Tyvek® Bags

Size of the covering bag might need optimization to fit the variable sizes of fruit bunches. Moisture is expected to increase if small fruit bunches covered with wide bags. A tied bag from base is prohibited and the lower portion of the fruit bunch must be exposed to fresh air. Fruit bunches can be safely covered 1-3 weeks before harvesting. Early covering had a positive impact on the fruit ripening during non rainy season from June and July, 2010 (an intermittent rain fall). Both sides of the Tyvek bag were used where the inner face inverted to test its profitability to rain water with no difference as compared to outer face of the bag. Covering of fruit bunch is a time-consuming process, however, a tree needs an effort of 1-2 persons for 30-45 minutes at least. Fear from moisture accumulation inside the bag remains the main concern of farmers to cover their fruit bunches in the last season. The impact assessment experiment for coming season could eliminate this fear and protect date bunches against monsoon rains.

Generally, fruit covering is a positive practice for protection from monsoon rains, birds, pests and dust which should be performed with a complete package of the proper usage instruction according to the different local cultivars, cultivation area, and time of covering.

2. Flood Affected Date Palms Mitigation Plan

Most of date palm areas in Pakistan are suffering from monsoon rains. Consequently, a plan should be prepared for a mitigation procedure to minimize the loss in date palm industry. The suggested plan includes:

2.1 Cultivation of early cultivars

This includes cultivars that can be harvested earlier and escape from monsoon rains. For example, “Gajjar” and “Kasho Wari” are two early local cultivars of Khairpur and internationally is “Al Mehtari” from Iran and “Naghal” which reaches to the Khalal and Rutab stage in May under the Sultanate of Oman conditions which is quite similar to Khairpur conditions. Also, “Naghal” is a luxury cultivar of UAE and earliest one to produce “Tamer“ in June. Plant Tissue Culture is a powerful and secure tool to support Pakistan with its needs from such cultivars. Utilizing the late cultivars could not succeed to escape from monsoon rains at a hot areas of Pakistan since the heat units requirements is expected to be fulfilled within the range of monsoon rain.

2.2 Introduce rain resistant cultivars

Only few cultivars in the world possess a relative resistance against the adverse impact of rain like “Orabi” in the Northern Part of Egypt. The harvest season of this soft cultivar is from the late October to Early January due to its high content of Tannins during “Khalal” stage. The edible stage of this cultivar is the “Rutab”.

2.3 Using cost-effective covering material to protect the fruit bunches

This practice was successfully being used at USA and the Sultanate of Oman. In the last season, a quantity of 300,000 Tyvek bags have been subsidized by [redacted] and disseminated in 2010 by [redacted] to date palm farmers in all over Pakistan. [redacted], Khairpur are carrying the assessment impact study of these bags[redacted]

2.4 Support the research to use artificial dehydrators

This is to dehydrate the un-ripened fruit by dehydrators machines and under controlled conditions. Few types of dehydrators using solar energy and a little fuel for operation were installed for the date palm farmers in Khairpur and D.I. Khan since 2-3 years ago. Nevertheless an optimization of the usage is required by conducting a research in order to make a model trial for other farmers as well. Moreover, the machinery development also should be adopted to maintain paramount quantities and high quality during the short season.

2.5 Soil elevation

Soil elevation to 2-3 feet is suggested to provide a new medium for the roots away from stagnant subsoil water particularly for the saline soils. River bed silt is a good source for soil elevation after the flood waters receded. On the other side, this process is necessary for the intercropped species and been followed at North of Egypt as a method for reclamation of the saline soils which are close to the Mediterranean Sea. Mango, Apple and Veggies have been successfully established by annual or biannual soil elevation

2.6 Establishment and promoting the date palm nurseries

This is of a prime importance. The sensitive small offshoots should be cultivated in established nurseries at protected areas instead of direct cultivation in open field in order to reduce the mortality after cultivation.
Due to the importance of the above mentioned points, a brief detail on the related issues is necessary to date palm farmers and specialists as a post-flood management. As well as, a focus on the obstacles and key factors of dates industry improvement in Pakistan such as low quality cultivars, pests and diseases, etc. will be discussed.

3. Establishment and Management of the Date Palm Nursery

Nursery, in horticulture, is an establishment or area for the propagation and early cultivation of plants. Some plants are now propagated from cells grown in a sterile medium then shifted to the nursery (Tissue Culture Plants). The modern nursery staffed by horticulture experts and equipped with facilities for mass production.

In general, the date palm nursery concept is not a practice in Pakistan for getting the offshoots which are ready for successful field cultivation with low mortality. Date palm farmers used to get their need from the old orchards by detaching the small offshoots then cultivating them directly in the field with mortality may reach 80%. For transferring these offshoots to far areas, the outer fronds were trimmed and offshoots of different sizes were shipped in trucks. Overwhelming majority of farmers used to establish new cultivation during the months of June and July (in the mid of summer). This is contrary with the procedure everywhere in the world which is recommending spring or autumn months to avoid high temperature and cold stress during summer and winter seasons. It could be reasonable practice under current situation in Pakistan and high infestation rates of Red Palm Weevil (RPW) in winter.

3.1 Offshoots Selection and Detachment

However, the date palm nursery is managed to provide special care during the initial stage of the offshoot growth without complete roots. Also, the nursery is saving the time consumed to grow date palm trees before fruiting for a period of 4-5 years, and minimize the number of missed plants after direct cultivation in the permanent place (Fig. 16). These gaps of missed plants mostly were replaced by other younger offshoots. The homogeneity of fruiting depends mainly on the uniformity of the initial offshoots during an orchard establishment. Nursery can provide farmers with uniform plants, their required number, complete root and free from symptoms of disease and insects.

Figure 16: Date Palm Offshoot Detachment

Farmers at Khairpur used to cultivate the detached offshoots at the same orchard among the adult date palms, which reduced the distance between the trees and increased the moisture. Subsequently the scales insects and leaf spot diseases rapidly increased. The ideal distance between palms should be 24 feet. Recently, the farmer trends to establish new date palm cultivation and specify a limited area for a small nursery. Improper practice was performed by intercropping vegetables in conjunction with frequent flood irrigation. Consequently, a big portion of the already 2-3 years established trees have devastated due to Diplodia disease (*Diplodia phoenica*) infection. This hits the offshoot and causes a substantial proportion of the new cultivation mortality (Fig. 17).

Figure 17: Mortality of the Small Date Palm Trees after Establishment Due to Diplodia Disease Infection at Khairpur

In order to establish a date palm nursery, few specifications and precautions should be taken in consideration. First is the group of instructions to select an ideal offshoot which include:

- Age must be not less than 3 years.
- Weight is 10-25 kg and diameter of the wider part of stem is 0.5-1.0 foot.
- Healthy and having a separate root system, and clear from any disease or pest symptoms.

For the successful nursery establishment as concerned to the offshoot selection, the second group of instructions for the detachment process includes:

- Offshoots from an infected area with an epidemic disease are forbidden.
- Removal of the early fruit bunches, if any (in the first year only to save food for further vegetative growth).
- Cut surface should be plain and clean.
- Sterilization of the tools before detaching an offshoot with any available Fungicide solution.
- Determination of the connection point between an offshoot and its mother palm by soil removal.
- Cutting-off the non-erect (suspended) outer fronds and trim other fronds and ties them with a rope.
- Carful detachment with a sharp metal tool.

- Dipping or spraying the offshoot with copper-based fungicides (Benomyl (Bavistin), Thiophanate Methyl (Topsin M) and Bordeaux mixture) has been found effective against the Diplodia disease. The procedure is to immerse the offshoot base in the fungicide solution 3-5 grams per liter of water for 4-5 minutes then leave for a while to heal the wound.
- Avoiding any hits to the offshoot heart.
- Moistening the offshoot with water every day until cultivation as soon as possible.
- Clothe the base of the offshoot with wetted piece of cloth and covering the fronds if possible.
- Spraying with any available pesticide and Malathion is preferred due to its bad smell the cut surfaces which made in the mother palm or the offshoot is compulsory to avoid RPW attack since the smell of fresh palm tissue attracts the insect.

How do you differentiate between offshoot coming from the nursery and another one freshly detached from a mother tree? It is a prime importance for the farmer to distinguish between these two types to avoid cheating. These differences include:

- The nursery offshoot is erect but the separated offshoot is almost curved.
- The nursery offshoot having roots from everywhere at the base but detached offshoot does not have roots on the cut surface portion.

3.2 Offshoots Cultivation and Further Nursery Management

Two types of cultivation are on terraces and ditches or on a plain land. Cultivation on terraces (Fig. 18) keeps indirect contact between the irrigation water and the offshoot which gave good results compared to direct contact through the flood irrigation. Drip irrigation is a better choice for regular irrigation supplement. The cultivation procedure as follows:

- Land preparation. Distance among offshoots should be 3-4 feet.
- Digging holes about 2-3 square feet and plant the offshoot in such a manner that the wider part of it is at the soil surface level to prevent water entrance inside the heart which may cause rot infection (Diplodia disease).
- Pressing soil perfectly around the offshoot. Keeping fronds tied for few months.
- Frequent and plausible irrigation for 4-5 weeks after cultivation. After then as per need according to soil type and climate conditions.
- Pressing of soil around the stem to give a strong foot hold to the offshoots in the nursery.

Figure 18: Date Palm Nursery at New Valley in Egypt

The offshoots must be kept at nursery for 1 year at least until new root formation and emergence of the new fronds. The place of the nursery could be under the shade of taller date palm trees or other spaces away from the direct sun light. As a sign for successful cultivation, the central fronds can be easily pulled out by hand after 2 weeks if the offshoot heart has infected and died (Fig. 17). Eventually, the offshoot selection, detachment process, cultivation and the maintenance were the four factors which are involved for successful nursery establishment.

On the other side, date palm derived from tissue culture can be cultivated directly in the permanent place or site while their age is 1-4 years. Detailed discussion will be given elsewhere.

4. Date Palm Tissue Culture

Date palm being a dioecious plant is conventionally propagated through its offshoots because propagation through its seeds will not bring the true to type progeny of Date Palm. The development of tissue culture techniques for the mass propagation of date palm plants has revolutionized the date palm industry in the World. Plant tissue culture is practicing in many date palm growing regions in the world, and recently in Sindh. On both commercial and research levels without a specified fund, the Biotechnology Laboratory of DPRI, SAL Univ., Khairpur has succeeded to produce few thousand of 7 Pakistani cultivars and 3 international in 2010 (Fig. 19, 20). These were “Dahkki”, “Gulistan”, “Dedhi”, “Kasho Wari”, “Gajar” and “Kurh” while international were “Barhee”, “Zaghloul” and “Partamoda”.

Figure 19: In Vitro Date Palm Laboratory of DPRI, SAL University, Khairpur

The production of tissue cultured palms takes 4-6 years and involves three sequential phases:

- Laboratory-based plant production (In vitro plants) for 2-3 years (Fig. 19).
- Plant establishment in a greenhouse (Ex vitro plants) for 1 year (Fig. 20).
- A growing-on phase in a shaded nursery or net house before field cultivation (In vivo plants) for 1-2 years.

After the full cycle of tissue culture production period, plants are ready to be cultivated in the permanent place and fruiting expectedly within 1-2 years. Date palm tissue culture plants are providing the following advantages compared to traditional offshoot cultivation.

4.1 Advantages of Date Palm Tissue Culture Plant

- Required cultivars are available on demand around the year in large numbers including the international with reasonable prices.
- Free from devastating pests such as RPW and diseases such as Decline disease.
- Healthy and early crop within 1-2 years where growing rapidly in the open field.
- It is easy to be transferred from a place to another in terms of volume, weight and health status.
- High survival percentage after cultivation in open field may reach to 100% due to the complete roots.
- Large quantity planned plantations simultaneously with uniform growth (Fig. 21).

4.2 Micropropagation Using Inflorescence Portion (Explants)

In DPRI, process of date palm micropropagation was started since 3 years with hope to produce the best cultivars in the world such as „Medjool", „Khalas" and „Deglet Noor". Shoot tip portion (Explant) of offshoots and the innovative technique of inflorescence explants that has been transferred by Dr. Adel A. Abul-Soad, consultant from Egypt were used (Fig. 19). It is important to mention that the quality and reliability of the product is essential. For this reason the in vitro and ex vitro plant samples were subjected to fingerprinting to ensure the genetic stability before fruiting in the open field which may need further 2-3 years.

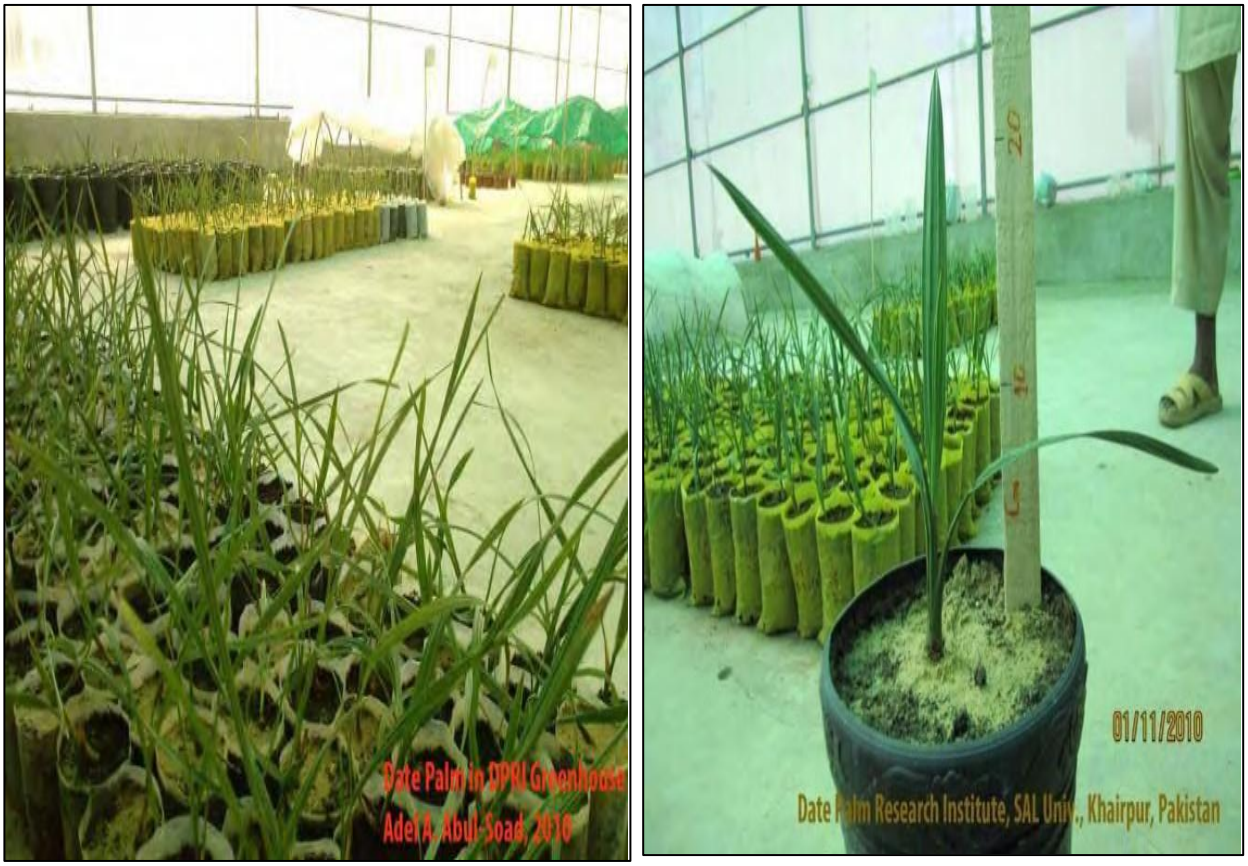

Figure 20: Tissue Culture Date Palm (9-Months Old) of 10 Cultivars Were Successfully Produced in the Greenhouse of DPRI

Inflorescence-based micro propagation holds a great potential for the multiplication of recalcitrant male and female date palm individual trees and cultivars of commercial interests with limited populations. The female individual that rose from seeds and explored superior crop is great repository for new cultivars. This can be accomplished in a short time with minimal efforts as compared to the traditional practice of using shoot tip explants. The aim of this technique is to pave the way to use the inflorescence explants to micro propagate date palm by direct formation of organs in conjunction with low effort. The pilot production trials in DPRI revealed that 1-2 immature spathes were enough to produce thousands of the plants while about 100 offshoots may require producing similar number of plants using the traditional explant shoot tip. Using the inflorescence explant is a dream of any laboratory in the word to micropropagate date palm. The achievement of DPRI could be a breakthrough in the date palm world.

4.3 Plantation of Tissue Culture Date Palms in Orchard

The ex vitro palms should be protected especially from high temperature whether cleared from the airport or from a local source (A laboratory). If plants imported, they must be taken out from their carton boxes for watering and kept in a net house or a shaded place. Plants should be kept for 2-4 weeks in their pots to gradually adapt to local conditions before cultivation. There are 2 methods may be followed for growing on the plants according to plant age, i.e. size:

The first method: Plants less than one year old (Torpedo pots) should be shifted to larger pots of 30-40 cm in length for 12-18 months under a net to allow more growth and reduce the root shock when they will be planted in the permanent place. A suitable potting mixture is that one provides an open structure for good drainage. The ideal soil mixture is peat moss, perlite, vermiculite at ratio (1:1:1) or locally Sindh river bed silt, desert sand (Polari) at ratio 1:1. Plants with good growing conditions should reach a height of 80 cm (including pots) and feathered fronds. On contrary, plants can be left without shifting to larger pots, however, for 3-6 months only. The containers must be placed on loose stone chippings, 10-15 cm deep or wooden carriers to allow free drainage. It is observed that the accumulation of drainage water caused burnt root tip.

The second method: When date palm plants are in appropriate age of 2-4 years with complete feathery fronds. Mostly this large size plants can be brought from a local source and can be planted directly after 4 weeks adaptation period at the permanent place. Plants grown on using this method will be very robust at the time of field cultivation with uniform growth. After cultivation, frequent irrigation with fertilization is demanded through drip irrigation or any available way with NPK chemical fertilizer (17-17-17) with Mg and foliar application of the trace elements. Cultivation distance is 18-24 feet and fruiting expected within 2-3 years according to the cultivar (Fig. 21).

The above mentioned information may vary according to the plant size, cultivar, and climatic conditions.

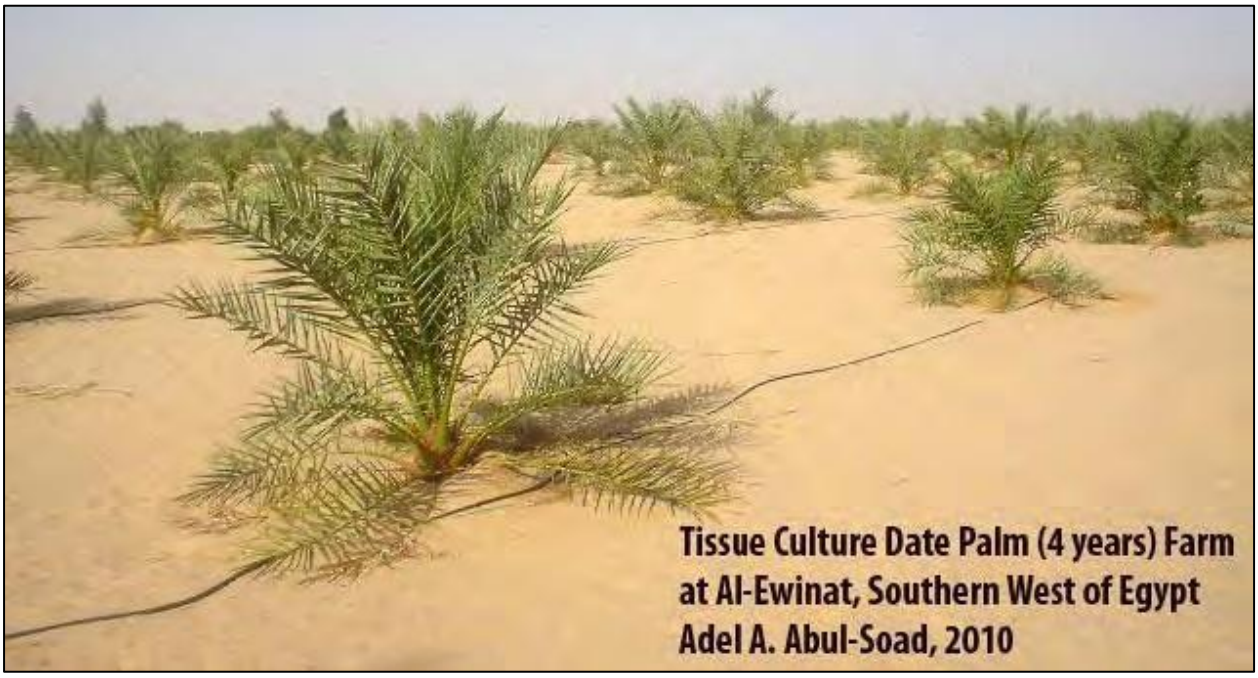

Figure 21: Large Quantity Planned Plantations of Tissue Culture-Derived Palms at East Owainat, located in the far southwest of Egypt

5. Constraints Facing the Development of Date Palm in Pakistan

Date palm cultivation in Khairpur has a long history, yet the efforts exerted by the GOs and NGOs on research and development, although significant, are still insufficient and fall below expectations. In general, the product quality is still low, the field and post-harvest losses are high and the date products and by products utilization need improvement. Lake of knowledge and training programs are required for date palm farmers. To address the above mentioned constrains, the government and research institutes should rank date palm as one of the high research priorities and offer the fund for researchers and subsides for farmers, processors and traders. Several problems and constraints might affect the future of the Pakistan date palm industry. Such problems include:

5.1 Low Quality Cultivars

Establishment of a collection farm at every date palm place can be a center for date palm cultivation. This collection farm (Germplasm unit) should include most of elite cultivars whether from other areas inside the country or from outside the country to conduct evaluation programs. The research activity in DPRI indicated high quality fruiting of some domestic cultivars from Baluchistan like „Husaini" under the Khairpur conditions (Fig. 22). Moreover, two categories of „Husaini" were recognized to fruit at different times. The fruit of the first matured in the mid of July and the second in the beginning of August. The other successful cultivars were "Shakri", "Ab-Dandan", "Koozan Abad" (Fig. 22) and "Gogna".

Figure 22: Fruiting of "Husaini" (left photo) and "Koozan Abad" (right photo) Cultivars at the Collection Farm of DPRI, Khairpur.

As well as, introduction of new cultivars with international marketing value is substantial. It is worth to mention that some progressive farmers in different areas of Pakistan and particularly in Sindh have established a successful cultivation of international cultivars such as “Medjool” (Fig. 23) and ”Barhee”. Also in DPRI, “Ajwa”, “Amber”, “Safawi” (Fig. 23) cultivars of Saudi Arabia are under the evaluation process with promising results.

The preliminary evaluation of “Ajwa‟ and”Safawi‟ indicated early fruit maturation under the conditions of Khairpur. Fruit of „Ajwa‟ harvesting started from the third week of June. Also, the fruit quality was similar to that fruit in „Al-Madden‟ at Saudi Arabia. Such advantage may be useful for the early fruiting to escape from monsoon rains. As international cultivars as concerned to rain, date cultivars differ in their susceptibility to rain and humidity. “Dayri”, “Khastawi”, “Thoory”, “Khadraw”, and “Sayer”, under Coachella Valley conditions, were found to be the least damaged of sixteen cultivars [16]. Zahidi, Khalas and Barhee cultivars had average damage, while Deglet Noor, Yatima, Hayani and Ghars were the most sensitive. Both very early (Al Mehtari/Iran) and late cultivars (Khissab and Hilali/Iraq) escape the rain and consequently their fruits are not affected.

Figure 23: Fruit Development of “Medjool” (Left) and “Safawi” (Right) at Sindh in Early July.

Nevertheless, more work has to be carried out on the elite cultivars of the world which are “Medjool”, “Deglet Noor”, “Khalas”, “Barhee”, “Sewi/Saidy’’, “Ammri”, “Khadrawi”, “Saji” etc. (Fig. 24).

The wide variation of the climate in Pakistan allows cultivation of most of the elite date cultivars of world change in the cultivars structure is a need of today to increase the export and to improve dates industry while a single Kg of “Ajwa” equals the income of 150 kg of “Aseel”.

Figure 24: Top Dates Cultivars in the World Now Are “Barhee”, “Ammri”, “Medjool, “Saji” and “Deglet Noor” (Deglet Nour)

5.1.1 Perspective Date Palm Cultivars and their Susceptibility to Rain

The world fame cultivars of date could be Medjool, Khalas, Barhee, Deglet Nour, Khadrawy, Sukkari, Saki, Dubas, Zahdi, Sewi, etc. Date fruit of such cultivars is internationally demanded. But it needs fruiting evaluation under different areas of Pakistan. Nevertheless, it seems local climate may allow the majority to give good fruit because of the average daily temperature of 35-40 centigrade and moisture less than 60% from March to August in 90% of date palm cultivation areas in Pakistan. There is no single cultivar can its fruit resist the rain but it could be moderately tolerant.

Therefore, dates cultivars differ in their susceptibility to rain and humidity. Dayri, Khastawi, Thoory, Khadraoui/Khadrawy, and Sair/Sayer, under Coachella Valley conditions, were found to be the least damaged of sixteen cultivars [16]. Zahidi, Khalas and Barhee cultivars had average damage, while Deglet Nour, Yatima, Hayani and Ghars were the most sensitive. Both very early (Al Mehtari/Iran) and late varieties (Khissab and Hilali/Iraq) escape the rain and consequently their fruits are not affected.

The large scale multiplication and plantation of international renowned cultivars is essential for reaching the international market and getting high value from the plantation. Local clones, which are exclusively of seed-origin, must be assessed for their suitability for commercial production. Some of these seedlings show signs of measuring up to the best internationally renowned cultivars, such as Medjool, Barhee, Khalas, Deglet Nour, etc. These seedlings must be thoroughly evaluated before large scale multiplication and planting can be initiated. In some private farms in Pakistan, distinguishable date palm clones arose from seeds and needs micropropagation.

5.2 Poor Farm Management

It is starting from the first point of cultivation, the source of new plantation, the offshoot. Farmers in entire Pakistan used to get the new offshoots from old orchards by direct detachment of the small offshoots. The mortality after establishment was high may reach 80% more or less.

5.2.1 Orchard Layout

Unfortunately, in Pakistan the spacing among date palms is not planned since beginning. But, mostly growers cultivate date palm from 15 feet by 15 feet apart to 30 feet by 30 feet with no conscious for the future plan. Most of date palm growers in Khairpur are planting new offshoots in between bearing tall palms which reduce the distance and reduce light penetration to the younger growing plants. Only in case of intercropping the wheat and rice, growers eradicate some trees to increase the distance. Recently some growers were increasing the space for the future intercropping. The modern trends are applying 20 by 20 feet.In Balochistan, the moderate yield in some of the areas in Balochistan (30-50 kg) can be attributed mainly to the lack of proper maintenance and management of the plantations. The principal reason may be the shortage of skilled labor required for new cultivation, orchard management including pruning, pollination, intercropping, harvest and post-harvest practices which increases the cost of production. The price of the product is also not very attractive in view of the lower quality. With lower profitability, it is not surprising that the growers tend to neglect or even abandon their plantations in some areas. Improving the cultivation practices can increase the productivity of the date palm trees. Selection and micro propagation of powerful males and IPM to control pest and diseases mostly will improve the productivity.

5.2.2 Fertilization

Date palm has similar fertilizer requirements to other cultivated crops. Intercropping with vegetables and other crops in Sindh and un-managed date palm plantations in Balochistan made chemical fertilization is not visible. The fertilization included mainly the addition of the farm manure in winter only in Sindh. Nevertheless, there is indirect application of the chemical fertilization through the intercropped chemical fertilization with N-P-K. It is important to mention that the soil of Sindh has Mg deficiency which requires exogenous application with source for this major element.

Fortunately, date palm can be grown in a wide range of soil types. Deep sandy soils with a good moisture supply are best. Good drainage and aeration are the main soil requirements for ideal production. Date palm tree will grow in heavier soils, but care must be taken not to waterlog these soils. It will grow in soils that are high in alkali and salt content, but growth and productivity will be affected. More sandy soils with their great drainage require more fertilization, as fertilizers are more easily leached out by irrigation.

Therefore, the initial land and orchard preparation aims at preparing the soil for establishment of the young tissue culture date palm or offshoots, but does not ensure proper establishment and growth after transplanting. A fertilization program should be included in the date plantation establishment phase for optimum growth.

In order to ensure strong, healthy plants for transplanting and to shorten the period in the nursery, a fertilization program is recommended in Table 2. The fertilization program starts at the time prior to transplanting, during the land preparation phase. At that stage, attention is to be given to the improvement of the soil which may have a direct influence on the utilization of certain nutrients which are necessary for the palm growth.

Actions that precede this phase include the initial hole preparation, application of lime/gypsum/organic material, and a leaching program in the case of saline soils. The recommended range of organic materials is 10-15 kg for each hole. Salt is mostly accumulated on the soil surface during January when irrigation water is routinely stopped and no water in the main irrigation canals of Sindh River (Fig. 25). Salt accumulation is increasing in lower level lands. Heavy irrigation for 1-2 times is required for leaching the salt of such land in Sindh Valley.

Figure 25: Soil Salinization at Khairpur in winter

Smaller 1-2 planting hole (± 2x2x2 feet) in two directions is prepared and the fertilizers are mixed with the soil from this hole before it is put back at transplanting. In the following year the planting holes will be dig in the opposite directions. Instead of digging, fertilizers can be mixed with the soil. Every year the exact amounts and types of fertilizers to be applied will be determined by soil, water and frond analysis. Generally 1.5-3 kg of nitrogen, 0.5kg of phosphorus and 2-3kg of potassium per tree yearly is recommended to maintain optimum growth of palm tree in Iraq. However, the recommendation presented for the estimated amounts in the following table can be used as an example.

Due to the high pH of soil in Pakistan (alkali) which may reach 7-8.5, the preferred formulas of chemical fertilizers could be Nitrogen in the form of Ammonium Sulphate (21% N), Phosphorus in the form of Calcium Super-Phosphate (45-47% P2O5), Potassium in the form of Potassium Sulphate (50% K2O), and Magnesium in the form of Magnesium Sulphate (27-33% MgO).

Table 2: General Recommendation for the Annual Requirements per a Date Palm Tree during Different Growth Stages

	Growth Stage	Nutrients	Estimated Quantity (grams)
1	Growing offshoots in the nursery	Nitrogen	250-400
		Phosphorus	200
		Potassium	200-300
		Magnesium	200-250
		Manure (matured and dry)	5000
2	After transplanting	Nitrogen	300-400
		Phosphorus	200-300
		Potassium	500-800
		Magnesium	200-300
		Manure (matured and dry)	5000-10000
3	After spathes emergence	Nitrogen	500-1000
		Phosphorus	300-400
		Potassium	800-1000
		Magnesium	300-400
		Manure (matured and dry)	10000-15000
4	Adult productive tree	Nitrogen	1000-1500
		Phosphorus	400-500
		Potassium	1500-2000
		Magnesium	300-500
		Manure (matured and dry)	15000-25000

Time of application, organic manure is to be added in December to January. Each year N fertilizer is to be added in three equal doses, in the mid of March (before flowering), mid of May (fruit setting) and eventually in June to July (fruit maturity). The P fertilizer is to be added approximately twice a year, in the winter with the organic material and in the mid of April. The K fertilizer is to be added mainly near to fruit maturity in June. All used chemical fertilizers can be divided to unequal amounts and disseminated around the year but, higher amount should be added according to mentioned dates according to growth stage and fruit development phase in the Northern Hemisphere.

Long-term experiments on the use of chemical fertilizers in different areas of date palm in Pakistan are needed.

5.2.3 Irrigation

Poor irrigation is practicing during intercropping with other vegetables which may increase the decline disease infection. Most of the nutrients were given through chemical fertilization of the intercropped species. The common irrigation system for date palm plantation in Pakistan can divided into two types:

Flood Irrigation System

This is the practiced irrigation system in Khairpur and Sukker at Sindh province. This irrigation method is the oldest method known, and is the method most widely used in date palm culture. It has, however, advantages low running costs and easy to apply and initial costs are low if the area is flat. As well as disadvantages which are low efficiency (percolation, time and wasted area among trees), labor intensive and not well suited for sandy soils.

Groundwater Irrigation System

This source is mainly used in Balochistan where the desert cultivation is prevalent. Furthermore, the groundwater depth (availability) has the major impact on the productivity of date palm in the desert areas of Balochistan. Drop of water level to 25-30 feet caused drought impact on the date palm forcing the growers to pump deeper groundwater for irrigation of the trees. The annual rainfall varied between 50 and 250 mm which recharge the aquifers. Water requirement of one healthy date palm tree in such areas is estimated at150 m3/year according to a study was undertaken by the Kuwait University at similar areas. The water requirement does not depend on the source of the water, and is same for the irrigated as well as non-irrigated plantations. The minimum water requirement for one tree throughout the year for survival is estimated at 25 m3. This quantity of water is enough for minimal vegetative growth and yield. The minimum productivity of one date palm tree from the dominant “Rabie” cultivar at Northern West of Balochistan was estimated at 10 kg/year. The newly planted offshoots in these areas are, however, manually irrigated for a period of 2-3 years until the young trees are able to extend their roots to access the groundwater. The extent of date palm plantations is dispersed to isolated plantations due to the availability of the groundwater or concentrated areas in South part of Balochistan. Thus, the plantations can be divided into two categories:

Irrigated Plantations (Furrow and Basin Irrigation)

Where the plantations are irrigated, the date palm tree will not extend its roots for more than 2 meters below the surface. If there is a deficit in irrigation water, the tree will extend its roots to access the water in the range of its root system. In these areas where the plantations are irrigated, the groundwater is at a depth of over 50 feet. The mature trees rely exclusively on the pumped groundwater to provide the irrigation water, with the root systems adapted to the depth at which the water is available. The groundwater is deeper and appears to be supported by the availability of cheap electricity and diesel fuel. Pumps powered by diesel engines are used, while some of the pumps are powered by electricity available from Iran. The water is delivered to the date palm plantations through unlined surface channels connected to a holding basin or a small reservoir which is fed by a pump.

Figure 26: Furrow and Basin Irrigation System of Irrigated Date Palm Plantations at Balochistan

Electricity procured from Iran by the Pakistan government is presently being provided to the farmers at a fixed charge of Rs 3-4 thousand/month. There are indications that the fixed charges will be raised substantially in the near future to account for the cost of electricity purchased from Iran, which is likely to make the irrigated agriculture uneconomic. In the irrigated areas, the plantations are irrigated approximately twice a week in the summer and once a week in the winter.

Non-Irrigated Plantations

The depth of groundwater mostly is less than 12 feet in these areas where the mature trees depend on the shallow groundwater and are not irrigated. The date palm trees can easily extend their roots to access the groundwater.

Figure 27: Non-Irrigated Date Palm Plantations in Balochistan which Rely on Shallow Groundwater.

Introduction of improved irrigation systems for the date palm plantations whether in Sindh River Basin or desert areas at Balochistan such as Drip Irrigation, Sprinkler and Micro Irrigation. However, water management will have to take into account the level of skills available, and will require training and education of the growers. Farmer organizations could be organized for the collective benefit of the growers, and the district authorities may have to be involved to organize the training, production, and marketing, and to settle conflicts among date palm growers.

5.2.4 Fronds Pruning and Dethorning

Pruning in date palm is in general the removal of yellow or nearly dead fronds on a regular basis. This will include dead, dying, and broken fronds. Depending on variety and cultural conditions, date palm fronds can remain alive for at least seven years. A date palm may have between 90 to 180 fronds up to 16 feet long. As the fronds do not drop of their own accord, they must then be cut off manually, keeping in view the necessity for ease in fruit harvesting. On well-grown date palms, the removal of a few more green fronds will not be detrimental to the plant. Under good agro-environmental conditions, functional fronds are those found below the current year's flowers. After the mature fronds are 3 to 4 years old, they slowly begin to die. Once the pinnae begin to yellow from tip towards the base of the frond, it is time to remove them.

Sharp pruning for other reasons such as handmade and fruit boxes etc., indiscriminately hack at palm. All green fronds produce the food needed to grow properly, producing a healthy palm tree. The reduction of the green frond area reduces food production, and in turn, the health and growth of the palm is placed in jeopardy. Pruning is desirable in order to improve date fruit quality and also enhance the bearing capacity. For each bunch approximately 7-8 fronds are required for an appropriate fruit growth and development.

Furthermore, unpruned dead fronds probably compete with the fruit, and create favorable sites for diseases and pests.

This may also hinder the process of climbing the tree for manual harvesting and pollination. In other countries, growers could use Ladders, non-spike climbing gear, and hydraulic lifts.

There are various procedures for pruning that followed by growers at different countries. In Pakistan, growers mostly going for frond pruning of adult trees after harvest in August and before spathes emergences in January. They also do pruning for the attached offshoots in winter which increase RPW attack. Third time is during pollination in March and April. The lower 2-3 whorls of fronds were cut and their base of half foot was left as steps for the common practice of manual pruning. Simultaneously 2-3 frond whorls were retained on the tree beneath the place of current year spathes (fruit bunches in future). Thus that fronds can help in carrying the heavy fruit bunches to avoid bunch break in most of the cultivars. In some cultivars, bunches are remained free without tying to the bases of fronds (Zaghloul Cv. in Egypt).

In other countries pruning could also be realized at any convenient time between the harvesting and the flowering season (thinning period is recommended) and because of the greater ease in cutting.

Considerable evidence shows that, other conditions being equal, the fruit bearing capacity of a date palm is in proportion to the number of green fronds it carries. During the pruning operation, unwanted offshoots should also be removed to foster the growth of rooted off shoots on the palm for further propagation, to make access to the palm easier and to promote growth and bearing of the parent palm. In very dense offshoots growth, some of the small plants may be seedlings rather than true offshoots, and must be discarded. However, where there is any fear of frost in the coming winter, no pruning is recommended and the fronds are left for the protection from the cold of the young tender fronds. No frond pruning is to be practiced during the first two years (only fronds that touch the ground could be removed).

Since the fungus usually enters the palm through wounds made during pruning or cutting when removing the offshoots, one precaution is to disinfect all tools and cut surfaces. Frond pruning should be coupled with treatment with Bordeaux mixture or any large spectrum fungicide (Mancozeb, Cupric Hydroxide, and Copper Oxychloride). Pruning normally keeps pest populations at tolerable levels. Another important pruning process is the removal of spines, also called thorns. Date spines are usually removed from the new growth of fronds in the crown of the palm just before the pollination season to allow easy access to the date spathes as they emerge. A total of about 26 to 36 fronds are dethroned every year. Such an operation will ensure a safe approach to the spathes for their pollination and also avoid any risk of injury to laborers during other technical practices (tying down, protection of bunches, harvesting, etc.).

For pruning and dethorning, a pruning knife mounted on a wooden handle 30 to 45 cm long, or a sickle type blade with a sharp cutting edge were usually used. Generally in Pakistan dethorning is carried out before or at the time of pollination.

5.2.5 Pollination

Date palm is a dioecious species bearing male and female flowers on separate individual trees. The male palm produces the pollen and the female palm produces the fruit. The flower stalks are produced from the axils of the fronds in similar positions to those in which offshoots are produced. The inflorescence covered with protective sheath and consists of a set of spikelets which are short in male and long in female at the time of bursting. One adult female palm, on average, produces 15 - 25 spathes that contain 150 to 200 spikelets each. The male flowers are borne single and are waxy white, while the female flowers are borne in clusters of three and are yellowish green in color.

Natural pollination by wind, bees and insects is found to yield a fair fruit set in various areas of the date growing countries. In the absence of such natural pollination, female flowers are not fertilized. This leads to the development of carpels and consequently parthenocarpic fruits without any commercial value are obtained. Date growers are aware of the need of the artificial pollination and pollination techniques for better fruit set and yield.

Commercial date production requires artificial pollination which ensures good fertilization and overcomes disadvantages of dichogamy (different opening time for male and female spathes) and also reduces the number of male palms (with no fruit production).

In most of date palm countries including Pakistan, the traditional pollination technique is to place few male spikelets in the center of the opened female spathe. The male/female ratio normally is 1/25 but, in a modern plantation is 1/50. Artificial pollination could be considered according to a traditional method or by using a mechanized device. Number of spikes depends on the cultivar. For “Aseel” Cv., 4-5 spikelets were used but, for good fruit quality some growers used merely 2-3 spikelets to get less fruit number along with bigger size. In Egypt, low rate of fruit set in ”Barhee‟ Cv. derived from the tissue culture was observed especially during its initial stage of cultivation. Thus, rows of male trees were cultivated alternatively with the productive trees.

Figure 28: Fresh Spathes Market at Khairpur as a Source for Pollen Grains

Fruit quality is dependent mainly on the pollen grain source. Farmers used to get the male spathes in the beginning of the season from the market with wide variation of quality. In advanced Arab World Countries, “Ghanami” and other many famous male trees are used as good pollinator source.

In Khairpur and most of the date palm areas in Pakistan, growers used to buy the male spathes from a market which held annually in spring (Fig. 28). Nevertheless, three pollination techniques can be used depending on the type of pollen available.

Pollination Techniques

Fresh Male Strands

The most common practice of pollination is to cut the strands of male flowers from a freshly opened male spathe and place two to three of these strands, lengthwise and in an inverted position, between the strands of the female inflorescence. This should be done after some pollen has been shaken over the female inflorescence. In order to keep the male strands in place and also to avoid the entanglement of the female cluster's strands during their rapid growth, it is recommended to use a twine (a strip torn from a palm leaflet or a string) to tie the pollinated female cluster 5 to 7 cm from the outer end.

Pollen Suspension

Laboratory and field experiments on three varieties from Saudi Arabia (Khalas, Ruzaiz and Shishi) have shown that a pollen grain suspension, containing 10 % sucrose and 20 Part per Million (ppm) Gibberellic Acid (GA3) could be used for pollination. Pollination sprays were found to be as good as hand pollination in relation to fruit setting. Fruit set was 80 % using this suspension technique while only 60 % was obtained when using the classical hand pollination technique. On the other hand, a suspension solution containing pollen grains, sucrose, boron, glycerine and GA3 did not match the results of hand pollination.

Dried Pollen

This pollination technique is more economical and allows proper use of the pollen as well as adequate control of the timing of pollination. Dried pollen could originate from the last season, from early maturing males of the same season, or from few days old male flowers. There are several techniques to apply dry pollen:

- **Cotton Swab:** The most common technique of using dry pollen is to dust it on cotton pieces about the size of a walnut and place one or two pieces between the strands of female inflorescences.
- **Use of a puffer**: A small manual insecticide duster, known as a 'puffer' is also used to apply dry pollen. This technique is used either alone or in addition to the cotton pieces technique [25].
- **Aircraft pollination**: Experiments with pollinating of dates with an aircraft were conducted in the Coachella Valley of California on Deglet Nour cultivar. Results showed that even though temperatures and weather conditions were favorable, both the helicopter and fixed-wing methods of application yielded less fruit sets than the hand pollination method. This technique was abandoned, as it required at least 4 to 5 times the amount of pollen traditionally used, and was also found to be not economically feasible.
- **Mechanical pollination:** Mechanical pollination was developed mostly in the New World of date palm (USA) where labor is expensive and not always available. It consists of pollinating freshly opened female spathes from the ground with the use of a special apparatus [Fig. 29]. Mechanical pollination has been one of the most important alternatives when the labor has been reduced by 50 - 70 %. It is estimated that a man

must climb a date palm few times from the time of pollination through to crop harvesting. Mechanical pollination from ground level for three times and with 1:4 (pollen/filler ratio) was recommended to achieve high yielding of most date varieties. It seems that the frequencies of mechanical pollination as well as the suitable concentration of pollen/filler ratio are the most important factors in date palm pollination.

Also, mechanization in planned farms would be use useful for some cultivars. FAO has donated a pollinator machine to DPRI and other progressive farmers (Fig. 29). A plan is set for next season to study the impact of such a machine.

Figure 29: Mechanical Pollinator donated by FAO to date palm growers in 2010

A ground-level duster is capable of pollinating 24 to 32 ha per season. In order to accommodate the palm height and also to direct the pollen delivery tube near the bloom area of each palm, the machine is equipped with a variable height platform capable of 4.5 m vertical movement. The duster is driven along one side of the date row and then returns on the opposite side to finish the pollination cycle. Such mechanical pollination will require two laborers and could be realized according to two approaches:

- Pollination of each freshly opened female spathe or
- Spraying of the whole female frond canopy just above the opened spathes.

The first approach is the more accurate one, but requires the farmer to have good knowledge of his plantation as well as good record- keeping ensuring the pollination of all spathes. The second technique is economically feasible and saves time. However, a high rate of aborted fruits could occur when this technique is used. During early season pollination, or when the pollination season is characterized by low normal temperatures, it is recommended to alternate pollination of sides of the palm at 4 to 7- day intervals. This overlapping of pollination was shown to yield more reliable results than full palm pollination at one time. The advantages of mechanical pollination could be summarized as follows:

- Reduction of labor and duration of pollination, both are contributing to the reduction of the cost of pollination. Furthermore, it does not require a highly trained labor as with the traditional technique.
- The possibility of pollinating a palm at several times in a short period of time is assured.
- The use of a mixture of pollen originating from different sources is permitted, thus ensuring good fertilization.

- The risk of accidents occurring as with the old method of climbing a palm several meters high is eliminated.

Pollen Harvest and Handling

A male spathe that is ready to split assumes a brown color and a soft texture. Immediately after the spathe opens longitudinally, the male inflorescence reaches its maturity and male flower clusters must be cut at this stage. To prevent wind or bees from causing loss of pollen it is recommended that the freshly-opened spathe be cut early in the morning.

Date growers traditionally harvest the male spathes one or two days after their opening and place them in a shaded and moisture-free area for drying. Strands are then detached and stored till needed for the pollination of female inflorescences. Transport of strands for a long distance (between two date plantations) must be handled with maximum care. The use of paper bags is recommended to preserve the pollen and avoid losses.

The common practice of cutting the male spathe a day or two before its natural opening as practiced in the Old World (Middle East and North Africa) is not recommended because it requires a high level of experience and familiarity with the male palms. The technique is to press the middle or lower part of the male spathe between the thumb and forefinger. If a crackling noise is heard, it is a sign of maturity of flowers. In such a case the spathe could be cut and flowers taken to the storage room for drying. A pollen-handling protocol necessitates the rapid and efficient dehydration of moist pollen before its storage.

High temperatures have a negative effect on pollen drying and storing processes. Pollen exposed to direct sunlight or placed near a source of heat, will rapidly deteriorate and lose viability (also called vitality). Viability is defined as the ability of a pollen grain to germinate and develop.

It is well known that, depending on climatic conditions, a date grower could face a season where a heavy early female bloom develops. Consequently, the storage of pollen within the pollination season (2 to 3 months) or from one season to another is necessary. Freshly opened male flowers contain a high level of moisture; consequently if they are not to be used immediately, their prompt drying is important in order to avoid the destruction of pollen by moulds. There are various ways and techniques to store the pollen depending on the quantity to be stored, storage conditions and the duration of storage.

Storage of Pollen

It is a simple way to store a small quantity of pollen; strands are separated and spread in a thin layer on paper in a shallow tray in a shaded/protected area.

Male Flower Clusters

Clusters are put on top of screen-wire trays or shelves with a container beneath to catch the dry pollen that falls from the flowers; Note that the pollen quality remains unchanged even though the flowers turn dark within 3 to 7 days. This storage technique is mostly used for handling larger quantities of pollen. Date growers in Iraq and in Egypt conserve the pollen by placing the flowers, usually dried and crushed, in a muslin bag and left in a well dried-ventilated area.

Mechanical Pollen Extractor and Collector

The machine can daily handle up to 450 male flower clusters and collects approximately 40 % more pollen than any other extraction method. The pollen viability and longevity were found to be unaffected by such mechanical extraction.

Once the pollen is well dried and cold stored in an airtight container, it could be safely re-used during the next season with very little loss of viability. It can be kept in container and placed in the refrigerator at 4 centigrade.

To maintain zero per cent humidity, dry pollen is placed in an open jar within a larger airtight container (a dessicator) in the bottom of which are well dried lumps of calcium chloride (CaCl2) as a dehydrating agent. Other absorbents that can also be used are saturated solutions of zinc chloride (ZnCl2), calcium nitrate ($N(CaO)^3)^2$-$4H^2O$) and potassium chloride (KCl). Approximately 500 g of calcium chloride is enough for 2-3 kg of pollen.

Pollination Time

Satisfying pollination results are obtained within 2 or 4 days after the female spathe has opened. February and March is the normal pollination period in Pakistan. Variety and season could delay or advance the opening of the flowers.

Factors Affecting Pollination

Male seedlings are highly variable in their growth vigor, spathe characteristics and pollen quality. Also, the amount of pollen grains produced by spathe varied greatly from one male to another (0.02 - 82.29 g/spathe). It is well known that different varieties of date palm require different amounts of pollen. Using fresh male strands, the number required for pollinating a female spathe may vary from 1 to 10 depending on variety. Most of the male date palms used throughout the world's date growing areas are of seedling-origin with a great variation regarding pollen quality.

The capacity of pollen to germinate and grow normally is known as viability. The assessment of viability of freshly collected as well as stored pollen is often desirable before using them for pollination. Applying enough pollen does not guarantee a good fruit set unless the pollen used is viable with a high germination percentage. Environmental conditions such as high temperature, low humidity, salinity build up and UV radiation may influence pollen viability.

The length of the receptivity period of the pistillate flowers could, in general, vary up to 8 or 10 days depending on the variety and prevailing environmental conditions in the region.

High temperatures inhibit the development of spathes resulting in a delay of the pollination season. Low temperatures, usually early in the season, also have a negative effect on the fruit set. However, if female flowers open early in the season and their pollination is essential, then the sets could be improved by placing paper bags over the female inflorescence at the time of pollination. During the pollination season, it is recommended not to pollinate in the early morning or late afternoon, because of the negative effect of low temperatures on the fruit sets. At locations where daily maximum temperatures during pollination are frequently less than 24°C, mechanical pollination method is not recommended.

In most date growing areas the latter part of the pollination season is usually characterized by severe hot and dry wind which dries out the stigmas of the female flowers. Cold winds disturb the pollen germination. This could be the predominant climate in West Northern part of Balochistan and causing varied fruit set along with groundwater depth.

In North of Balochistan, most of the growers bring the pollen grains from other areas where the male trees have flowered earlier and the quality of pollen grains is better as the male spathes have been able to avoid the adverse impact of the winter. It was also observed that a number of trees produced non-pollinated fruits as the male spathes were spoiled by the extreme and prolonged winter in 2007-2008.

Boron is an essential nutrient in pollination and the subsequent reproduction processes, i.e. the formation and growth of flowers and fruits. It also plays a role in the uptake of calcium, magnesium and potassium.

Effect of Rain on Pollination

There is controversy concerning the effect of rain on fruit set. Some consider rain that occurs just after pollination as a washing agent that takes away most of the applied pollen before it

plays its role. In such a case, it is necessary to repeat pollination after the rain has ended. Other people consider the negative effect of rain on fruit set as an indirect effect via low temperatures that accompany or follow rain. If temperatures are between 25 and 28°C, most of the pollen tubes reach the base of the style of Hayani variety flowers within 6 hours; while at 15°C, pollen tubes do not reach the base of the style even after 8 hours. A third explanation of the effect of rain is the reduction of the pistillate flowers' receptivity by contact with water. Rain is also responsible for increasing the relative air humidity which favors attacks by cryptogamic diseases that result in the rotting of inflorescences. This high relative humidity is also associated with reducing the pollen's blow out.

In conclusion, date growers must assume that rain can cause all the above effects, and any pollination operation immediately followed by rain must be repeated in time. There is a limited period (4 to 6 hours either before or after pollination) during which, if rain occurs, pollination and fruit sets are affected and the pollination operation must then be repeated.

Xenia and Metaxenia

It is well known that the pollen not only affects the size of the fruit and seed (affected more by fruit thinning) but also the time of ripening. Metaxenia is not to be confused with Xenia, which is the effect of the pollen on the endosperm (embryo and albumen). The effect of pollen on the time of fruit ripening was proven to be beneficial and is actually considered as the most important practical application of Metaxenia. Producing and selling date fruits at high prices early in the season, along with the aim of having more uniform and short ripening period (avoiding a prolonged harvest) are the two main objectives of using selected pollen of high Metaxenia effect. A third useful application of Metaxenia is where the development period of the plant is characterized by an insufficient sum total of heat for the fruit ripening of late varieties.

It is worth mentioning that Metaxenia effect could also be successfully used to speed up the fruit maturity and consequently escape the rain damage that is usually expected at the end of the fruit development period (Pakistan, Algeria, Tunisia, USA, etc.)

5.2.6 Fruit Harvest and Handling

The key problem in the Pakistani date"s industry is the fruit harvesting which made Pakistan occupied the position number 72 among world dates exporters in regard to export value (FAO, 2007).

Dates harvest means physically collecting the fruit from the head of the palm. Harvesting is according to differences which are both visible, such as the fruit color and the degree of ripeness; and invisible, such as the percentage of water and sugar. Whole dates are harvested and marketed at three stages of their development. The choice for harvesting at one or another stage depends on varietal characteristics, climatological conditions and market demand. The three stages are as follows:

- **Khalal:** Physiological mature, hard and crisp, moisture content: 50-85 %, bright yellow or red in color, perishable;
- **Rutab:** Partially browned, reduced moisture content (30-45 %), fibers softened, perishable;
- **Tamar:** Color from amber to dark brown, moisture content further reduced (below 25 % down to 10% and less), texture from soft pliable to firm to hard, protected from insects it can be kept without special precautions over longer periods.

In general, when dates reach the Khalal stage, they are regarded to be ready for trading as "fresh" fruit. Dates in Khalal stage are the first in the harvesting season and therefore have a

ready market. Only date varieties with a low amount of tannin at Khalal stage are suitable for consumption. In Pakistan, these cultivars are few such as “Dedhi, “Mathri” and “Gulistan”.

The low amount of tannin results in low astringency. Furthermore, it is important that the fruit is sweet and not bitter. Internationally, date varieties suitable for marketing at Khalal stage are “Barhee, “Zaghloul, “Hayany” and “Khalas”. Of these varieties, only “Barhee” is sold in England, France and Australia, while the other two are mostly consumed locally [7].

Experience in most date producing countries showed that a well matured Rutab, handled with care, is one, if not the most, appreciated form in which the dates is consumed and which gives the grower the highest rate of return. However, Rutab has three serious setbacks:

- It is produced in comparatively short periods with the tendency of production peaks.
- It is highly perishable.
- It is delicate, which makes handling and transport difficult and expensive. Major commercial date varieties harvested at Rutab stage are Deglet Nour and Medjool.

The polluted date with mud which is mostly present on the packed Pakistani dates was due to the poor handling of fruit during harvest rather than processing. The manual harvesting practice in the biggest two areas is different. In Khairpur, growers were used to manually pick the early ripening fruit of “Aseel” and other cultivars by shaking the bunch few times before the final cut of fruit bunch. The fallen fruit were collected in baskets or shallow trays and loaded down by aid of a robe to another person receiving fruit on the ground (Fig. 30).

Figure 30: Fruit Harvesting Practice in Khairpur

The harvested fruit at early Rutab stage were extended on mats made from the leaflets of date palm fronds. After 5-6 days of sun curing, partially dried dates were usually collected in wooden boxes. Cracks of outer fruit skin (Pericarp) and curing date fruit over the mats extended on dusty place without any conscious to avoid the contamination caused technical problem to clean these fruit in processing factories. It is important to mention that the majority of harvested date fruit were occurred during Khalal stage while fruit is not edible yet. But, fruit is usually harvesting at early stage to avoid monsoon rains. Thus, harvested fruit were subjected to boiled water for 15-20 minutes, then draying on mats for 4-5 days to get this type which is called "Chohara". Pakistan is occupied advance position with about 60 thousand ton (FAO, 2008) due to exported "Chohara" to India which is the biggest importer of dates in the World (FAO, 2007) mainly for celebration purposes not for eating. This type of boiled date fruit cannot be acceptable for eating in most of dates importing countries.

In Balochistan particularly in the Western Northern part, growers utilize "Baat" to protect the growing fruit from hot sandy wind. The weight of one bunch of "Rabie" cultivar ranges from 3-6 kg. The "Baat" is tied with the one or two fronds from upper edge and rests on one or two lower fronds. The matured fruit is cut by a specially made tool. Harvesting starts in July in the Mashkhel area located towards the south of the Hamun-e-Mashkhel, and the harvesting time varies slightly from area to area due to the climatic conditions. Harvesting in areas located towards the north of the Hamun-e-Mashkhel such as Gualishtop, Rajai, and Wadian starts around the end of the first week of August.

For the plantations that depend on groundwater the productivity of the date palm trees increases as the level of groundwater rises, which is the expected trend for the date palm. The average of productivity of a date palm tree in the Brouhook where the depth of water is 1.5 m is 20-40 kg/palm/year, as compared to 10-30 kg/palm/year for other non-irrigated locations. The average of total yield of date palm increases to 50 kg/palm/year in the irrigated areas of Tahlab and Washab. Most of the cultivars are semi-dry and dry cultivars which is harvesting in Tamar stage.

Fruit harvested at Tamar stage is non-perishable, i.e. micro-organisms cannot grow on it, moisture uptake and its consequences, and changes in colour and taste occur during storage. Most of the dates of "Dayri", "Halawy", "Khadrawy", "Thoori", "Zahidi" and "Sayer" cultivars are harvested after the fruit has undergone the process of ripening and drying on the palms [7].

Fruit at the Tamar stage is ideal for marketing as dried dates. This fruit is used for preservation and year-round consumption and also for the production of various types of products, e.g. cakes, sauces and components of granules or date honey. Harvesting the fruit entails the use of experienced workers, or investment in aluminium ladders, in attaching ladders to the palms permanently or in purchasing mechanical appliance to lift workers to the top of the palm.

Harvesting must be faultless and clean, since it significantly affects the rest of the process (packing and marketing). Harvesting the fruit straight into containers suitable for transport to the packinghouse prevents the infection of the fruit by the soil and sand under the palm and ensures that the fruit arrives in good condition, and that it is not crushed. The harvested fruit in advanced dates countries is transferred into containers (large plastic bins) for transport to the packing station. Large wooden, plastic or cardboard cases of various sizes are also used, focusing on the need to prevent damage to the fruit (especially to soft and sensitive fruit). Baskets, sacks (for very dry fruit), and trays are also used. It is desirable to separate damaged fruit which is not destined for the market, while still at the site. Dates that are rotten, sour, with remains of insects, crushed, shriveled up, unfertilized, or unripe fruit which are not intended for artificial ripening should be removed from the plantation. These fruits should be destroyed or fed to animals, in order to maintain sanitation of the plantation.

When transporting the fruit one must also take into account its sensitivity, and the importance of every link in the chain in the treatment of the fruit. Dates harvested at the Khalal stage must be transported as soon as possible to receive appropriate treatment, whether it is for local consumption or for export. The fruit must be transported in the early hours of the morning to avoid the heat; if the distance is great, refrigeration during transport is advisable. Speedy transport will also prevent infection by pests which attack the fruit during the post- harvesting period.

Once cured dates arrived to dates factories in Khairpur, which collected in the beginning of Rutab stage and extended on mats, and washed from the dust, labor are classifying them into 3 categories according to size and blemishes existence into small, medium and large fruit (Fig. 31). Most of factories are using few cultivars whether produced in Pakistan such as “Aseel”, “Begum Jangi”, “Dhakki”, ”Rabie” and “Muzafati”, or imported from Iran and Iraq such as “Zahdi”, “Sayer“ and “Rabie”.

Figure 31: Sorting the “Rabie” Dates to Three Categories According to Size and Free from Blemishes

In Pakistan, no facilitated warehouses are present. The cured Rutab are always packed in wooden boxes or hand-made baskets. On the other hand, the dried dates of boiled “Chohara” are collected in wooden boxes or fiber sacks (Fig. 32), and then transferred to the market for auction by brokers to be exported mainly to India. In the market, the transferred dried dates were subjected to sorting process by labor according to their size and free from blemishes at the market place (Fig. 32). The usual measurement unit for dates selling in Pakistan is 40 kilograms

which is mostly equal to 1500-6000 Pak Rs. (70 USD). Production of a single tree of “Aseel” (100-120 kg. fresh fruit) can give 40-50 kg. dried dates of “Chuahara”.

Figure 32: Warehouses in Dates Market at Khairpur.

In various countries there are several kinds of contracts between growers and the packinghouse. Family packinghouses may be small or large, built in or near the

plantation, and they are owned by the grower. In such a packinghouse there is continuity and coordination between the activities at the plantation and in the packinghouse. Workers at the plantation supply the fruit in accordance with the potential of the packinghouse and the relevant installations to receive it, for instance for fumigation, refrigeration and storage. The packinghouse also adapts itself to the constraints of harvesting, such as the speed of ripening of varieties harvested at the Khalal stage, adding another shift when necessary, increasing its workforce (temporarily), renting storage space and operating fumigation rooms continuously.

Handling the crop after harvest is lacking the experience. Subsequently the microbial load of the dates was dramatically increased before processing and storage which caused problems for processors.

From the above discussion, it is noticed that date palm tree in Pakistan does not receive great attention as far as fertilization and other agricultural practices which resulted in low growth rate and low production. A national program for date palm maintenance and improvement is recommended in order to increase the productivity and fruit quality consequently the export value of Pakistani dates.

5.3 Pests and Diseases

5.3.1 Wilt Disease (Sudden Decline) at Khairpur, Symptoms and Remedy

Date palm trees at Sindh particularly Khairpur are suffering from a critical disease which is the sudden decline syndrome (Fig. 33). The date palm sudden decline disease could resemble some symptoms of similar wilt diseases in the world such as Palm Lethal Yellowing caused by Phytoplasma which is a fatal disease of coconut and also infectious to date palm. The drying manner of fronds displayed similar symptoms of Bayoud (Fusarium wilt) disease caused by Fusarium oxysporum Schlechtendahl f.sp.albedinis in Morocco and Algeria.

Figure 33: Normal (Left Tree) and Infected (Right Tree) Date Palm Tree with Sudden Decline Disease in Pakistan

Symptoms

The symptoms are starting with orange yellowish coloring of the lower part of the fronds midrib (rachis) then drying out the fronds from outside toward central fronds. Draying starting from the leaflets (pinnae) of a frond base on one side up to the tip then twists to the leaflets of the opposite side. Eventually, draying out the entire frond is occurred. Fronds drying sequence is in order and gradually not all fronds drying at the same time. This is a prominent symptom of such disease (Fig. 34).

Figure 34: Frond Symptoms of Date Palm Decline Disease

Infection can be occurred at any time of the year. The most elusive thing is the selective behavior of the disease to individual palms among many trees in the orchard, i.e. the synchronization (Fig. 33). Rarely all palms in an orchard are found infected at the same time. Furthermore, the decline symptoms can appear on different stages. Infection at early stage of fruit development caused fruit to drop and failure to reach maturity stage. Fruit bunches drying if the disease attacked the date palm at late Khalal and Rutab stages. Overall drying affects fronds and fruit together. Fruiting breakdown or cessation occurred when trees have infected before spathes emergence. The breakdown of trees dramatically occurred within 3-6 months to reach to complete drying of the entire tree. But, sometimes, it takes 1-2 years during which trees stopped fruiting.

Cause(s) of the Problem

The problem has started approximately since 10 years in Pakistan; still it is not an epidemic problem. The problem was recorded in Khairpur district and other areas of Sindh province. Since that time a controversy was started. In the beginning some opinions attributed this problem to the termites infestation where it is a problem for the date palm in Pakistan. The support to this opinion came through some local recipes made from a mixture contained the extract of Neem Tree (Azadirachta indica) followed by relative recovery of the tree after the foliar application in some instances. However, so many trees are suffering right now and in the past with no such symptoms.

A haphazard estimate was delivered by some agricultural officers with no real scientific background who have visited the affected areas and mentioned that this is a viral disease! Other specialists from different institute have taken samples but with no feedback remedy for their problem which is inflaming day after day.

Furadan is the trade name of Carbofuran which is insecticide-nematicide suggested by National Nematology Research Center. Their findings were "heavy infection of Plant Parasitic and Root Knot Nematodes in the root zone". Application of Nematicide is recommended for nematodes control. Unfortunately, field application with Furadan was frustrating trial when applied at HEJ, Karachi University backyard garden where some date palm trees are falling one after another (Fig. 35).

Figure 35: The Decline Disease Selectivity to Date Palm Trees in the Backyard Garden of HEJ, Karachi University in 2010

Crop Disease Research Institute (CDRI), Pakistan Agriculture Research Council, Karachi University Campus, their findings indicated that Pathogenic Fungi associated with the bark disease of tree were isolated frequently from the plant samples. In visual examination it was noticed that all samples were severely infested with insect pests. Root-knot nematode and other Tylenchida[3] observed. The suggestion was Topsin-M or Carbendazim which used as bud drenching and soil drenching. Three to Four grams of Carbofuran have been recommended.

[3] An order of nematodes is consisting of many species which are plant parasites. Female worms lay eggs that hatch either in soil or in the host plant.

Unfortunately, this treatment had no effect. Eventually, the treated trees died and symptoms started to appear on the adjacent trees associated with the common symptoms of the disease. DPRI has established an activity with the hope to find a quick and active remedy. The DPRI way to treat such a problem will be discussed.

Remedy

All these trials pressurized DPRI, SAL Univ., to conduct a comprehensive study to initially apply all pesticides and fungicides -which are available in the market since 3 years- to the infected trees with hope for a quick remedy. Two fungicides applications with Bavistin (a broad-spectrum systemic fungicide of the benzimidazole group) and Topsin M (Thiophanate Methyl) gave good results and trees up to high extent recovered, i.e. started to produce spathes and its fruiting was normal and drying out entirely stopped but, yellowish of the outer fronds midrib didn't not changed. As an initiative the group of DPRI has recommend the following four-tiered approach as a remedy for the trees showing same symptoms:

Cultural Practices

The infected fronds that showing such symptoms must cut and burnt but, there is no need for cut if they are at the initial stage of the infection showing the yellowish midrib (sometimes the inner heart fronds turned into pale green yellowish color particularly with the 5-7 years trees).

As the drainage water as noticed to be in conjunction with any field having the infected trees, irrigation water percolation should be optimized. The majority of the infected trees were found planted on the terraces of irrigation canals or at areas with low level land. For garden palms, daily irrigation for surrounded grass must be suspended and replaced by periodical irrigation with enough quantity of water according to climatic conditions, soil, etc.

DPRI has made a survey of seventeen locations at Khairpur viz., Noor pur, Ahmed Pur, Machyoon, Baberloe, Garhi Mori, Kot Mir Mohammad, Piryalo, Hadal Shah, Drib Mahesar, Munghan wary, Khan Pur, Maher Ali Shah, Rupri, Shadi Shaheed, Therhi, Noonari and Nizamani to estimate the incidence and mortality of date palm decline disease and to collect disease samples from affected trees. The disease intensity was greatly varied from location to location and ranging from 0.25 to 50.17% (Fig. 36). The highest disease incidence of date palm decline was recorded at Noor pur (50.17%) followed by Baberloe (35.58%) and Ahmed Pur (32.47%).

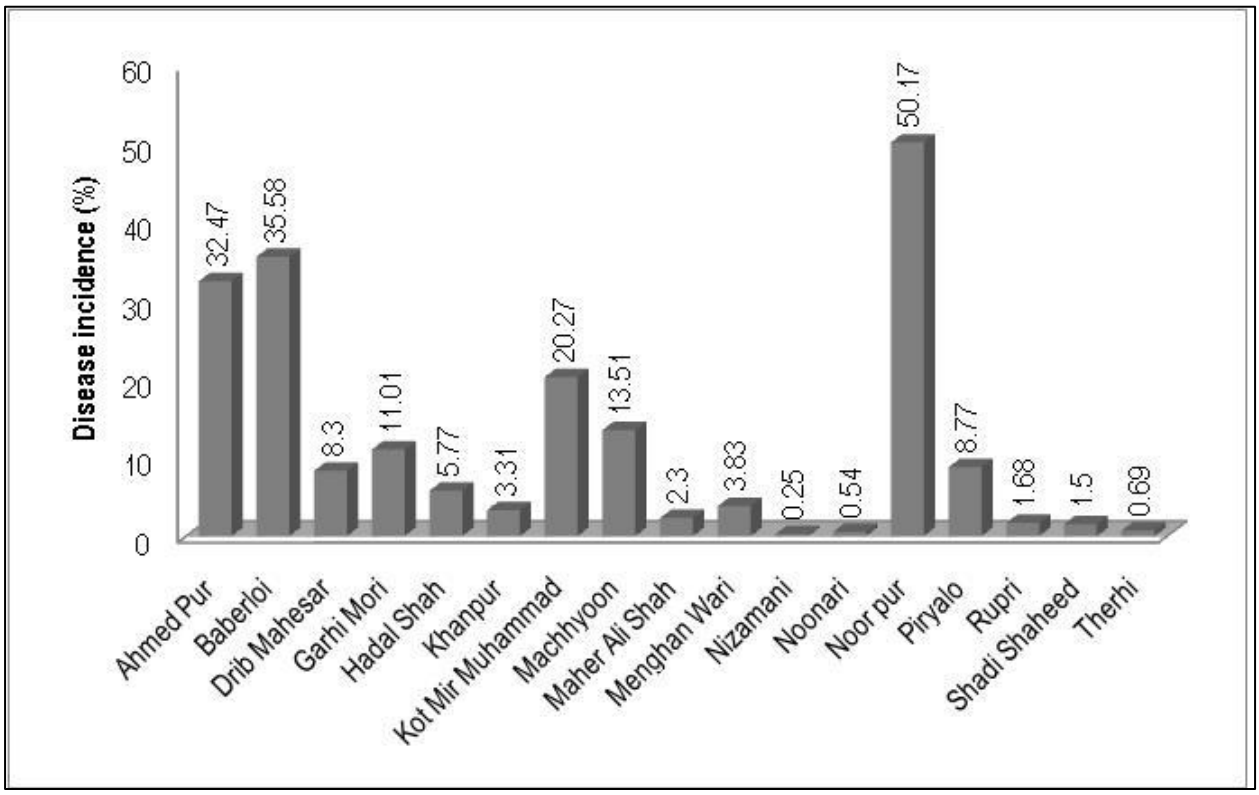

Figure 36: The Disease Incidence of Date Palm Decline at Different Locations of Khairpur

Foliar Application

Three foliar sprays with Cupper Oxychoride (A contact fungicide and fertilizer) solution 5 grams per liter of water through 10 days intervals alternatively with Bavistin solution 3 ml per liter of water.

Soil Application

Three soil application of Topsin M dissolved with the irrigation water around the tree. Infected and adjacent trees which showing no symptoms must treated with Topsin M solution 3 grams per liter of water (0.3%) applied as three fortnightly soil or foliar application.

Fertilizer Application

Tree is infected and needs special care regarding fertilization, while most of date palm farmers did not apply chemical fertilizers to the affected trees.. Two applications of 250 grams each per palm N-P-K fertilizer 17-17-17 on monthly soil application 2-3 feet away from the trunk should be applied. It is worth to mention that the above procedure has applied on an infected tree during fruiting and all fruit bunches dried out at Khalal stage and failed to reach Rutab stage. Once the tree was affected, the lower 2-4 whorls and old fronds started drying and dangled down within 2 months. A tree with dangling dried fronds and yellowish to central young fronds is a general symptom of the latent infection. The remedy treatment stopped the drying out of remained green fronds at the center (Fig. 37).

Figure 37: Infection during Fruiting (Top Photo) and Remedy Treatment Application (Below Photo)

Isolation and Identification of Actual Pathogen

Based on the positive results of an urgent remedy experiment, the isolation and identification of the pathogens from infected parts of the plants was started through a Ph.D study of a DPRI member [redacted] under the supervision of [redacted] and [redacted] in collaboration with [redacted], Hyderabad in 2007 with preliminary results showed that the pathogen is the soil-borne fungus Fusarium Solani. In recent years several reports on the isolation of Fusarium species from roots, fronds and trunks of date palm trees showed wilt and decline. Fusarium oxysporum and F.solani were the most frequent and most abundant in the roots of date palm trees showing decline in middle of Iraq.

Fusarium monliforme and F. solani were found associated with declined date palm trees in Egypt. In Iraq, a similar disease symptoms caused by F. solani have been reported recently. More recently, a serious disease of date palm was reported caused by F. solani associated with yellowing and death of the fronds. The disease occurred in date palm groves in Kazeron district, west of Fars province in Iran. An investigation was reported on the incidence of date palm disease in Saudia Arabia and in particular in Al Qassim and Medina Al Monawara regions, several trees showed symptoms of wilt and dieback very similar to those caused by Fusarium oxysporum albedinis. Three Fusarium species were isolated from the infected fronds and roots of the date palm trees. These identified as F. proliferatum, F. solani and F. oxysporum. All previously mentioned reports are in agreement with the findings of [redacted], however, more work has to be done on the side of remedy. Real effort with sanitary procedures should be taken to prevent the transmission of the disease to other production areas and finding cost effective and innovative solutions to control this disease.

5.3.2 Preventive and Curative Methods to Control Red Palm Weevil Problem

The Red Palm Weevil (RPW) is widely considered the most devastating insect to attack palms. In addition to Pakistan, RPW causes severe problems in many areas of the world including the Arabian Peninsula, Northern Africa, USA, Spain, France, Italy, Greece, Iran, India, Southeast Asia, and the Caribbean. In addition to date palm, RPW can attack and kill ornamental, coconut, oil, and sago palms.

In Date Palm Research Institute, Shah Abdul Latif University, Khairpur during 2009, a study has carried out on an extensive survey of tissue boring pest of date palm, Red Palm Weevil (Rhynchophorus ferrugineus Oliver). The survey covered 46 orchards of 8 different locations at Khairpur area. The results of the survey indicated that 219 date palms (5.81 %) were infested by red palm weevil. The pest incidence indicated that the maximum infestation percentage by red palm weevil was 9.29 % and occurred in the tree group age of 8-10 years, followed by 7.96 % in 11-15 years tree group age.

However, trees of 35-40 years old had very low infestation incidence (0.02 %).The deleterious phase is the larvae which bore tunnels through palm trunk as they feed, eventually may kill the tree. Adult weevils can spread by flying up to 4 miles in 3-5 days. One infested tree may maintain 164 larvae in addition to other insect phases. Infestation is occurring around the year; however, infestation increases in winter months.

The infestation area mostly located at the basal portion of the offshoot where it joins the mother tree. Brown sap is secreting from the infestation area with bad smell (Fig. 38). Infection rate is high during winter season accompanies the regular pruning process in the beginning of December. Cutting surfaces and distinguishable fragrance of cut fronds attracts the insect to make new infestation. Preventive methods include spray on cut surfaces and entire fronds are strongly recommended to repel the RPW until the dryness of cut surfaces. Also, cleaning the area around the productive trees and removal of the ready offshoots to be separated could help for early discovering of new infestation.

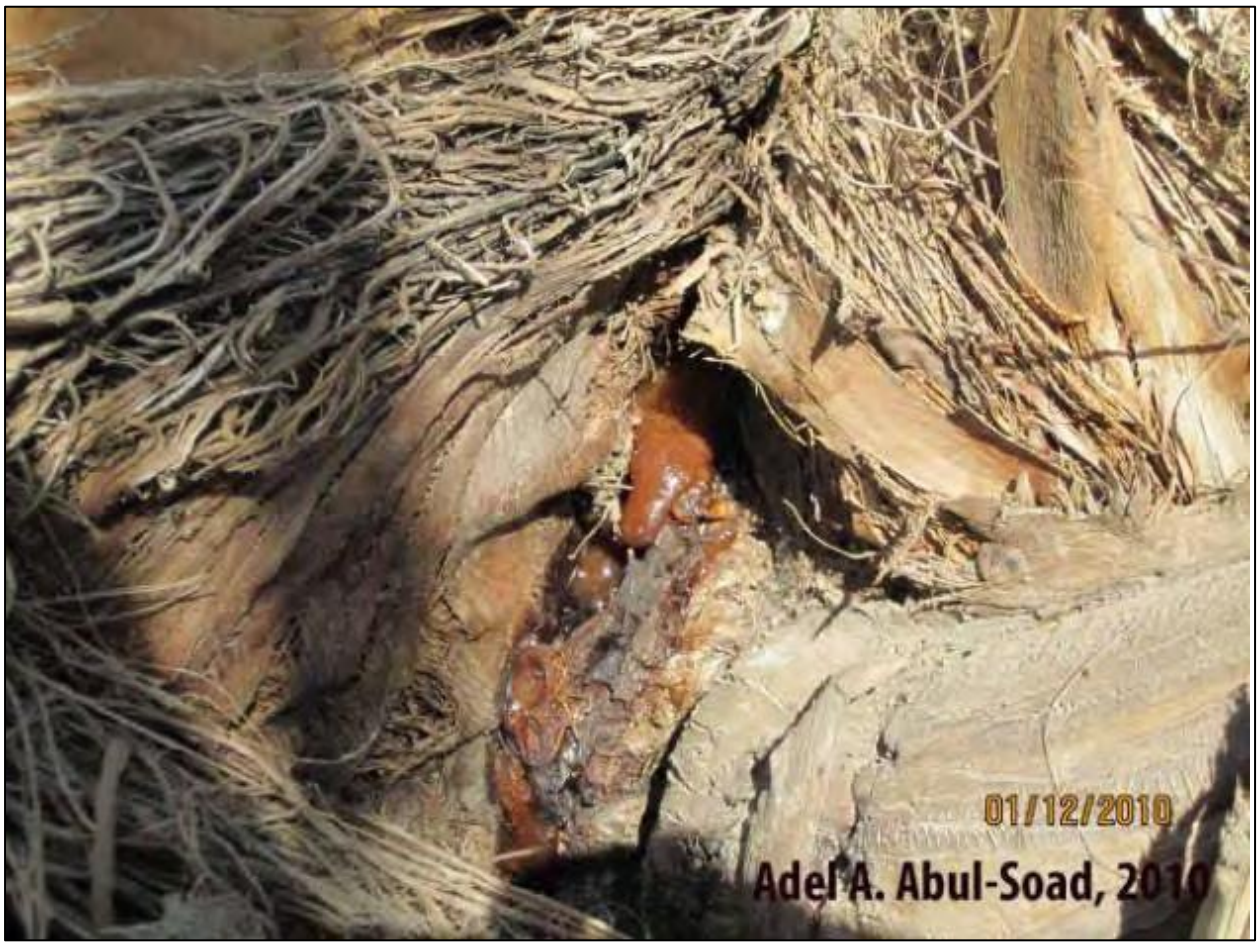

Figure 38: Symptoms of RPW Infection to Young Trees (8-10 Years), Brown Sap Along with Bad Smell

Although the strict tree monitoring of date palm orchard remains the only viable way to protect your trees, the control of RPW includes:

- Preventive methods: The prophylactic or preventive methods are meant to delay or prevent the entry of the palm weevil into new palms or orchards. For this purpose most vulnerable stages of the palms are treated with pesticides, cultural practices like leaf cutting are modified, phytosanitation, plant quarantine besides use of pheromone trapping system to attract and kill the adult weevils.
- Curative methods: After detection of infestation, most suitable method of control should be applied.

Date palm tree could maintain all fronds green while it is infested with RPW. Mostly the outer suspended fronds change its color to yellow after few months of the infestation when contain pupa ready to produce new adults for a new infestation somewhere else (Fig. 39). The procedure of RPW control in case of discovering an infestation of RPW (Fig. 38) could be as follows:

- In the beginning, the colored fronds were pruned and the adjacent offshoots were separated. During this process, only one offshoot was infested at its base (Fig. 38), while other offshoots were free. The infested tissues were chipped to pieces and treated with pesticides or gasoline, then buried deeply in a hole of 4-5 feet depth. Good sanitation practices are needed to prevent RPW escape and spreading from infested palms.

Figure 39: Infestation with RPW since Few Months for the Mother Tree and Adjacent Offshoots

- Cleaning the base of mother tree from the superficial larvae and pupa by removing the outer leaf bases to uncover the decayed tissue (Fig. 40).

Figure 40: The Larvae and Adult Insect of RPW were Collected from Infested Tree.

- Phostoxin gassing tablets which contain aluminium phosphide were placed in the entrance of larval galleries and the stem is entirely covered with clay mixed with the pesticide Thiodan (Endosulfan) 5 ml per liter water (Fig. 41). Aluminium phosphide reacts with normal atmospheric moisture to liberate phosphine (hydrogen phosphide) gas. Aluminium phosphide is a highly toxic substance and the phosphine gas which it liberates is lethal to all animals at low concentrations in the air in nests, warrens and burrows. Before working with Phostoxin, users must be given musk and told not to breathe the gas. Tablet has no residual effect on the soil, nor will it in any way harm plant life in the treated area.

Figure 41: Tools Required for Remedy Are the Tree Borer Tool, Pesticide, Plastic Tubes (1 Inch × 1 Foot), and Phostoxin Tablets.

- Holes of one inch in diameter were dug in the trunk by the tree borer tool (Fig. 42). A plastic tube one foot in length was inserted in the trunk 0.5-1.0 foot above the infestation place. The tube filled with the diluted pesticide with water at the ratio 1:3 (v/v). Number of used tubes is depending on the infestation size. Mostly the number ranges from 3-9 tubes distributed around the trunk on different levels. Orchard should not be irrigated before the curative process, however, after along with chemical fertilization.

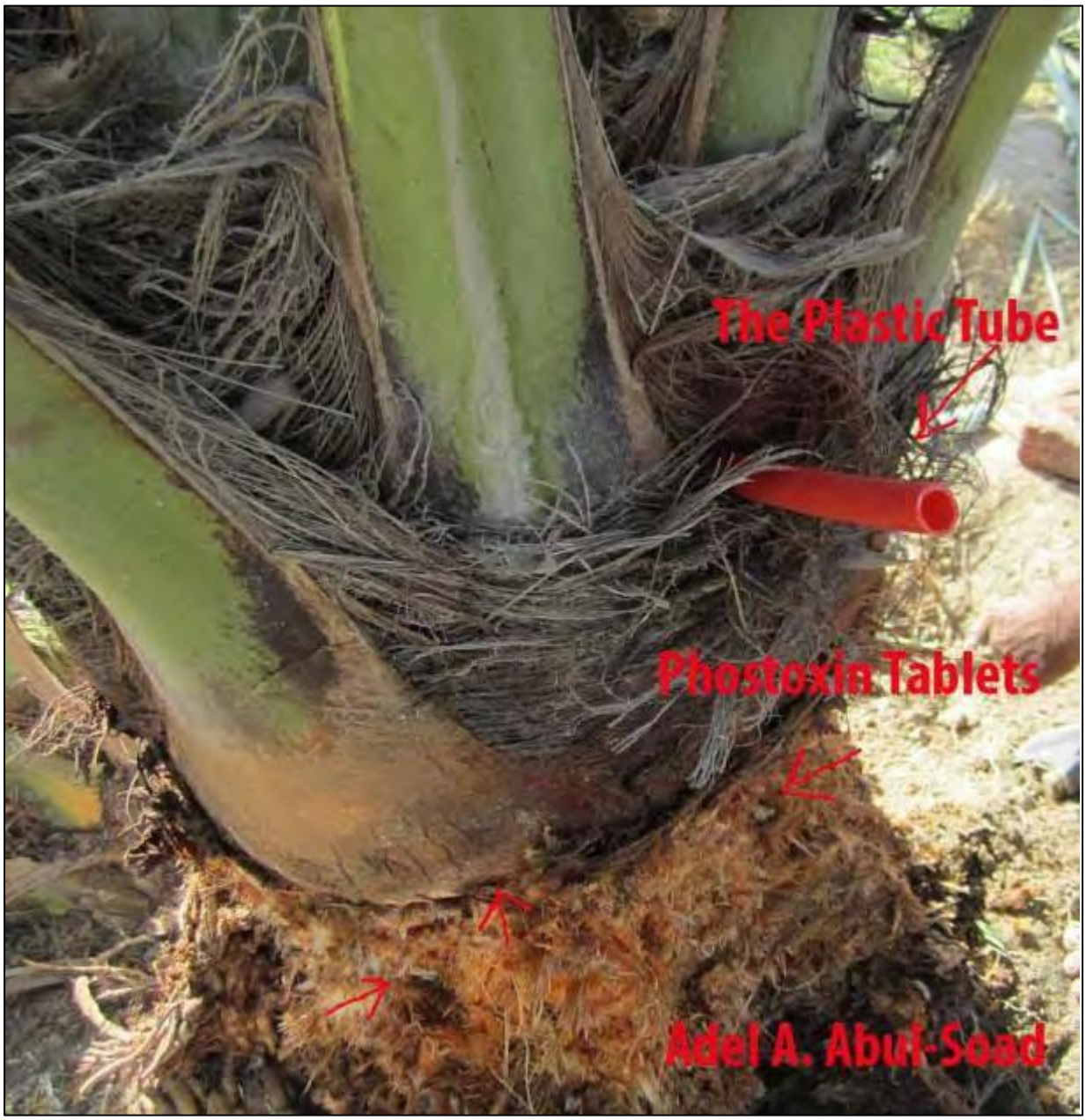

Figure 42: Cleaned Date Palm from RPW Phases and Pesticide & Phostoxin Tablets Were Applied

- Almost 1-2 offshoots were left joint their mother tree for its balance and survival. Moreover, supporting may require in case of severe infestation as a result of tending the mother tree, otherwise it may fall down.
- Spray the cut surfaces of remaining offshoots and pruned fronds with different pesticide Malathion (organophosphate insecticide) 5 ml per liter of water as foliar application to repel RPW. Lots of care should be taken during detachment process which may cause the tree to fall down due the decayed tissue. In such a scenario, if the tree started to tend to any side, the process of detachment should be banned and support should be provided to the trunk.

- After all infested trees were curatively controlled (Fig. 43), a spray with a pesticide for all trees should b applied in the orchard every 2 weeks at intervals of 3 times. The pesticide must be changed to avoid natural resistance.
- It is difficult to understand the behavior of this pest. In some cases the adjacent offshoots of infested palm were found free from infestation while the head of mother plant had fallen down. The incomplete destruction of its future food materials indicating planned feeding policy for such insect. Simultaneously this creates more pressure on the control policy. Also, cultivar preference was detected where the RPW was selecting preferably “Dedhi” cultivar from among 25 cultivars are there. The prominent characters of this cultivar are the wide trunk, soft tissue and sweet fruit at Khalal stage.

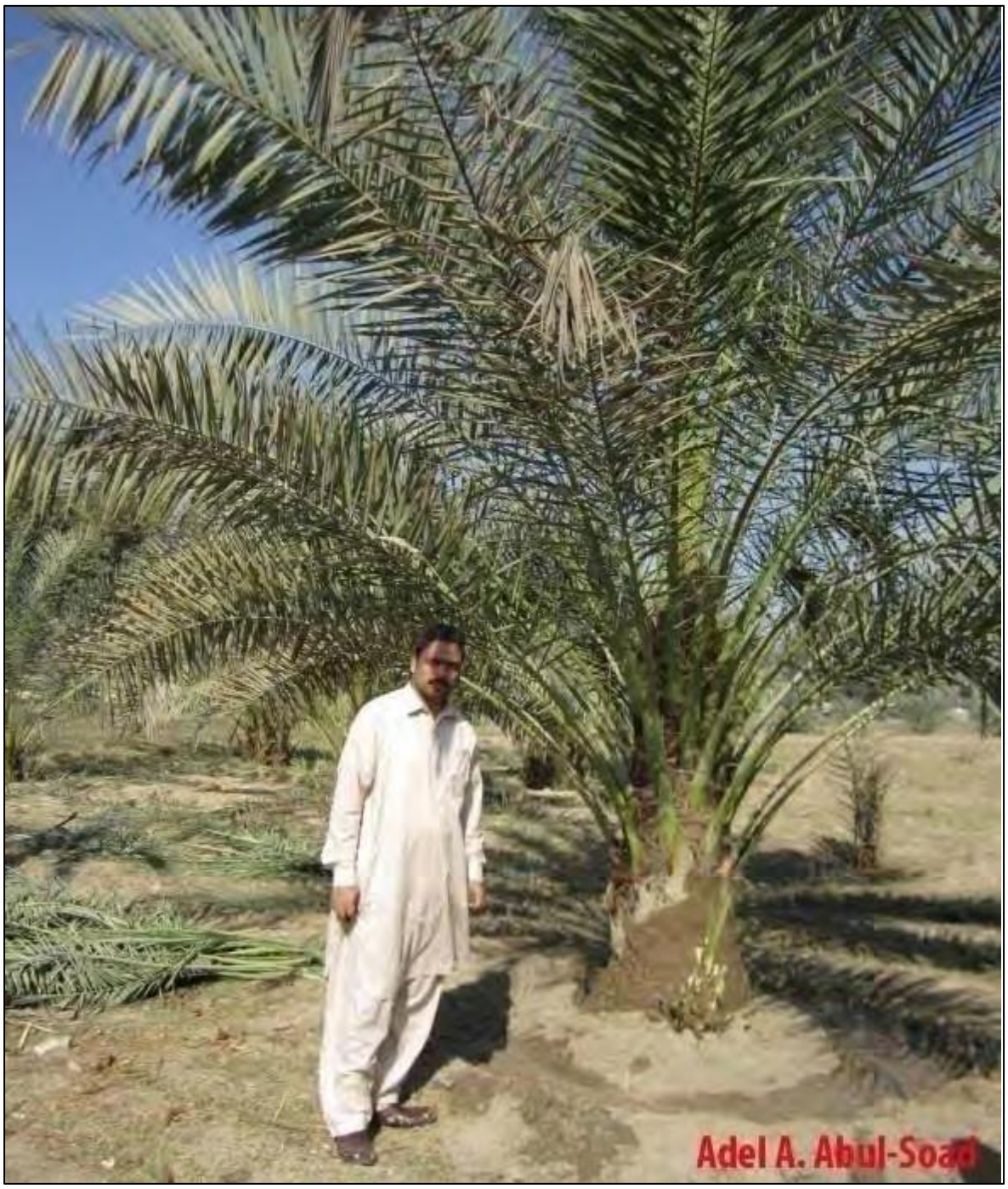

Figure 43: Controlled Date Palm Tree after Remedy Application

- There is advanced machinery tools can be used for artificial infection of the trunk. Also, pheromone traps are effective tool to capture the insects of RPW and to give an indicator for the population inside the orchard. It is worth mentioning that control of date palm weevils is a difficult process and needs an integrated set of methods. The machinery injection and pheromone is unlikely not applied in Pakistan compared to advanced date palm countries. In order to successfully implement RPW management the cooperation and interaction of the farmer is necessary. IPM of RPW is the need of a viable control in conjunction with the environment protection.

5.3.3 Integrated Pest Management (IPM) of Date Palm

Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment.IPM takes advantage of all appropriate pest management options including, but not limited to, the judicious use of pesticides. IPM is not a single pest control method but rather, a series of pest management evaluations, decisions and controls. In practicing IPM, farmers who are aware of the potential for pest infestation follow a four-tiered approach. The four steps include:

- **Monitoring**

The monitoring removes the possibility that pesticides will be used when they are not really needed or that the wrong kind of pesticide will be used. Pheromone traps could be the most suitable way for monitoring.

- **Set Action Thresholds**

Before taking any pest control action, IPM first sets an action threshold, a point at which pest populations or environmental conditions indicate that pest control action must be taken. Sighting a single pest does not always mean control is needed. The level at which pests will either become an economic threat is critical to guide future pest control decisions.

- **Prevention**

As a first line of RPW control, IPM program work to manage the crop to prevent RPW from becoming a threat. This may mean using cultural and mechanical means. These control methods can be very effective and cost-efficient and present little to no risk to people or the environment.

- **Control**

Once monitoring and action thresholds indicate that pest control is required, and preventive methods are no longer effective or available, IPM program then evaluates the proper control method both for effectiveness and risk. Effective, less risky pest controls are chosen first, including highly targeted chemicals, such as pheromones to disrupt pest mating, or mechanical control. If further monitoring, identifications and action thresholds indicate that less risky controls are not working, then additional pest control methods would be employed, such as targeted spraying of pesticides. Broadcast spraying of non-specific pesticides is a last resort.

Mass trapping has been used to reduce Red Palm Weevil densities. In this instance, aggregation pheromones are loaded into bucket traps along with palm material and granular insecticides. RPW adults are attracted by the pheromones and the plant material and fly into buckets. Once inside the bucket trap, the pesticide kills the weevils before they can escape. Biological control is the use of natural enemies, like predators, parasites, and pathogens to kill a pest. Red Palm Weevil is attacked by a cultivar of different natural enemies including parasites and small predators that attack weevil eggs, while bacteria, fungi, and nematodes can kill weevil larvae. Many of these biological control agents do not provide adequate control of Red Palm Weevil in the field. Host plant resistance can reduce the ability of Red Palm Weevil to damage palms because the weevil is unable to effectively exploit these hosts. The California fan palm, Washingtonia filifera, which is native to southern California and western Arizona, and the European fan palm, Chamaerops humilis, appear to be resistant to Red Palm Weevil

infestations. With these steps, IPM is best described as a continuum. The goal is to move farmers further along the continuum to using all appropriate IPM techniques.

5.3.4 International Methods to Control RPW

- **Plant Quarantine**

The transport of offshoots as cultivation material from infested areas can contribute to the spread of the pest. Strict quarantine at international and national levels should be applied.

- **Cultural Control**

Field sanitation and cultural practices are one of the important components to prevent weevil infestation through:

- Clean the crown of palms periodically to prevent decaying of organic debris in leaf axils.
- Avoid cuts and injuries.
- As palms affected by leaf rot and bud rot diseases are more prone to weevil infestation, they are to be treated with suitable fungicides; after that, application of any insecticide to prevent egg laying by weevils is essential.

- **Mechanical Control**

Destroy all discarded palm tissues, which may harbor the pest by chipping to small pieces and burning.

- **Trapping the Weevils**

Trapping the weevils and destroying them is another method by which weevil populations can be brought down.

- **Biological Control**

No effective biological agent, which can be employed for the biological control of the pest, has been found.

- **Chemical Control**

Preventive and curative methods (discussed above).

Training and Education
For any large scale pest management program to succeed, it is imperative that the farmer cooperate and involve himself at the operational level. This can be achieved by making him aware of the seriousness of the problem and training him in various IPM skills. The trunk of the palm needs to be split open and all stages destroyed. Burning the head does not kill the stages in the middle of the trunk. Thus, the whole trunk should be chopped and burned [54].

5.3.5 Severe Infestation of Scale Pest to the Fronds

White scale insect is widely infected green fronds of date trees in Khairpur. The symptoms are white scales on the leaflets of the fronds. Nymphs and adults suck the sap of the fronds and spots turns brown then fronds drying. Brown spots are extending to cover the entire fronds of the date palm tree which delay the photosynthesis and vegetative growth. Heavy infestation causes leaflets to turn yellow and contributes to the premature death of the fronds then the production (Fig. 44).

Figure 44: White Scale Pest Infestation on Date Tree Leaflets at Khairpur

White scale, caused by Parlatoria blanchardii Targ., is widely present in most date palm growing areas of the world. It is considered a serious pest in Algeria, Kuwait, Libya, Mauritania, Morocco and Tunisia. Iraq, Oman, Saudi Arabia and Sudan consider this pest a moderate one, while Egypt, Jordan, UAE and Yemen consider it a minor pest. Damage by white scale is very serious on young palms between two to eight years of age, but even under severe attacks, the palm and its offshoots do not die. Chemical control appears to be conducted occasionally in young plantations.

Mineral oils are used. Distance in between trees works to avoid integration of fronds and transfer the pest faster within the orchard. Collecting the infested fronds and burning them reduces the infestation size.

5.3.6 Rodents Damaging Date Palm Orchards in Balochistan

The villagers in Gualishtop near to Nok-Kundi claim that within the last decade a rodent that has an appearance of a big rat has become a threat to the date palm plantations in this area (Fig. 45A). The author has made a study at these areas in 2009 and recorded that the rodent moves in tunnels of 0.3-0.6 m in diameter burrowed by it, extending to more than a hundred meters (Fig. 45B). The rodent digs these tunnels in sandy soil approximately 0.3 m below the surface, and reaches the pith of date palm tree. The rodent damages the fronds at the base of the young date palms (10-15 years), which leads to a fungal infection (Fig. 45C) and consequential devastate the tree. In mature trees the rodent is said to eat the sweet and soft bulb of the trunk, again resulting in death of the tree.

The rodent attacks date palm trees has recorded in Nok-Kundi, Mashkel and Dalbandin causing complete destruction for both adult and small offshoots (Fig. 45D). This exotic pest mostly became principal pest due to some change in the equilibrium of natural forces particularly because of prolonged drought periods may reach 4-5 years in this arid region of the province.

Vertebrate Pest Control Institute, Karachi University Campus has made a study covered the area of Nok-Kundi and Dalbandin. Their salient findings indicated that mole rat (Nesokia sp.) has a narrow feeding niche, and in non-crop lands of Balochistan is largely herbivorous in diet.

The food habit studies shows that rodent throughout the season feeds principally upon the date-palm fruits, stem, grasses and roots but date-palm pith was the main component of the diet.

Rodenticides bait and trapping were used to eliminate the rodents. Underground modified PVC pipe bait station was suitable to place the rodenticides bait. Highest mortality was obtained by the use of 5g sachet of milk powder as bait base containing 0.22% Sodium monofluroacetate (1080) which were inserted deep into the live burrows of rodents. Aluminum phosphide tablets also used to reduce rodent activity because of the sufficient moisture in the soil increased the release of Phosphine gas in the burrows. Brodifacoum and Zinc phosphide burrow baiting gave also encouraging results and reduction in rodent activity

Figure 45: Rodent Attack on Date Palm Trees at Gualishtop, Balochistan

These attempts to control the rodents were not successful hitherto. Therefore, used Rodenticides baiting was not safe for grazing ruminants and livestock. Recognizing the damage caused and the risk of the threat of spreading to Rajai, Wadian and other areas, further studies are needed to understand the nature of the problem and to develop control techniques like launching augmentation programs for the natural predator Barn Owl. This is necessary in order to rescue the date palm plantation in Balochistan from this new menace.

In the international scenario, the only control measure was by using poison. It is composed from a mixture of zinc phosphate at 30 to 50 g with 1 kg of millet flour and 3 % of cooking oil. The paste is to be placed around the palms at the entry to the galleries. A chemical product „Finale"

gave excellent results at the Eersbegin project (Namibia). It is highly active anticoagulant bait at 0.025 g/kg as an active ingredient. The death of rodents takes 4 to 12 days. The chemical was used (July and August 1997) in both the Eersbegin and Naute date plantations (Namibia) with a sound success rate against Mus musculus.

5.4 Processing

5.4.1 Dates Quality Standards

Processing of such dates can be improved through a good treatment for curing away from boiling process “Chohara”. Subsequently, grading the fruit according to their size is very important for marketing. There are nowadays modern machines for grading by optical methods as shown in the following two figures (Fig. 46).

Figure 46: Machinery Sorting of Dates According to their Sizes in Al-Saad Factory, UAE

An index for the different grades should be developed through a research institute for each cultivar to Grade A, B and C according to size and clearance from defects. Number of dates in kg will be accounted accordingly. Packaging in different shapes of containers whether carton, metal or plastic made package (Fig. 47). These types have market even inside Pakistan due to the growing local consumption of dates. The turnover of dates in Karachi city reached 40,000 tons during holy Ramadan in 2010.

Figure 47: Packaging of Dates to Fulfill the Wide Variety of Consumers Demand

Table 3: Export Quantity, Value, Ton Value and Kg Value of Pakistan Compared to Number of Dates Exporters in the World (FAO, 2007)

Export (2007)	Quantity (ton)	Value (1000$)	1 Ton Value ($)	1 Kg Value ($)
Cyprus	6	121	20166.67	20.17
Bahrain	2	27	13500.00	13.50
Occupied Palestinian Territory	18	131	7277.78	7.28
United States of America	3259	18863	5787.97	5.79
China	258	402	1558.14	1.56
Jordan	2806	2924	1042.05	1.04
Egypt	4704	3014	640.73	0.64
Pakistan	104090	38271	367.67	0.37
Iraq	37063	9532	257.18	0.26
Libyan Arab Jamahiriya	20	4	200.00	0.20

Dates have vast potential of export, but efforts are required to apply post-harvest management and processing techniques in order to qualify for the international standards. A number of countries have formulated and applied date standards at the national level, which include the

US, Canada, Algeria, Tunisia, Oman and Israel, both for locally produced and imported dates. Therefore, Pakistan has to follow such type of systems and standards. According to latest statistics of FAO in 2007, Pakistan is the second exporter after Iran (Fig. 48).

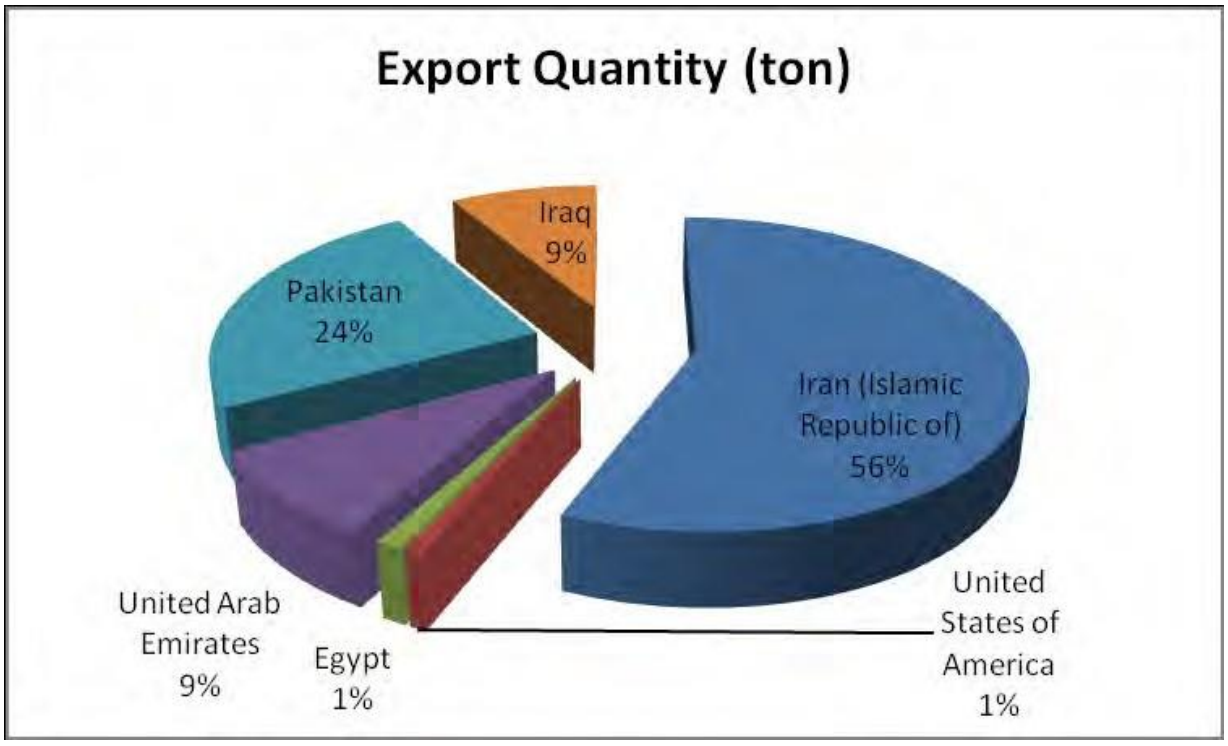

Figure 48: Pakistan Export Figure as Compared to Five Dates Countries (FAO, 2007)

Nevertheless, the value per ton equals $ 367.67 compared to the highest value in the world Cyprus $ 20166.67 (Table 3) or even famous dates producers such as Iran, Iraq, Egypt, UAE and USA (Fig. 49). This amount made Pakistan occupy the position number 73 of the highest values per ton of dates.

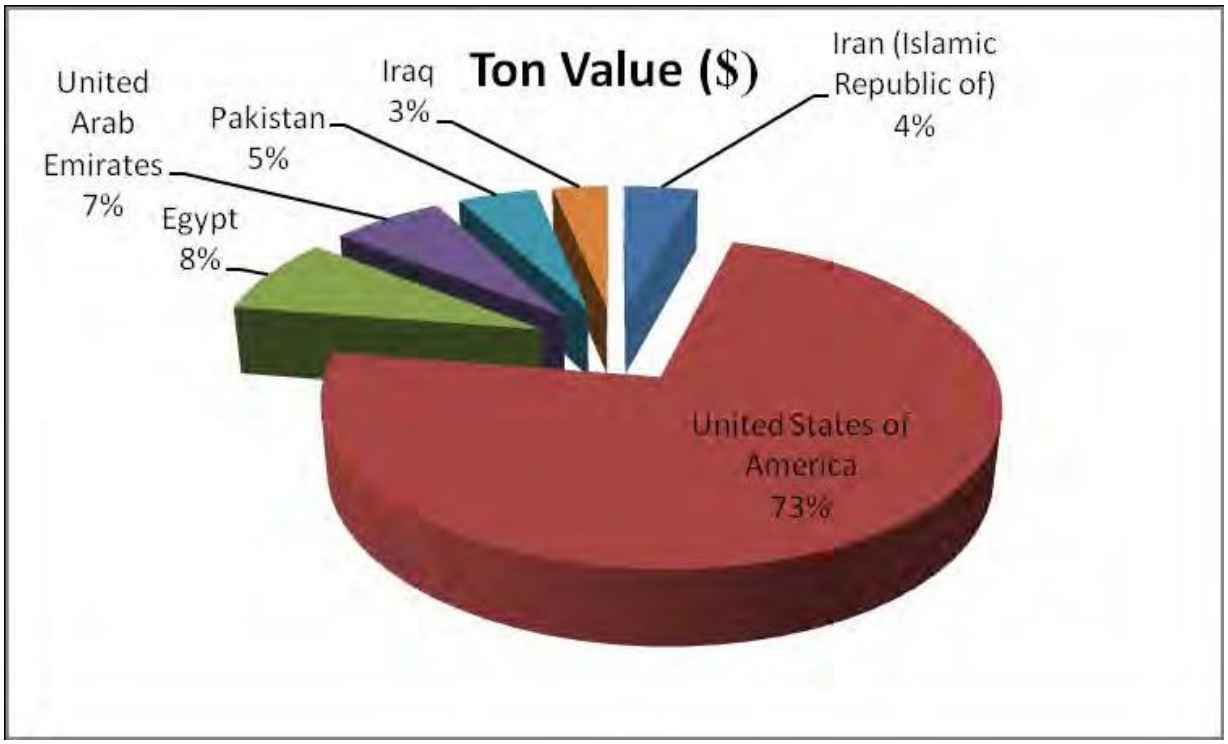

Figure 49: Value of Pakistani Dates Export per Ton Compared to Iran, Iraq, Egypt, UAE and USA (FAO, 2007)

There are technical regulations issued by international organizations such as (FAO- Codex Standard For Dates Codex Stan 143-1985/WTO-SPS agreement); EU regulations, and European Good Agricultural Practices (Euro-GAP) developed by chain stores associations in Europe.

According to FAO, this standard applies to commercially prepared-whole dates in pitted or un-pitted styles packed ready for direct consumption. These styles may also included the pressed (dates which are compressed into layers using mechanical force), un-pressed/loose (dates which are free-flowing or packaged without mechanical force or compression) and clusters (dates with the main bunch stem attached). It does not apply to other forms such as pieces or mashed dates or dates intended for industrial purposes. Dates may be designated according to size names i.e. small, medium and large sizes; however, it is optional (Table 4).

Table 4: Number of Date Fruit in 500 Grams Weight

Size	Un-pitted Dates	Pitted Dates
Small	More than 100	More than 110
Medium	80-100	90-110
Large	Less than 80	Less than 90

Quality factors includes general requirements in which dates shall be prepared from such fruit and under such practices that the finished product shall possess a characteristic color and flavor for the cultivar and type, be of proper stage of ripeness, be free of live insects and insect eggs and mites and meet the following additional requirements (Table 5).

Table 5: Quality Factors of Dates Fruit Moisture Content, Size and Mineral Impurities

Moisture content	Maximum
Cane Sugar Cultivars	26%
Not Processed Deglet Noor	30%
Invert Sugar Cultivars	30%
Size	Minimum
Un-pitted Dates	4.75 grams
Pitted Dates	4.0 grams
Mineral Impurities	Not more than 1 gram/kg

Table 6: Definition of Defects for Dates Fruit

1	Blemishes	Scars, discoloration, sunburn, dark spots, black nose or similar abnormalities in surface appearance affecting an aggregate area greater than that of a circle 7 mm in diameter.
2	Damaged	(Un-pitted dates only) dates affected by mashing and/or tearing of the flesh exposing the pit or to such an extent that it significantly detracts from the visual appearance of the date.
3	Unripe dates	Dates which may be light in weight, light in color, have shriveled or little flesh or a decidedly rubbery texture.
4	Un-pollinated dates	Dates not pollinated as evidenced by thin flesh, immature characteristics and no pit in un-pitted dates.
5	Dirt	Dates having embedded organic or inorganic material similar to dirt or sand in character and affecting an aggregate area greater than that of a circle 3 mm in diameter.
6	Insects and mites	Dates damaged by insects or mites or contaminated by damage and contamination the presence of dead insects or mites, fragments of insects or mites or their excreta.
7	Scouring	Breakdown of the sugars into alcohol and acetic acid by yeasts and bacteria.
8	Mold	Presence of mould filaments visible to the naked eye.
9	Decay	Dates that are in a state of decomposition and very objectionable in appearance.

Unfortunately, the processed dates in the big factories of Pakistan are still in a need to apply the mentioned quality standard and to minimize the defects (Fig. 50).

Figure 50: Defects of Dirt and Damaged Dates Processed in Khairpur

Allowance for Defects

The maximum allowances for the defects defined above (Table 6) shall be: A total of 7% by count of dates with defect (1) A total of 6% by count of dates with defects (2), (3) and (4) A total of 6% by count of dates with defects (5) and (6) A total of 1% by count of dates with defects (7), (8) and (9) Utilization of instructions required by shipping organizations, forwarders and insurance companies may be applied such as Transport Information Services (TIS).

5.4.2 Growth of Yeast and Molds in Stored Dates

Inappropriate post-harvest treatments and poor storage conditions of dates made a problem for processors in Pakistan. “Carba” cultivar is growing in Balochistan and widely used in processing plants. Such dates have a tendency to grow mold/mould[4] during storage and sometimes it goes up to 250×103 cfu (colony forming units per gram or square inch) per gram when tested in the laboratory. The preferable level of mold is 102 cfu g-1 and max 103 cfu g-1. However, it should not increase in any case by 104 cfu g-1. The problem can also come up with the temperature fluctuations during the storage period or even starts before the time of receive in the factory.

[4] Mostly Canadian English uses “ou” instead of “o” in a word like mould, colour, flavour, etc. In addition, in USA uses mold and UK uses mold.

Good post-harvest practices are necessary to prevent or reduce the infection after harvest in an open field.

Moulds are microscopic fungi that live on plant or animal matter. Most are filamentous (threadlike) organisms and the production of spores is characteristic of fungi in general.

These spores can be transported by air, water, or insects. Ozone is a strong oxidant and potent disinfecting agent. There are numerous application areas of ozone in food industry such as sanitation of food plant equipments, surface hygiene and reuse of waste water. The promising results indicated the efficacy of ozone to reduce the microbial populations in date fruits. Escherichia coli and S. aureus were not found on cultured plates inoculated with the treated samples after treatment with 5 ppm in 60 min.

On June 26, 2001, the US Food and Drug Administration (FDA) released an official determination on the permissible use of ozone as an antimicrobial agent for the treatment, storage and processing of foods in gas and aqueous phases in direct contact with foods, including raw and minimally processed fruits and vegetables. The main purposes of ozone application at the postharvest stage are inactivation of bacteria and prevention of fungal decay.

5.4.3 Using Methyl Bromide and its Alternatives to Reduce Pest Infestation of Stored Dates

Since infestation begins in the field, methyl bromide (MeBr) is used to rapidly fumigate harvested dates on arrival at processing plants on a daily basis. Most fumigation occurs over several weeks, during the peak production season, as the bulk of the harvest moves from the field into storage and shipping channels. Upon arrival from the field, each load is fumigated with methyl bromide in preparation for processing and shipment to national and international markets. Any one load of dates is fumigated with methyl bromide only once.

Sulfuryl fluoride indicates that this fumigant is a likely methyl bromide alternative for most commodities. In Dates, MeBr is used primarily to control the carob moth (Ectomyelois ceratoniae, Zeller) and other insects infesting dates. Sulfuryl fluoride is currently labeled for use on dried dates. The California Date Commission reports that it is currently testing the efficacy of Sulfuryl Fluoride on dates, with preliminary results showing less than adequate egg kill, even when the amount used is twice that needed for comparable methyl bromide fumigation.

Figure 51: Carob Moth Pest and its Pupae Infect the Flower and Fruit of Date Palm Tree

Carob moth was found in date palm orchards (Fig. 51). The larva of the Carob moth attacks dates in plantations, packing houses and stores. Eggs are laid on the dates and hatching begins four days later. The larval period is about three weeks in warm months and eight weeks in colder months. The pupae period is about five days.

Taking into account the moth's life cycle, it is recommended to protect the fruit bunches, to clean the plantation from wind-fallen fruits and to fumigate harvested and stored dates. The use of pheromone traps will not only help to determine the emergence of moths but also to estimate the population level. The rate of infestation could be lowered by spraying the infested fruits with Bacillus thuringiensis.

5.5 Insufficient Research and Development Activities

There is a need of extensive research for better quality and yield of dates so that quality could match with international requirements of sanitary and phyto-sanitary (SPS) measures; selection of disease-free plants; screening out of bad cultivars pre and post-harvest management, processing and behavioral trainings of the staff for their role in the system, processing, packing, marketing and export of dates and date products.

The shortage in national qualified and trained staff & labors delays the dates industry in Pakistan to come up with similar industries in date palm countries. Training programs and documentary materials mostly will be viable way to improve the awareness of Pakistani farmers toward such important methods.

Cooperation between Pakistan and the Scientific Institutions dealing with date palm studies is decisive to face the economical competition with other developed date palm countries in the world. Large steps to modernize dates production, storage and processes need to be taken to make date palm cultivation is more beneficial to the growers, processors, and exporters in Pakistan.

6. Modern Techniques in Other Countries

6.1 Fruit Bunch Covering in USA

Deglet Noor is the major date cultivar grown and packed in the United States. The crop is increasingly attacked by insects while ripening on the palm, especially carob moth. These pests are presently a serious threat to the livelihood of both conventional and organic date farmers. Infestation rates already average 10% to 20%. Malathion, the only insecticide registered for use on dates, is ineffective because the insects have developed resistance. A physical barrier in the form of cloth bag to exclude insects was used. This date-bunch cover also protects the on-tree crop from birds, heavy rain, high winds, and sunburn. The cover is composed of a flexible fabric, preferably white, woven, open-mesh polyester, which allows free circulation of air throughout the fruit cluster. Layering the fabric on top of the bunch provides rain protection. Accordingly, many advantages over prior art are realized in terms of effect upon the fruit and economy of use. The manner and time of installation are crucial. The cover is durable, light-weight and reusable.

Another type of Punched Paper Bags was used to hasten the ripening of date fruit. It is recommended to cover the bunches directly after fertilizing with punched paper bags and to be kept for 45 days in order to obtain earlier ripening as well to improving their physical and chemical specifications.

Medjool, Barhee and Deglet Noor date trees were wrapped in July and August with large brown paper bags around each date bunch in order to keep off the rain (occasionally there is some rain in the desert) and also to deter birds, sunshine and insects from ruining the soft mature dates (Fig. 52). Also, wrap a nylon mesh bag around some date cultivars; the nylon bags completely block out insects, dust, rain, and birds.

Figure 52: Barhee Dates that Will Turn Yellow Sometime in August at California, USA. The Brown Paper Bag Keeps the Rain off the Fruit (Brown Date Garden).

Deglet Noor date trees are about 55' to 60' tall. Each field worker can "bag" 14 trees per day; this requires climbing a 48' ladder from the ground to get to the bottom of the 20' ladder that is tied to the top of each 55'-60' Deglet Noor date tree.

6.2 Drip Irrigation in Egypt

The total area of date palm cultivation in Pakistan is about 93.3 thousand hectares with 680 thousand Mt and thus Pakistan stands at the fourth position in the world in terms of dates production. If this figure is compared to the ever biggest country in the world for dates production Egypt, a gap between the production and cultivated area will appear in terms of production and quality. The total production of Egypt is about 1300 thousand Mt produced only from 87 thousand hectares.

As date palm is a salt and drought tolerant plant, Egypt has established by private and governmental sector a large number of date palm plantings. The water source of such plantings is the ground water. Drip irrigations system is the appropriate choice for this type of cultivation (Fig. 53).

Figure 53: Date Palm Farm of Barhee Cultivar under Drip Irrigation System through Ground Water in Desert in Egypt

Tissue culture derived palms of valuable cultivars like Barhee, Nabout Sief, Medjool, etc. provided a large number of the offshoots that uniform in growth to establish new farms (Fig. 53).

Zaghloul is one of the large size fruit cultivar in Egypt (Fig. 54). It is widely cultivated at the Middle and North of Egypt. Fruit is red with crispy and sweet test.

Figure 54: Date Palm Superb Fruit and Tree of "Zaghloul" Date Palm Cultivar (Soft Cultivar)

6.3 Dates Processing in UAE

Dates are the UAE's major crop and this country is the seventh largest producer in the world after Egypt, Iran, Saudi Arabia, Iraq, Pakistan, and Algeria. The highest population of date palms is believed to be concentrated in various oases of Al Ain region.

The total number of date palm trees has grown to nearly 41 million, stretching over an area of 1.85 million hectares. Equipments process fruit dates before packaging by fumigating to eradicate insects and pest from the fruits, washing by pressurized spray, drying by hot air, sorting manually picking spoiled fruits in conveyor, paste production of dates fruits by steaming, seed extraction and mashing by strong centrifuge to produce paste mass of date.

As an example, [redacted] is equipped with machinery. The factory utilizes the best selected, fumigated, washed and graded varieties of the fruit from the farms located in different parts of the UAE. A team of experienced professionals and engineers supervise the functioning of the factory, including date processing under strict quality control standards and hygienic measures.

The factory has been producing a wide range of products, many of which are made as per the customer's requirements. Dates are packed in cardboard boxes, foam plates, plastic boxes, and tissue bags to accommodate different quantities from 250 grams to 25 kg. Other products include filled coated date sweets, vacuum dates, pressed dates, date paste, date syrup, date jam, mudabbas, ground pits, sparkling dates drink, fancy dates for gift packages, and dry date pulp.

The factory is marketing products that include vinegar, chocolate wafers, medical alcohol, liquid sugar, sparkling drink, pitted coffee, and animal feed. These products are available in the UAE market and they are very well received by the customers. Some studies were being conducted to change certain products in accordance with the public demand for finding ways to enhance the production and sales of the factory.

Eight different popular types of dates are used in the factory to make different products. These types include “Khalas”, “Lulu”, “Barhee”, “Rezaiz”, “Buma'an”, “Jabri”, “Fardh”, and “Khuneiz”. The quality control and hygiene are the core of the factory management philosophy, therefore the quality of product and process are frequently checked at all stages of processing by highly qualified quality control personnel, production is fully outstand also by controlling the quality and the standards of dates as the major input as well as the ingredients used, in addition to packaging materials, health and physical fitness of the personnel and systemized technology to maintain, the uniformity and sustainability of the end products to achieve the full satisfaction of the consumer, traders and industrial companies.

In order to produce and maintain high quality products, factory has HACCP System certificate by DET NORSKE CERATAS (DNV) and 1S0 9001 (2002) by Lloyd’s Register Quality Assurance.

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