A SURVEY OF MECHANIZATION EFFORTS ON DATE PALM CROWN OPERATIONS

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ABSTRACT

Many of the farm operations involving the date palm involve manual work at the crown of the tree, i.e., from 4 to 15 m above ground level. These operations take place at various times during the growing season. Thus de-thorning of the bases of leaves is carried out annually to facilitate the moving about of a person during subsequent operations. Pollination needs to be carried out in the spring, whereby the pollen is brought into the proximity of the flowers. Thinning is the selective removal of fruit from the tree with the objective to obtain a uniform crop comprising large, properly grown dates. Pruning involves the selective removal of some fruit strands for the same reason. Bagging or covering is the operation of partially sealing of maturing date bunches, to protect the crop from rain, insects, birds, and other pests. Harvesting involves the operation of picking of dates at various times, as they ripen.

The present study commences with an introduction to the date palm and its fruit. The crown-related operations are then reviewed. The past and present mechanization efforts on date palm crown operations are surveyed, and conclusions are drawn.

Keywords: *crown, date, date palm, de-thorning, harvesting, mechanization, pollination, thinning.*

الملخص

كثير من أعمال العناية بالنخيل تحتوي على أعمال يدوية عند تاج النخلة على ارتفاع يتراوح ما بين ٤ إلـى ١٥ متـراً فوق سطح الأرض. هذه الأعمال يتم تنفيذها خلال أوقات مختلفة أثناء الموسم الزراعي. وهكذا يتم قطع قواعد الجريـد سنويا لتسهيل حركة العامل في العمليات اللاحقة. تتم عملية التلقيح في الربيع حيث يتم إحضار اللقاح إلى الأزهـار. التخصير هي عملية إزالة بعض الثمار للحصول على محصول منتظم وكبير. والشئ ذاته يتم بإزالة بعـض الخصـل. تغطية الثمار الناضجة يتم من أجل حمايتها من المطر والطيور والحشرات. جني المحصول يتم بقطف البلح المسـتوي على عدة مراحل حسب استوائه.

تبدأ هذه الدراسة بمقدمة عن لنخيل ومنتجاته. ثم العمليات المتعلقة بتاج النخلة التي تم مراجعتها. ثم الآليات السـابقة والحالية المتعلقة بعمليات تاج النخلة التي تم مسحها. ثم تختم الورقة بالخلاصة.

1. INTRODUCTION

In the *Holy Qur'an* and the *Hadith*, many passages make mention of the importance of the date palm. In the Qur'an, it is referred to 29 times, and it is called *a blessed tree.* When the Prophet (p.b.u.h) built his mosque in Madinah, the pillars were constructed from the trunks of palm trees and the roof was woven from palm fronds [Anon-1, 2002]. In surah 19, verses 23-25 of the *Holy Qur'an*, during the birth of Jesus, Mary is guided to the palm tree to eat the dates to lessen the pains of childbirth: *But (a voice) cried to her from beneath the (palm-tree): Grieve not! for thy Lord hath provided a rivulet beneath thee; and shake towards thyself the trunk of the palm-tree: it will let fall fresh ripe dates upon thee.*

With the encouragement and assistance of the Saudi government since 1980s, the Kingdom has become a major producer of dates, supplying 17.6 percent of the world market [Morton, 1987]. After wheat, dates are the second biggest sector of the nation's agricultural economy, with an annual production in 1994 of 568,000 tons.

Table 1 [Barreveld, 1993] lists the production of dates by five major producing countries. From these figures it can be concluded that date production worldwide has been steadily increasing over the last 30 years and in 1990 reached 3,400,000 tons, 85% more than in 1960. Over 75% of this tonnage is produced in six major date producing countries, 90% of total world production comes from 10 countries out of a total of 32 date producing countries.

Table 1 Variation of date production with time (thousand tons) [Barreveld, 1993].

	Average 1961-65	Average 1971-75	Average 1981-85	1990
Egypt	407	386	457	580
Iran	305	293	385	540
Saudi Arabia	170	280	417	525
Iraq	336	400	346	490
Pakistan	96	177	234	290
Algeria	122	159	193	212
World	1839	2208	2645	3411

Date palms flourish where other fruit production would be marginal at best [Barreveld, 1993]. The date palm grows about 30 cm a year [Morton, 1987; Anon-2, 2002], and it may reach an age of over 100 years and reach a height of 35 m [Morton, 1987]. Normally the useful age limit is less and consequently the height will not be more than 15-20 m before it will be cut down because of declining yield and increasing difficulty (and danger) to reach the crown

during pollination, bunch management and harvesting. A schematic picture of the date palm during a one-year productive cycle is given in Fig. 1. Growth of the offshoot (or sucker) that is attached to the mother palm may take 5 to 8 years. Growth of the offshoot after separation from the mother palm, and transplanting may take another 4-6 years. Thus the start and increasing of fruit yields and formation of offshoots occurs at the age of 14 to 20 years. Full productivity in terms of fruit yields is obtained at the age of 30 to 35 years, after which offshoot formation ends, and the period of declining fruit yields onsets.

The trunk is clothed from the ground up with upward-pointing, overlapping, persistent, woody leaf bases. The feather-like leaves, up to 6 m long, are composed of a spiny petiole, a stout midrib, and slender, gray-green or bluish-green pinnae 20 to 40 cm long, and folded in half lengthwise. Each leaf emerges from a sheath that splits into a network of fibers remaining at the leaf base. Small fragrant flowers (the female whitish, the male waxy and cream colored), are borne on 25 to 150 strands 30 to 75 cm long on female plants, and only 15 to 22 cm long on male plants. One large bunch of flowers may embrace 6,000 to 10,000 flowers [Morton, 1987].

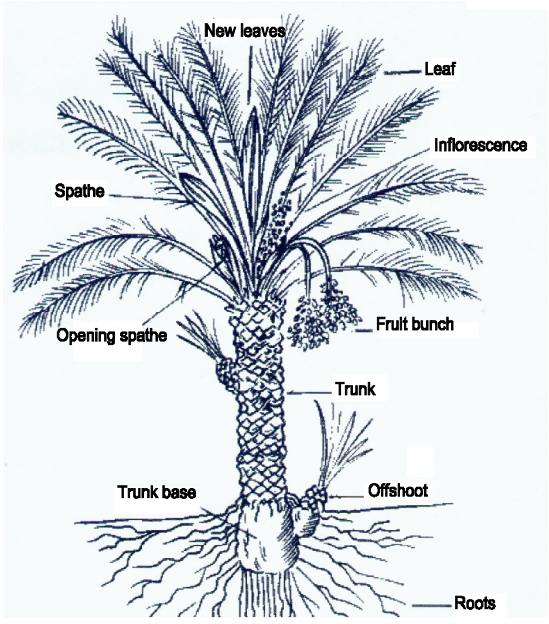

Fig. 1 The annual cycle of the date palm (Barreveld, 1993).

Commercial fruit production is possible only where there is a long, hot growing season with daily maximum temperatures of 32°C and virtually no rain—less than 1.25 cm in the ripening season [Anon-3, 2002]. Date palm will flower only when the shade temperature rises over 18ºC; will fruit at temperatures above 25ºC and vegetative growth will stop under 10ºC [Barreveld, 1993].

The date palm has a high water requirement. An indicative figure is that about 2 m^3 water is used per kg of fruit in the best of circumstances [Barreveld, 1993]. The average water use by date palms in California is reported to be between 200 and 250 m3/year per tree [Lutrick, 2002; Nixon and Carpenter, 1978]. In Saudi Arabia, water use with open channels has been found to vary between 27000 m^3 to 38000 m^3 per ha / year [Abdurrahman and Al-Nabulsi, 1996]. The date is extremely drought resistant and can survive several years of intense heat with no water or rain whatsoever once firmly established, although it is unlikely to fruit well and may appear stressed [Anon-4, 2002]. Interestingly, dates withstand waterlogged conditions better than most plants and grow well with their roots actually submerged in running water or in soils with a high even saline water table.

The optimum planting density is considered to be 50 trees per acre (120/ha) [Anon-4, 2002], and this is about the standard in the Coachella Valley of California [Anon-3, 2002]. This corresponds to a spacing of 9.1m x 9.1m. The spacing of trees on conventional farms is around 6m x 6m [Anon-5, 2002]. A comprehensive survey conducted in Saudi Arabia [Al-Suhaibani et al., 1988] indicated that the average distance between neighboring trees is less than 4m, this average varying from 2.7m to 4.8m between farms. The averages of tree heights ranged from 4.4m to 10m, with an overall average of about 8m. The trunk diameters varied from 0.3m to 0.8m. Radial distances of centers of date bunches from the crown center were found to lie between 0.7m and 1.5m, with an average of 1.2m. Most irrigation ditches were 20 to 30cm deep and 50cm wide. Almost without exception, irrigation ditches were parallel to the rows of palms.

Date palm trees provide enough space for intercropping even if they are fully grown as they do not cover much area being a very tall tree. It is possible to grow a mixed fruit orchard, such as date intercropped with citrus [Anon-6, 2002]. Field crops, such as fodders and vegetables may also be grown together with date palms [Anon-5, 2002; Anon-7, 2002]. In mechanized plantations, intercropping is not possible inasmuch as space must be left for the mobile equipment [Morton, 1987].

Dates distinguish themselves from most other fruit in that they have at least 3 distinct commercial maturation levels; the sweet *khalaal*, the *rutab*, and the *tamr* stage. As not all female flowers are produced at the same time, the stage of maturity of the dates is also staggered for the different bunches. Even on one particular bunch, ripening will usually start from the lower end of the hanging bunch going upward [Barreveld, 1993].

The fruit is green at the initial *kimri* stage, when moisture is content up to 85%. At the *khalaal* stage weight gain is slow but sucrose content increases, and moisture content goes down to about 55%. The tips of the fruit start turning brown in the *rutab* stage, which is characterized by a decrease in weight due to moisture loss, a partial inversion of sucrose into invert sugar and softening of the tissues. The moisture content goes down to about 35% and the dates at this stage are sold as fresh fruit. Only when the dates are left to ripen further on the palm will they turn into *tamr*, climatic conditions permitting, characterized by a moisture content at

which the date is self-preserving. The upper limit for the date to be self-preserving lies at around 24-25% [Barreveld, 1993].

It is difficult to give an average figure for the size of the annual crop per palm because it depends on the stage at which the fruit is harvested, for instance fresh hard dates (*khalaal*, at about 50% moisture) yield much more in fruit weight than a dry desert date (*tamr* at 15% moisture). Ordinarily, in palms 5 to 8 years old, the first crop will be 8-10 kg per palm, reaching at 13 years a crop of 60-135 kg [Anon-8, 2002; Anon-4, 2002]. Some improved cultivars may yield 11-17 tons/ha [Barreveld, 1993].

2. CROWN OPERATIONS

There are a number of operations that must be performed during various times of the year at the crown of the palm tree. It is maintained [Anon-8, 2002] that each palm must be climbed about 18 times a year, to carry out many hand operations. These are may be described briefly as follows:

Fig. 2 Thorns on new fronds (Anon-9, 2002).

De-thorning: Each palm frond is lined on two sides with needle-sharp thorns that range from two to six inches in length [Anon-9, 2002] (Fig. 2). When these thorns are new and green in color, they easily puncture clothing, boots, and skin. By January, many of the thorns are dry and brittle. As they dry, they puncture tractor tires and steel-belted tires. The thorns can be very hazardous to those working and caring for the palms. It is therefore necessary to remove thorns the with a special curved knife [Morton, 1987] from the new growth of fronds (Fig. 2)

Pollination: Date palms are dioecious, that is, the yellowish male flowers that produce the pollen and the female flowers that produce the fruit are born in separate palms. For commercial fruit production, the female flowers must be pollinated (Fig. 3) by hand and /or special machinery two to four times each season [Shabana and Mohammed, 1983; Brown, 1983]. Date palms rarely wind pollinate, and un-pollinated dates do not develop viable seeds or good sugar [Morton, 1987; Anon-4, 2002].

Fig. 3 Stages of pollination (left to right) Remove male pollen from palm, Collect pollen powder, and Apply pollen to female flowers (Anon-9, 2002).

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Thinning the bunches and strands of fruit (Fig. 4): The aim of thinning is to avoid overbearing of the palm with a consequent poor yield the next year. Without thinning, fruits would be borne only every other year [Morton, 1987; Barreveld, 1993; Olin, 2002]. The result of fruit thinning is less overall yield but bigger sized fruit [Barreveld, 1993]. Thinning also prevents delayed ripening of dates [Anon-4, 2002]. Pruning is akin to thinning, and involves the selective removal of some strands in order to promote uniformly spaced bunches [Ali, Akyurt and Abu-Mansour, 1993].

Fig. 4 Thinning when the fruit is the size of a pea (Anon-9, 2002).

In general, removal of 40 % to 60% of the berries from the cluster will nearly double the weight of the remaining fruit at harvest [Olin, 2002]. Normally 50 to 80% of the fruit is removed during thinning [Morton, 1987; Anon-2, 2002; Anon-9, 2002; Anon-4, 2002]. The process is labor-intensive, where each field worker can thin only 1-1/2 trees per day [Anon-2, 2002].

Covering: Rain and high humidity may cause physical damage to the fruit in the period preceding ripening. When this happens, cracks appear on the fruit surface through which fungi and bacteria may enter. Fermentation or souring of the fruit rapidly follows [Olin, 2002]. Fruit clusters can be protected by placing heavy waxed ripple kraft bags around clusters, and tying them tightly to the fruiting arms just before the fruit begins to ripen. (Fig. 5)

Fig. 5 Covered deglet noor dates in California (Barreveld, 1993).

Harvesting is the selective removal of fruit from the date palm. As not all female flowers are produced at the same time, the stage of maturity of the dates is also staggered for the different bunches. This is true for dates on one particular bunch as well as for different bunches of the same palm. Ripening will usually start from the lower end of the hanging bunch, and it will go upward. This means that the grower will be required to climb his palms more than once for harvesting. The time lapse between the first date to reach maturity and the last one on one palm may be from 3 to 4 weeks for early maturing varieties, and 2 to 3 months for the later ones [Barreveld, 1993].

The date cultivator will each year remove the old leaves in order to give him better access to the crown. The leaf base will remain attached to the trunk and where palms are still climbed, are used as steps for the climber's feet [Barreveld, 1993; Anon-8, 2002].

3. CURRENT PRACTICES IN CROWN OPERATIONS

Traditionally date trees are climbed several times a year to carry out the various cultural operations. There are several techniques to climb a palm with the help of a rope; from a safe tucked-in position in a belt (Fig. 6a), as in Fig. 6b [Anon-7, 2002], to the more daring and quicker technique of using the rope only as a hand support, and throwing it intermittently about one meter upwards whilst stepping up the palm [Barreveld, 1993]. The climber is usually barefoot (Fig. 6b), and he uses a rope that is connected to a wide harness (Fig. 6a).

Fig. 6a The belt and rope of a date palm climber

Fig. 6b Climber using a belt and a rope (Anon-7, 2002).

Fig. 7 Climber using a permanent ladder (Anon-2, 2002).

On some date farms in the US, growers pick each tree from two to five times in order to harvest only those dates which are ready [Anon-2, 2002]. During this process each worker can harvest 8 trees per day. Since the trees are about 16 to 18m tall, to climb each tree, they still use a 14m ladder to get from the ground to the bottom of a 6m ladder that is permanently tied to the top of the tree (Fig. 7). They move the longer ladders from tree to tree [Anon-4, 2002; Gibson, 2002].

Top

In North Africa, harvesters climb the palms, and use forked sticks or ropes to lower the fruit clusters, or they may pass the clusters carefully down from hand to hand [Morton, 1987]. Elsewhere [Anon-2, 2002] hooks on ropes are used to lower the cut bunches. Metal-ringed cloth chutes are used in Iran [Anon-6, 2002] to gently harvest fresh dates. The top of each chute engulfs one bunch of dates, and once the stem of the bunch is shaken, ripe dates slide down the chute and into plastic baskets on a trailer underneath.

A major change that has taken place in U.S. date cultivation, under the impact of increasing labor costs and ever-increasing height of the palms, has been the mechanization of cultural practices, and in particular the timing and method of harvesting [Barreveld, 1993]. During the 1940's and 1950's a few growers in the US built large tractor–pulled harvesting towers which eliminated the need for ladders. The towers, however, were expensive. Starting with 1960, the use of truck-mounted hydraulic crane-like man-positioning machines was tried, to move workers from palm to palm. Neither attempt provided a significant increase in worker productivity [Brown, 1983; Brown, Sarig and Perkins, 1984; Brown and Perkins, 1964]. Despite these observations, scarcity of labor was such that by 1966, 80% of the date crop in the US was being harvested mechanically by the use of these devices [Brown,1983; Brown, Sarig and Perkins, 1984]. The harvesting system was owned by grower cooperatives. Each grower paid a fee for having a crew, hired and trained by the cooperative, harvest his fruit.

Fig. 7a Hard desert dates, harvested on the bunch, and thrown to the ground (Barreveld, 1993).

Today, in many instances, the dates are left longer on the palm, and are often harvested all in one go. One major grower [Anon-3, 2002] reports that since 1990, the majority of growers in the US have been using metal platforms attached to 9-ton forklifts for pruning, pollinating and harvesting operations. When attached to a forklift, the platforms can lift up to eight workers high enough to do their work at the crowns of palms.

Fig. 8 Harvesting by platform lifted by forklift (Anon-9, 2002).

It is claimed that platforms are not only more efficient than ladders, but also much safer for workers. (Fig. 8) A crew of three machines will harvest up to 15,000 pounds a day. As

each branch is harvested, workers open the bags covering the dates over shallow, metal-ringed harvesting baskets.

These baskets, which capture any loose dates that might be lost when the bags are opened, are lined with canvas. As their baskets fill up, pickers lower them to workers on the ground, who empty them into shallow boxes.

4. RESEARCH AND DEVELOPMENT EFFORTS

The Date Grower's Institute in the US published annual reports containing technical research results and articles of general interest for the date industry [Barreveld,1993] from 1924 until 1979, when the 54th and last issue was published. During this time the industry was transformed from small, private plantations to large holdings. With the gradual change of ownership of the date plantations in the US, and concentration of date products use in large multi-food companies, development work nowadays is largely done under cover of proprietary rights and does not come out in the open as it used to. This phenomenon is also confirmed by an increasing number of patent applications in this field [Barreveld, 1993].

The latest major manifestations on all aspects of the date palm were organized in three symposia by the National Date Palm Research Center of King Faisal University, Al-Hassa, Saudi Arabia [Anon-1, 2002]. The results and full text of the papers of the symposia, held in 1982, 1986 and 1993, were published.

Research findings have affected the pollination process. Thus pollen can be collected from the males, and in combination with a carrier (such as flour), can be dusted on the female flowers with a mechanical device [Barreveld, 1993]. The pollen may be dusted on by a tractor-drawn, convertible pollen/pesticide machine, or applied with a cotton pad, or sprayed on with a long tubular applicator or other device [Morton, 1987]. As another major development, scientists have devised a method for growing trees from tiny pieces of the heart of the palm which are cultured in the laboratory [Anon-1, 2002].

Owing to the substantial scope for possible mechanization of date farming in the Kingdom, a large variety of field machinery was imported during the past twenty years. So great was the interest in this regard, that companies in some developed countries with little or no tradition of manufacturing such machinery started providing prototypes, with the object of securing a slice of this lucrative market [Al-Suhaibani et al., 1991]. A number of these machines were tested at KFU [Sial, 1984], originating in USA, Australia, France, Italy and Germany. Still others were tested in Iraq [Shabana and Mohamad, 1983]. Some machines were modified [Hassan et al., 1989]. It was clear that no single machine was satisfactory. All machines had insufficient elevation. Most suffered from traction problems. Many had difficulty in traversing irrigation channels. Some of the machines were not of a suitable width, and others were not maneuverable enough between the trees. All were very expensive.

[Sial ,1981] reported on work on a light-weight vertically-telescoping hijack that can be mounted on, and powered by a small tractor, to elevate a worker up to the crown. A hydraulically-driven date palm service machine, with a wheel base of 3.5m and underneath clearance of 0.5m, was built in UK for KSU [Al-Suhaibani et al., 1988]. This machine was equipped with a telescopic boom and an operator basket that can reach the crown of trees 10m in height. The self-propelled KSU machine did not have wheels large enough to be navigable on soft and wet soil or on uneven and rough terrain, including irrigation ditches [Al-Suhaibani et al., 1991]. Investigators [Hassan et al., 1989] in Al-Hassa developed a special date palm basket (Fig. 9a) for a commercial aerial platform.

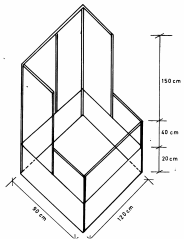

Fig. 9a The Al-Hassa basket [Hassan et al., 1989]

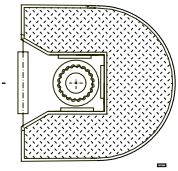

Figure 9 The service platform (Ali, Akyurt and Abu-Mansour, 1993).

Ali et al. [Ali, Akyurt and Abu-Mansour, 1993; Ali, 1994; Ali and Akyurt, 1998] proposed a set of design criteria for equipment for the servicing of date palms in the region. These involved factors like navigability, affordability, reliability, safety and overall performance. The authors presented the design of a generic service platform (Fig. 9) to serve as a safe working area during operations at the crown of palm trees. The platform features anti-slip decking and continuous railing that is one meter high. A docking bay is provided with a tapered opening for facilitating the docking of the platform to the trunk of the tree.

The platform is further equipped with rollers around the docking bay for minimizing friction and damage during the raising and lowering operations. The service platform is to be of light-metal construction, and is designed to allow the servicing of virtually all parts of the crown. A safety chain with a roller (Fig. 9) is furnished for preventing accidental separation of the tree trunk from the platform. A rope ladder will be available on the platform for emergencies. The operator will be required to wear a safety harness. During crown operations, the platform would be anchored to the palm by the use of a force-intensifying gripper [Ali, 1994; Ali and Akyurt, 1998].

Figure 10 depicts one of several designs that were proposed in this regard, where a multi-stage hydraulically operated boom system is mounted on a purpose-built three-wheeled trailer (Fig. 11). The boom assembly is erected by means of a single stage hydraulic cylinder. The low-pressure tires are large enough in diameter to result in a contact pressure of 300 to 1000 kN/m^2 for trouble-free operation on soft and wet soil. The rear axle of the trailer is provided with a wide U-opening to allow for the positioning of the trailer such that the tree trunk is located inside the docking bay of the platform. The road-width of the trailer is 2.5m. It is provided with front and rear outriggers to enhance stability during palm servicing.

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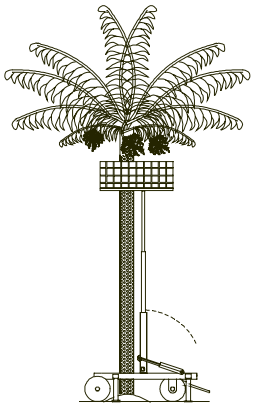

Fig. 10 A hydraulically operated palm service machine (Ali, Akyurt and Abu-Mansour, 1993; Ali, 1994; Ali and Akyurt, 1998).

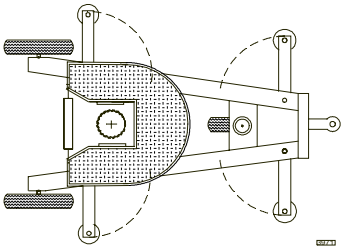

Fig. 11. The trailer for palm service machines (Ali, Akyurt and Abu-Mansour, 1993; Ali, 1994; Ali and Akyurt, 1998).

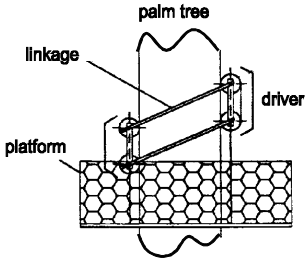

Fıg. 12 The palm-climbing machine of Bankhar (Bankhar, 1994).

A novel concept was studied by Bankhar [Bankhar and Akyurt, 1995; Bankhar, 1994] for undertaking crown-related operations on palm trees. Shown schematically in Fig. 12, the machine consists essentially of an internal combustion engine, rollers and connecting links as the driver, and a one-man platform in which the operator rides up and down the tree.

When mechanical means are used for pollination, the best method of pollination is to dust pollen over the female flowers repeatedly [Anon-4, 2002]. The process of mechanical pollination has to be repeated a number of times over a period of several weeks because not all palm fronds grow at the same rate [Anon-2, 2002]. There are pollen applicators available now that can spray the mixed powder of pollen and flour at a height of 10 meters [Anon-10, 2002].

5. DISCUSSION AND CONCLUSIONS

The most common way of climbing date trees for a bare-footed person is to climb the palm by the use of a *rope and a belt*. The harvested fruit is handed down by rope or by forked sticks, or fruit bunches are simply thrown on the ground. The idea of using metal-ringed cloth chutes to convey the harvested fruit down needs to be time-tested for practicality. It is clear that climbing palm trees by the *rope and belt* method is not safe, and it is not efficient from the point of view of worker productivity. Date growers almost always stop watering those palms that reach a height which is considered unsafe for climbing.

Climbing date palms by the use of narrow *ladders* is generally considered to be easier than the *rope and belt* method. Some growers still use tall ladders, even in California. It must be pointed out however, that climbing by ladders requires considerable effort and skill, and it is not altogether safe. People still fall and get hurt.

The alternative to physically climbing the tree, whether it is by *rope and belt* or by *ladder*, has been to mechanically lift one or more workers to the vicinity of the crown. This option has been tried in the form of tractor-pulled harvesting towers, truck-mounted hydraulic man-positioning machines, and more recently, forklift-manipulated tall platforms. Admittedly the first two solutions were found to be expensive, for both the US and the Saudi growers. More significantly, these machines would not be able to service the majority of existing farms in the Kingdom due to the un-even and close spacing of the trees.

The newer trend of utilizing forklift-manipulated tall platforms seems to offer a more economical and realistic approach to the issue of mechanization, both in the US and in the Kingdom. Being less than 2m wide, it would be expected that the commercially available, farm-type articulated forklifts with large low-pressure tires, can effectively navigate within most farms in the Kingdom. Furthermore, the latter system has been recognized to be safe for the workers, and to promote worker efficiency.

It may be noted that independent studies conducted at KAU has led to the development of equipment that parallels the developments in the US, being perhaps more advanced in concept. These designs have emerged with particularly the date palm in mind, although none of these have been field tested. These include the design of a generic service platform to serve as a safe working area during operations at the crown of palm trees. The platform features anti-slip decking and continuous railing. A docking bay is provided with a tapered opening for facilitating the docking of the platform to the trunk of the tree. The platform is further equipped with rollers around the docking bay for minimizing friction and damage during the raising and lowering operations. The service platform is to be of light-metal construction, and is designed to allow the servicing of virtually all parts of the crown. A safety chain with a roller is furnished for preventing accidental separation of the tree trunk from the platform. A rope ladder will be available on the platform for emergencies. The

operator(s) will be required to wear safety harness(es). Available literature suggests that none of these advanced features have been incorporated on the platforms in use in the US.

The KAU designs further include a purpose-built three-wheeled trailer for transporting and docking of the platform. The low-pressure tires of the trailer are large enough in diameter to result in a contact pressure that is low enough for trouble-free operation on soft and wet soil. The rear axle of the trailer is provided with a wide U-opening to allow for the positioning of the trailer such that the tree trunk is located inside the docking bay of the platform. The trailer is provided with front and rear outriggers to enhance stability during palm servicing.

In retrospect, current trends in the mechanization of crown operations bring the design of the tall platform back into focus. One basic requirement is that the platform must necessarily be light. Furthermore it must be safe, featuring locking gates, full-perimeter hand rails and toe boards to prevent accidental falling of tools. The platform must be positively secured to the forklift. Yet another essential feature is that the platform must provide means for the lowering of cut fruit to the ground.

It may be concluded hence that, perhaps time is rife to review the designs of the KAU platform and its trailer, and to combine the lifting ability of the forklift with the built-in features of the platform and its trailer with outriggers. Conceivably the trailer can be used to transport the platform off-road or on the highway. During the deployment of the platform around a palm tree, and during the undertaking of crown operations, the forklift can benefit from the non-tipping features of the trailer by hooking itself to the trailer. Thus the trio of platform, trailer and forklift can perhaps provide a flexible and practical approach to date mechanization.

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