REPORT OF

Twenty-first Annual

Date Growers' Institute

APRIL 22, 1944

HELD IN

COACHELLA VALLEY

CALIFORNIA

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Published by

The Date Institute

Indio, California

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A cooperative, non-profit Date Growers' Educational Institute held annually since 1924.

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Annual dues $1.00, entitling each member to all privileges of the Institute, including a printed copy of the annual proceedings.

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THE DATE INSTITUTE
Indio, California

Twenty-first Annual Date Growers' Institute

Saturday, April 22, 1944

Chairman: H. B. Richardson, Assistant County Agent, U. S. D. A., Riverside County

THE USE OF IRRIGATION WATER

By J. B. Brown, Extension Specialist in Irrigation, University of California, Berkeley, California

It is a matter of common knowledge that water behaves differently in different soil types. Sandy soils dry out more rapidly than heavier types of soil and must be irrigated frequently. In the heavier types of soil water lasts a longer time and the interval between irrigations may be considerably longer than for sandy soils under the same conditions of climate, crop and depth of wetting.

There is an upper limit to the amount of water which can be retained in a free draining soil. This upper limit for a given soil is a fixed amount depending upon the texture, or fineness of soil particles and to some extent on the structure or aggregation of soil particles. The upper limit of contained soil moisture is known as "field capacity," and it is expressed as a percentage of the dry weight of the given soil. For instance, if 100 pounds of soil wet to field capacity weighs only 80 pounds when thoroughly dried out, then 20 pounds of water will have been driven off in the drying process. This would indicate a field capacity of 25% obtained by dividing 20 by 80.

There is a limit below which soil moisture cannot be reduced by the roots of growing plants. This lower limit is known as the "permanent wilting percentage." This moisture condition is defined as "that percentage of moisture, determined as above on the basis of dry weight of soil, at which plants wilt." A long series of investigations, with 40 or more plants, indicates that the permanent wilting percentage is a function of soil texture and that any plant growing in a particular soil will wilt when the moisture content is reduced to the permanent wilting percentage.

The speaker then showed, by using simple demonstrational material, the relative water-holding capacities of various materials. For demonstration purposes small stones were used to represent sandy soils, gravel for loam soils and sand for clay soils. Using three flower pots containing respectively rocks, gravel and sand and pouring through each pot a pint of water, (the hole in the bottom of the pot being open) it was visually demonstrated that the sand representing clay soils retained more water than the gravel, and the gravel in turn retained more water than the small rocks. Tables of relative water-holding capacities of sand loam and clay soils were shown on the blackboard.

The amount of water yield from a given soil is represented by the cubic capacity of the soil multiplied by a factor of water yield per cubic foot. This factor is the difference between percentage of soil moisture at field capacity and percentage of soil moisture at permanent wilting percentage.

The soil is a reservoir in which water is stored for plant use between irrigations. Like any reservoir, it has length, breadth and depth. Length and breadth represent the dimensions of a tract or on a similar scale the spacing of trees. Depth is represented by the depth of the majority of the feeding roots of the tree or other crop grown. These factors multiplied by the water yield per cubic foot of soil give the volume of water used between irrigations; if the moisture content is reduced from field capacity to permanent wilting percentage. This amount of water, plus some additional to care for evaporation in the surface mulch and to take care of other unavoidable irrigation losses, is the amount that must be added at each irrigation.

A convenient rule of thumb for the wetting of various soils is useful in determining amounts of water to apply, as follows:

One inch in depth of irrigation water will wet

Clay soils	4" - 5"	in depth
Loam soils	6" - 10"	in depth
Sandy soils	12" +	

Applications at the above rates would raise the moisture content from permanent wilting percentage to field capacity.

In many date gardens the moisture content is rarely reduced to the parmanent wilting percentage.

Investigations of the average rate of extraction from various depths are reported by Pillsbury in "Report of Fifteenth Annual Date Growers Institute, 1938" as follows:

Depth below 5" surface mulch	0' - 2'	2' - 4'	4' - 6'	6' - 8'
Per cent of total use	50%	30%	15%	5%

These percentages of total water used in a given period are the relative extraction from each zone.

The total water requirement for dates in Coachella Valley, including allowance for unavoidable losses, is given by Pillsbury as follows: (Rpt. 15th Annual Date Growers Institute. 1938)

Month	Inches Depth
January	4.7
February	5.6
March	7.7
April	12.6
May	11.4
June	13.5
July	12.6
August	13.1
September	9.4
October	7.4
November	4.9
December	3.8
Year	106.7

In the planning of seasonal irrigation the critical months are April through August. The capacity of the irrigation system must be sufficient to supply water to a depth of nearly 15 inches during each month and over the entire area of the orchard. Due to small pumping capacities of some wells in this area, it is difficult to apply this much water even though the pumping plants are operated 24 hours per day, 30 days per month.

A simple calculation will give the depth of water in a given time to a given area at a given rate of flow, or conversely the number of hours necessary to apply a given depth on the area.

Assume:
Flow - 45 miner's inches
Area - 20 acres
Time - 15-24 hr. days or 360 hours

$$\frac{\text{No. miner's inches x hours}}{\text{50 x No. acres}} = \text{inches depth}$$

In the above problem

$$\frac{45\text{x}360}{50\text{x}20} = 16.2 \text{ inches depth applied}$$

The converse problem—How many hours in one month must a plant be operated to apply two 7" irrigations on 30 acres with a pump discharging 60 miner's inches.

$$\frac{60\text{xH}}{50\text{x}30} = 14$$

60H - 30x50x14
H - 350 Hours

These two irrigations would involve operating the pump in two periods of about 175 hours each.

Methods of Irrigation

With many of the smaller capacity plants irrigation must be by the furrow methods. Fairly uniform distribution may be obtained by this method by the following practices:

1. Locate furrows close enough together so that the wet areas meet. (sandy soils not over 3 feet apart).
2. Run water in furrows long enough to get desired penetration.
3. Use of short furrows to prevent over wetting at the upper ends. (In lighter types of soil furrows should be 300 ft. or less in length).

Many of the pipe installations in various date gardens are installed to handle present low flows. The capacities of these farm irrigation systems may not be sufficient to handle the larger delivery heads contemplated under the Bureau of Reclamation project. If it is desirable to use larger heads of water, thereby decreasing the time of irrigation, many farm systems will require larger pipe.

Other methods of irrigation are:

Flooding in single tree basins, flooding in contour basins and strip irrigation down the row. These methods require larger irrigation heads than the furrow method. Flooding in single tree basins requires considerable shovel work in controlling water, but does give great uniformity of application.

Nearly as effective from the standpoint of uniformity is the method of flooding in contour basins. These basins are enclosed by level, irregular ridges which may enclose several trees. The ridges are located by an engineer's level and the enclosed basins are successively 0.2 feet lower than the next above. There will be five basins to each foot of fall across a given area. Irrigation water is started in the highest basin. All basins are filled individually from a field ditch. The water is not run from basin to basin. Ridges are constructed by machinery and much less shoveling is required by this method than by the single tree basin method.

Flooding in strips is similar to alfalfa irrigation. The area in each strip should be in accordance with the delivery head and soil type—strips not too long.

The proposed delivery head under the Bureau of Reclamation project is 150 miner's inches to 40 acres. Should the whole of this head be used on a forty acre tract, it would require 187 hours to apply 2-7 inch application in any one month.

$$\frac{150\text{xH}}{50\text{x}40} = 14$$

In other words in each month there would be two irrigation periods of about 94 hours each. Water deliveries will probably be on a 24-hour basis, because of the remoteness of control points on a large canal system. This will necessitate night irrigation. Hence, in the above assumed case the owner would have a 150 miner's inch flow for 4 days or 96 hours twice each month, which would result in slightly more than 14" in depth for the two periods.

The following references may be helpful in planning changes of irrigation systems. California Agricultural Extension Service—

1. Circular 50—Essential of Irrigation and Cultivation of Orchards.
2. Circular 73 — The Contour Check Method of Orchard Irrigaiton.
3. Leaflet—The Irrigation of Alfalfa, Border or Strip Check Method.

These publications may be obtained from the Riverside County Farm Advisor.

THE FUMIGATION OF DATES

By Jack Walker and D. H. Mitchell
California Date Growers' Association

The purpose of this paper is to review data on fumigation as available from various publications and reports, and to summarize fumigation practices, and types of fumigator construction employed in the handling of dates.

Mr. Dwight F. Barnes of the Bureau of Entomology, United States Department of Agriculture, presented a paper concerning dried fruit fumigation during the Date Growers' Institute of 1935. The principles and proceedures described therein continue to serve as an accurate guide to successful fumigation. A list of other bulletins consulted in the preparation of this report is appended hereto.

The Objectives of Fumigation

The objectives of fumigation are to reduce losses of fruit chargeable to insect infestation during handling and packing, and to start the pack on its way to the consumer free from all stages of insect life.

It seems probable that a reduction of damage caused by moulds and incipient fermentation is a secondary benefit to be expected as a result of the elimination of insects. It has been demonstrated that insects are carriers of spores and yeasts that cause deterioration in ripening figs, but apparently this factor has not been investigated in the case of dates.

Controlling Infestations in the Packinghouse

Fumigation of all fruit as it enters the packinghouse arrests infestations that commonly occur in the gardens, and helps to prevent a high insect population within the house. The fact that the dried-fruit beetle —our most troublesome pest—can pass through a complete life cycle in fifteen days has been proved.

Eggs can hatch into larvae within twenty-four hours from the time they are deposited. These facts indicate the necessity for control measures within the house. Houses of moderate size and tight construction may periodically be given a complete fumigation at small cost and with very beneficial results. Complete plant fumigation is harder to achieve in the larger house, but here the separate rooms used for maturation, drying, or fruit storage at room temperature should be fumigated at frequent intervals. Cull dates should not be stored in rooms where good fruit is handled.

Final Fumigation of the Pack

It is virtually impossible to maintain a packinghouse entirely free of insects, so the opportunity for reinfestation of fruit is ever present. A thorough fumigation after the fruit has been packed for shipment is good insurance against deterioration while it is on its way to the consumer.

Atmospheric Fumigation Room Construction

To achieve effective and economical fumigation it is essential that the compartment or room be as nearly gas tight as possible. All fumigants are highly volatile, and should be regarded as continually seeking avenues of escape. Regardless of what stuctural materials are used, a definite barrier capable of preventing the passage of gas should be established, a gas-proof envelope, so to speak. This barrier should be located as near to the interior surfaces of walls, ceiling and floor as is practical, so that no considerable amount of porous material is exposed to the gas. Porous materials absorb gasses and thus reduce the effective concentration.

Sheet metal linings with soldered seams form an ideal barrier. Plywood or dense panel boards, with all joints bedded in a plastic material that will not crack away upon hardening, are good. A good barrier can be developed of strong building paper of the type composed of two or more sheets laminated together by heavy layers of asphalt. Ordinary asphalt saturated roofing felt is not impervious to the passage of gas, but smooth-surfaced ready roll roofing, which is saturated and also coated with asphalt, is good. When paper or roofing is used all joints should be carefully lapped and cemented, and the whole protected from mechanical injury by means of a covering of wall board or lumber. Masonry or concrete walls should receive a coat of dense plaster or be sealed with hot asphaltum or asphalt emulsion. Masonry is usually quite porous.

Wood floors should be of double thickness construction with the paper barrier located between layers and protected against decay by a mopping of hot asphaltum. Concrete floors may be treated with floor hardener to reduce their absorption of gas. Particular care should be exercised to secure a tight seal at the junction of walls with floor. Doors should be few in number. They should be equipped with carefully fitted gaskets and with a means for clamping them tight. The threshold is the most difficult point to seal and is quite important because most fumigating gases are heavier than air. A new type of door seal is said to utilize water pressure to expand it against door and jamb after the door has been closed.

During the early years of the industry vacuum fumigation was widely used, but with the advent of more effective fumigants, its popularity declined until at the present time atmospheric fumigation with its lower labor cost is used almost exclusively. Penetration of the volatile fumigants now used into almost any commercial pack is sufficient to assure a kill.

Fumigating Gases

Only a few fumigants have been widely used by the date industry. Carbon disulphide was almost the universal fumigant during the early years, and is still used to some extent. Hydrocyanic acid gas generated by the pot method was used to a lesser extent where conditions permitted. Ethylene oxide, and a mixture of ethylene oxide with carbon dioxide sold under the trade name of Carboxide, were widely used during a later period. Methylbromide, the latest addition to this list, is the fumigant most commonly used today.

Factors Affecting the Susceptibility of Insects to Fumigation

It has been frequently demonstrated that the susceptibility of insects to fumigants increases as the rate of respiration of the insects increases. Respiration is stimulated by an increase in temperature, especially at points below normal room temperature, by an increase in the carbon dioxide content of the air, and by a reduction of the oxygen content of the air.

Temperature, being the one stimulating factor that can easily be controlled, is most important and should receive constant attention. It has been frequently demonstrated that the efficiency of fumigation is low at temperatures below 60 degrees and shows a considerable increase above that point. Associated in importance with the temperature to be maintained during fumigation is the temperature at which the insects may have been held for a prolonged period prior to fumigation. If held at 50 degrees or below for several days, the susceptibility of insects will not increase as rapidly as a subsequent rise in temperature would predict. In other words, a considerable time lag occurs during which they remain hard to kill. It follows that fruit which has been cold for some time should be thoroughly warmed throughout well in advance of fumigation.

The addition of carbon dioxide to an atmospheric fumigator to increase the susceptibility of insects is not justifiable in this locality from the standpoint of overall economy alone. The ethylene oxide-carbon dioxide mixture which was widely used a few years ago contained sufficient carbon dioxide theoretically to blanket the ethylene oxide content against explosive hazard, and it was this safety factor that justified the carbon dioxide content. However, it is interesting to note that the amount of ethylene oxide required under specific conditions was greater when used alone than when it was a component of this mixture.

Oxygen deficiency in the atmosphere of a fumigator is of interest only where vacuum fumigation is employed. The stimulation of respiration is here accomplished at no increase in cost, merely by holding the vacuum throughout the fumigation period. The short exposure periods possible in vacuum fumigation are largely due to this factor.

When an inflammable fumigant is used in vacuum fumigation it is customary to reduce the vacuum after the fumigant has been admitted with an innert gas, such as nitrogen or carbon dioxide. This prevents the leakage of air into the chamber and thus reduces the explosive hazard. Carbon dioxide was used for this purpose by the California Date Growers Association at one time, but it was found that the presence of high concentrations of this gas during prolonged exposures resulted in the splitting of many dates when the fumigator was. subsequently exhausted.

Several investigators have determined that susceptibility of insects of a given species varies with the stage of development, usually being highest in adults and successively lower in pupae and larvae. Data on the susceptibility of the egg stage is not listed as frequently, but at least one reliable source states that eggs of the common insects attacking dried fruits are usually no harder to kill than larvae of the same species. The available data on susceptibility of the various stages indicates that larvae, rather than adults, should be used in routine checking of fumigator performance.

Procedure

For fumigation to be effective and efficient it is necessary to expose the insects, while in a susceptible state, to a lethal concentration of gas and maintain that concentration for a suitable period of time. Temperature, dosage rate, and time of exposure are interdependent one on another, and all three factors should be considered whenever one must necessarily vary toward an extreme. Best results will be secured by standardizing these conditions for the particular room so that a regular routine may be followed.

Rooms should have adequate provisions for heating in cold weather and the product should be warmed, at least to the pre-determined minimum, before the gas is admitted. A heater combined with a circulating fan will effect a uniform temperature throughout the room. If the fumigant is non-inflammable, this fan may also be used to secure rapid mixing of the gas with the room air.

The rates of dosage for various fumigants will not be listed here, as this information is widely available in publications and from the various gas manufacturers. An increase in rate of dosage may be employed to compensate for low temperature or short exposure within reasonable limits, but may result only in wasted effort if these other factors are too far out of line.

Fumigants that are shipped in metal cylinders under pressure are usually introduced by means of a metal tube which terminates in a spray nozzle or a shallow pan located close to the ceiling near the center of the room, or in the draft of a fan. Such fumigants usually are in a liquid state in the cylinder and do not vaporize instantaneously upon release. A fan provided for dispersion of the vapor, heretofore referred to as gas, should be operated for at least thirty minutes after the fumigant is introduced. The vapors of most fumigants are considerably heavier than air, but if thorough mixing is accomplished, there will be little subsequent stratification. A measuring device, commonly called an applicator, is very helpful in introducing the fumigant. Special applicators are available for use with single dosage cans.

If methyl bromide or ethylene oxide is used in tight atmospheric fumigators at standard concentrations and a temperature of 70 degrees or above, a twelve hour exposure should give a perfect kill of the common insects attacking dates. It is a good practice to make frequent checks of the efficiency of fumigation, using larvae of insects that are more difficult to kill. Indian meal moth larvae are suitable for this purpose.

Safety Precautions

All fumigants are hazardous in high concentrations and should never be handled carelessly or by uninformed persons. No fear need be felt if the operator understands his task and has suitable equipment to work with. Rooms should be thoroughly ventilated after fumigation before people are allowed to enter or work in them. Rooms opening off work areas, and all large rooms not susceptible to thorough natural ventilation, should be equipped with exhaust fans that discharge outside of the packing house. Provisions should be made for admission of fresh air in a manner to create a cross draft to the outlet or fan.

A halide torch leak detector will detect methyl bromide in concentrations too low to cause any ill effects, even upon long exposure. Its use will also reveal leaks in the fumigator that are otherwise hard to locate. Warning signs should be displayed on fumigators while gas is present and removed promptly when entry is safe.

Methyl bromide offers no fire hazard. Many fumigants are inflammable, however, and no source of high temperature or sparks should be permitted in the room while gas is present.

Applicators should be maintained in good condition and frequently tested for leaks with soap suds or, in the case of methyl bromide, with the halide torch.

Cylinders containing fumigant should be stored away from high temperatures, and in such manner as to prevent them from being knocked over.

Insect infestations have sorely tried all packers during the past season, and have caused some doubt to arise as to the effectiveness of our fumigation practices. There is a need for wider study of our insect control problems. However, it is the opinion of the authors that difficulties of this season were due to weather conditions which favored rapid development of insects, superimposed on the general problem of handling a large crop, which ripened very rapidly, with a minimum number of experienced employees.

Publications consulted in the prepaation of this paper:

U. S. Department of Agriculture, Circular No. 157, "Fig Insects in California."

U. S. Department of Agriculture, Technical Bulletin No. 853, "Studies of Methyl Bromide in Greenhouse and Vault Fumigation."

A mimeographed bulletin entitled, "Dried Fruit Fumigation" by Perez Simmons, Dwight F. Barnes, Charles K. Fisher and Heber C. Dononohoe of the Bureau of Entomology, U. S. Department of Agriculture and Charles D. Fisher of the Dried Fruit Association of California.

Journal of Economic Entomology, Vol. 25, No. 5, October, 1932, "The Relation of Respiratory Metabolism of Insects to Their Susceptibility to Fumigants" by R. T. Cotton, Bureau of Entomology, U. S. D. A.

Numerous bulletins published by the manufacturers or distributors of fumigants.

GLAZING AND HYDRATING DATES

By G. L. Rygg, Associate Physiologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture

INTRODUCTION

The need for hydrating and softening dry dates has been recognized in this country since the early days of the industry. Published records of investigations to attempt to determine the most effective manner by which to accomplish the desired results go as far back as 1911, when Freeman (5) made his report from Arizona. By way of definition, the term "dry dates" as used in this paper refers only to dates of the semi-dry and soft types which are too hard and dry to be marketed as they are. According to the present marketing regulations this includes dates of these types which have a moisture content lower than 18 per cent. The No. 1 dry and waxy-tip grades of the Deglet Noor and the No. 1 dry grades of the soft varieties are included. There is no intention of including the "bread" varieties such as the Thoory and Kenta.

Although I have seen no published accounts of any methods used, there is evidence that the softening of dry dates has been practiced in the date-growing regions of the Old World for a considerable period of time. Freeman (5) said "Vinson reports that a certain fruit dealer in Algiers whose dates are considered superior is said to have a secret process by which they are treated in order to soften the hard imperfectly ripened individuals. Other fruit dealers of the same locality are quoted as suspecting that this process consists of steaming or soaking the fruit." Mr. Roy W. Nixon has stated in conversation that he observed a certain amount of hydration being practiced in Iraq in 1929. This consisted simply in sprinkling the fruit with some water to soften it sufficiently to permit it to be compressed into solid blocks preparatory to shipment.

Mr. Nixon has also referred me to a statement on hydrating dates in the Mediterranean region by Joseph I. Touchette, American Vice Consul, Algiers, Algeria. This statement is found in "Algerian Date Culture and Trade", Voluntary Report No. 18, 1932, and is as follows:

"Dates having a too soft consistency and containing too much humidity are placed in an evaporator. Dates which are too dry are given a warm water bath which lasts according to the quantity of water that the fruit must be made to absorb. The correct percentage is determined by weighing the baskets containing the dates before being immersed in a bath which may last from 2 to 24 hours. Experience has shown that slightly salted water is best. If warm water is used the length of the bath is greatly reduced. When taken from the bath the dates are placed on screens in a warm shed having a temperature of from 75 to 80 degrees Centigrade where they remain from 40 to 50 minutes. When the dates are taken out of the warm shed they are cooled as quickly as conditions permit.

"Deglet Noor dates of the 'Frezas-Exportable' type are given baths in water heated to a temperature of about 35 degrees Centigrade in order to assist maturity. The 'Frezas-Not Exportable' having a sugar content of about 45 per cent is consumed by natives."

The meager information which is available from foreign sources has been of little value in guiding the experiments and practices of American investigators, except perhaps at the very beginning. It is very probable that the problem of softening dry dates is not so important in the date-producing areas of the Old World as it is in the United States because the standards of quality are not the same, nor are the methods of packaging alike.

As I have already stated, the earliest suggestion by an American worker of a procedure to prepare excessively dry dates so as to make them suitable for marketing is that of Freeman (5). His suggestion, which applied to the Deglet Noor variety, was to wash the fruit and then soak it in water at 40° to 45° C. for 6 to 7 hours. Soaking for this length of time in cold water did not result in sufficient absorption of water; soaking at the given temperature for as long as 12 hours resulted in souring.

In 1924 Drummond (3) stated that "mumified" or dry dates could be reclaimed by holding in a container with "saturated air" at a temperature from 160° to 200° F. for a period from 5 to 18 hours. I attempted to repeat these experiments but the results were not encouraging. Fruit that was held 7 hours at 180° F. (82° C.) in an atmosphere that was approximately saturated with water vapor became very dark and sticky and dripped syrup. The flavor was also greatly impaired. Another experiment in which the fruit was held 2 hours at 189° F (87° C.) also gave an inferior product that was dark and syrupy and had a somewhat cooked flavor.

A slower method of evaporation which combines a short storage period with processing was given by Postlethwaite (6, 7) in 1930 and 1936. This consists in holding the fruit at 110° F. and 70 per cent relative humidity for 30 days. It was admitted, however, that the product was not "A-grade quality."

In 1936 Barger (2) showed that lower temperature was sufficient for hydrating dry Deglet Noor dates if sufficient time was available. Fruit that contained 14 to 15 per cent moisture at the start softened satisfactorily in 2 days at 100° F. and 98 per cent relative humidity, in 4 to 5 days at 80° and 98 per cent relative humidity. If a combination of hydration and storage is desired this can be accomplished by holding the fruit at 34° F. and 98 per cent relative humidity for 15 weeks. The products which he obtained by hydration at high humidities were not sticky or syrupy. In 1933 Barger (1) reported that Deglet Noor dates held at 82 per cent relative humidity may absorb 1½ per cent moisture in 1 month at 32° F., and in 2 weeks at 70° F.

In the passing of the years a considerable number of persons in and out of the date industry have carried on numerous trials which have resulted in the development of the steam hydration method which is in general use at the present time. Other attempts at hydration which yielded varying degrees of success consisted of sprinkling the fruit with water while it was held at a certain temperature; the temperature of holding varied with variety, condition of fruit, and back-ground and experience of the operator. Unfortunately, innumerable experiments have remained unpublished since the results were not to the satisfaction of the experimenter, whether he was a packing house operator or a research man. If some of these negative results had been recorded and thus made available to suceeding generations of workers they would without doubt have saved countless hours of time and hundreds of dollars in costs to the date industry and to those engaged in working on the problems of the date industry.

The steam hydration method which was evolved from the experiences of the operators in the industry varies somewhat with the different operators and with different lots of fruit but consists in general in placing the fruit on shallow trays in a dome-topped room and introducing steam at intervals for a period of approximately 1 day. A dome-shaped ceiling is used for the purpose of preventing water from dripping directly into the fruit. The fruit temperature is not allowed to exceed about 140° F. at any time. Heating and cooling are alternated in order that hydration and "breaking down" of the flesh of the fruit may be accomplished with a minimum effect on the flavor. A considerable amount of experience is necessary before an operator can consistently turn out a good product. The product is generally more or less sticky from sugar which has passed through the skin as a result of the presence of water on the surface of the fruit.

Other procedures for softening excessively dry and hard dates have been developed by commercial concerns for their own use, but no published descriptions of their methods have come to my attention.

In recent years the practice of marketing foods in attractive consumer packages has become increasingly prevalent. This is no less true of dates than of other foods. Since the present commercial hydrated dates generally tend to be soft and sticky they do not lend themselves so readily to handling in this sort of package as might be desired. For this reason it has become desirable to reinvestigate the entire field of softening dry dates, especially those of the Deglet Noor variety, and preparing them for market. The objective of the work that I am reporting, then, was to find some way of softening and otherwise changing the dry grades of dates in such a manner as to make them attractive to the prospective consumer and still have them retain a reasonably dry surface and sufficient firmness so that the fruit can be handled in such containers as cellophane and pliofilm bags without undue mashing.

METHODS AND RESULTS

Most of the work which is reported in this paper has been done on the Deglet Noor variety. In addition, some work has been done on the Khadrawy, Zahidi, Barhee, and Dayri.

Hydration

Many experiments have been conducted in an attempt to soften dates by controlled hydration. The procedure consisted in making available to the dates only enough water to bring the moisture up to a predetermined safe value. The maximum limit was determined by (1) the amount possible to use without making the fruit sticky, syrupy, or excessively soft; and (2) the amount possible to use without making the fruit unduly subject to spoilage from molding or fermentation. This objective was accomplished by enclosing a weighed quantity of fruit in an air-tight container along with a pan containing a definite quantity of water. A preliminary moisture determination was made on the fruit and only enough water was supplied to permit the moisture content to be increased to the desired value. The container with the fruit and the pan of water was held in an oven at the desired temperature for the necessary length of time.

Numerous trials were conducted in order to arrive at the most favorable temperature and time combination. It was found that at temperatures from 113° to over 122° F. (45° to over 50° C.) moisture was absorbed so slowly by the fruit that it was necessary to continue the treatment for two days, whereas at 131° F. (55° C.) one day was sufficient. If the temperature was raised to more than 131° F. the flavor of the Deglet Noor was adversely affected during the 1-day treatment, but the Khadrawy was not injured even when it was held at 140° F. (60° C.) for one day. With the Deglet Noor the most uniformly good quality was obtained when the fruit was held at 117° F. (47° C.) for two days since occasional lots had an off flavor after being held at 137° F. for one day. The color was also better than after the one-day treatment. Zahidi and Khadrawy fruit softened satisfactorily in one day at 131° F. and gave a product of good quality that was free from objectionable stickiness. The Dayri gave best results with the two-day treatment.

Satisfactory results were obtained by the method described above when small lots were processed. However, it was realized that difficulties would be encountered in adapting the procedure to a commercial-scale use, since it would be difficult to construct and operate a processing room in which all of the water added would be absorbed by the fruit and none lost from the system.

Another small-scale laboratory method which gave good results was to use a compartment in which the heat was introduced through the walls and a continuous high humidity was maintained by placing several traps of water in the moisture-proof container. With this method of heating there is little or no tendency for condensation to take place on the walls provided the temperature is not allowed to fluctuate. This procedure was carried out in the laboratory by using a vacuum oven without vacuum. The relative humidity in the oven during processing, as determined by a Precision human hair hygrometer which had been checked with a psychrometer at room temperature and humidity, was 88 to 90 per cent.

When the procedure described above was used, dates could be caused to gain 7 to 9 per cent in weight at 131° F. in 20 to 22 hours, or at 117° F. in two days. Some lots of Deglet Noor dates developed an off flavor after exposure to 131° F. for one day whereas this was not true of those held at 117° F. for two days. Consequently, the latter conditions are preferred in spite of the longer time required. Unless the initial moisture content was quite high, no stickiness or excessive softness was produced, and none of the fruit was sufficiently moist to permit spoilage from molding or fermentation when held at room temperature. When the initial moisture content of the fruit is so high that the finished product would have a moisture content higher than 23 to 25 per cent under the conditions that have been outlined, the time of treatment or the temperature, or both, must be reduced, unless there is no objection to having a perishable product on hand upon completion of the treatment. If the untreated fruit is very dry it may be desirable to increase the time or raise the temperature very slightly, or both.

The mtehod of hydration that has just been described is beneficial to incompletely ripened dry fruit in that it promotes the ripening processes and removes the "green" flavor.

Dates that have been hydrated by this method are not sticky, hence are easily handled by packers, dealers and consumers. Furthermore, they need not be so moist that they have to be refrigerated in order to prevent spoilage. A disadvantage of dates that have been hydrated by this method, however, is the fact that they are rather dull and unattractive in appearance. Since the consumer makes his purchases somewhat according to eye-appeal, this feature is undesirable. The glazing treatment, which is described below, can be used to overcome this characteristic.

Attempts were made later on a larger scale to soften dates in a room at the U. S. Date Garden at Indio. I am indebted to Dr. Walter Reuther of that station for much assistance in the preparation and operation of that room. The usual difficulty of obtaining a high humidity at a high temperature was encountered, largely as a result of condensation caused by low wall temperatures. When the insulation was increased, material aid was obtained, but the relative humidity was still only 80 to 83 per cent. That this was insufficient is shown by the fact that fruit under treatment gained only from 2 to 4 per cent in weight after one day at 131° F. (55° C). This experience illustrates the main difficulty that one is likely to encounter in attempting to soften dates by this method, namely, that of obtaining a high enough humidity. This difficulty is not at all insurmountable; it is mentioned only with the intention of calling particular attention to it so that it may be given special consideration by anyone who may wish to design a room which is to be used for this purpose.

Glazing

In the course of experimenting with various temperatures it was found that if a high enough temperature was used, the fruit came out of the treatment with an attractive luster. Unless great care was exercised, however, the flavor was seriously injured. A glossy surface was produced by placing the fruit in a small tight container and holding it at 221° F to 230° F (105° C to 110° C) for 50 minutes. When this procedure was followed the flavor was not impaired. While the product was glossy and attractive in appearance and had an excellent flavor, it had the defect of still being too hard and dry. Even when a pan of water was enclosed with the dates during the treatment the fruit increased in weight by only one-half to one per cent. The process is satisfactory for brightening fruit that is already soft enough to be consumed but unattractive because of dullness, especially if the dullness is caused by a large amount of bloom. A fairly good product was also obtained by holding the fruit in an air-tight container in an approximately saturated atmosphere for one hour at 172° F (78° C.) or for 45 minutes at 176° F (80° C). The product had a good luster but had not softened as much as many consumers would desire. Dates held at 158° F. (70° C.) for one hour in a nearly saturated atmosphere failed to soften materially and also failed to become as glossy as those held at temperatures of 172° F. (78° C.) or higher.

It was found later that the glossiness appeared when the surface of the fruit reached a temperature of about 183° F. (84° C.) and that there was a sharp line of demarkation between the glazed and the unglazed portions of the same fruit. The time required to produce the luster depended upon the exposure of the surface of the fruit to the surrounding air and upon the closeness of the contact of the skin with the flesh beneath, as well as upon the moisture content of the flesh; i. e., it depended upon the rate at which the heat was conducted away from the surface of the fruit toward the interior as well as upon the rate at which heat was conveyed to the surface from the outside.

The glossiness which is produced by this treatment is the result of melting the wax with which the fruit is normally coated. As the wax melts it spreads and makes an attractive smooth glossy surface. While the composition of the waxy material has not been determined, a small fraction of it was extracted with ethyl ether and was found to have a melting point of about 160° F. (72° C.) More of the material was obtained by collecting the flocculent precipitate that formed in the 80 per cent alcoholic extract of dates that was produced in the routine of sugar analysis. Only ripe fruit gave this precipitate. The melting point of this material was approximately 183° F. (84° C.), or about the same as the surface temperature necessary to bring about a glossing over of the fruit. The fact that the fruit brightened somewhat at temperatures as low as 158° F. was no doubt due to the softening or melting of the fraction of the wax that has been found to have a melting point close to 162° F. The major portion of the wax, which melts at about 183° F., also softens appreciably at 158° F.

Combined Glazing and Hydration

When it was found that it was not feasible to combine hydration and glazing in the same treatment because of injury to the flavor when the time of glazing treatment was prolonged enough to permit satisfactory hydration, a quicker method for producing the luster was sought. It was found that this could be accomplished by holding the fruit in a single layer on an open tray in an oven held at 356° F. to 365° F. (180° to 185° C.) for 7 minutes. This method was satisfactory in most instances, but occasionally there was a noticeable change of flavor. This difficulty was corrected by installing a fan in the oven so the air could be stirred rapidly. With this change it was possible to reduce the treating temperature to a range of 266° F. to 284° F. (130° C. to 140° C.), and the time of treatment to 5 minutes, and yet produce an attractive luster without causing injury to the flavor.

Since the glossy surface which is produced by a short exposure to a high temperature is the result of the melting of the natural wax present on the surface of the dates, it might be thought that this treatment would affect the rate at which the fruit would absorb moisture during the softening or hydrating process. This has been checked several times by hydrating dates from paired lots, one of each pair having been glazed before hydrating and the other hydrated without glazing. That there was no noticeable difference in the rate at which moisture was absorbed is shown in table 1.

Similar results were obtained in other trials, including those in which the dates were held at 117° F.

TABLE 1

The effect of glazing before softening (hydrating) upon the rate of absorption of moisture by Deglet Noor dates. The softening treatment consisted in holding at 131° F. and 90 per cent relative humidity for 22 hours.

	Untreated previous to softening	Glazed before softening
Initial weight, grams	386	383
Final weight, grams	420	418
Gain, in per cent of initial weight	8.8	9.1

(47° C.) and 90 per cent relative humidity for two days. The percentage gain in weight was approximately the same as shown in table 1, for corresponding lots of fruit.

The development of a quick method for producing a glossy surface on the fruit makes it possible to give the two treatments to the same lot of fruit without injuring the flavor. While it has been shown that it does not make any difference in the rate of absorption of moisture as to whether hydration or glazing is done first, there is an advantage in glazing first and following this with hydration. When this sequence is used there is less skin rupturing in the final product than when the sequence is reversed.

In general, the best results in improving the texture and the appearance of No. 1 dry and waxy-tip grades of Deglet Noor dates have been obtained by (1) holding at 266° to 284° F. (130° to 140° C.) for five minutes while the air in the oven is being stirred rapidly, and then (2) holding at 117° F. (47° C.) and 90 per cent relative humidity for two days. No humidity control is necessary during the glazing part of the treatment. Fruit that is already soft enough but needs to be brightened can be improved by using only the glazing part of tne treatment.

The conditions for hydration when applied to the Zahidi and the Khadrawy varities are 131° F. (55° C.) and 90 per cent relative humidity for one day. Dayri requires the same conditions as have been given for the Deglet Noor. The possibility exists that there would be an advantage in increasing the relative humidity to somewhat more than 90 per cent. Equipment with which to determine this point is not at hand at the present time. The conditions for glazing are the same for all the varieties that have been tried, namely, five minutes at 266° to 284° F. (130° to 140° C.).

DISCUSSION

It must be emphasizede very strongly that the temperature and humidity conditions used in treating dates by the methods that have been described must be carefully controlled. The temperatures used are extremely high and relatively slight variations in either the temperature or the time of treatment may be disastrous. The exact conditions which will give the best results will no doubt need to be determined for each processing unit, and will need to be adjusted to some extent according to the initial condition of the fruit that is to be treated and according to the degree of softening that is desired. In order that the treated fruit shall not be unduly subject to molding or souring, the final moisture content should not be allowed to rise above 25 per cent, and preferably not above 23 per cent (4), unless the finished product can be held under refrigeration until it reaches the consumer.

SUMMARY

Deglet Noor dates of No. 1 dry and waxy-tip grades can be caused to gain weight to the extent of 7 to 9 per cent by holding them two days in an atmosphere maintained at 117° F. (47° C.) and 90 per cent relative humidity. This hydrating treatment softens the fruit enough to make it acceptable commercially, but does not impart stickiness to the surface. The dull finish which this treatment gives to the skin can be prevented or remedied by exposing the fruit to a temperature of 266° to 284° F. (130° to 140° C.) for five minutes while the air is being vigorously stirred. This process melts the natural wax which occurs on the surface of the ripe date fruit and imparts a luster to the skin. The glazing treatment may be given before or after the hydrating, but peferably before. Similar conditions are recommended for Dayri.

Zahidi and Khadrawy dates may be softened by holding at 131° F. (55° C.) and 90 per cent relative humidity for one day. The conditions for glazing these varieties are the same as those given for the Deglet Noor.

Dates that are soft enough for the market but are lacking in luster can be made more attractive by giving the same glazing treatment of five minutes at 266° to 284° F. (130° to 140° C.) in rapidly circulating air.

LITERATURE CITED

1. Barger, Wm. R. 1933. Experiments with California dates in storage. Date Growers' Inst. Ann. Rept. 10:3-5.

2. Barger, Wm. R. 1936. Experiments in hydrating dry Deglet Noor dates. Date Growers' Inst. Ann. Rept. 13:14-16.

3. Drummond, Bruce. 1924. Artificial maturation of dates. Date Growers' Inst. Ann. Rept. 1:27-28.

4. Fellers, C. R. and J. A. Clague. 1942. Souring of dried dates by sugar-tolerant yeasts. Fruit Prod. Jour. and Amer. Vinegar Indus. 21:-326-327.

5. Freeman, G. F. 1911. Ripening dates by incubation. Univ. of Arizona Agri. Exp. Sta. Bull. 66.

6. Postlethwaite, R. H. 1930. Notes on processing and packing dates. Date Growers' Inst. Ann. Rept. 7:22-23.

7. Postlethwaite, R. H. 1938. Coachella Valley and its date industry. 47 pp. V. V. Green, Coachella, California.

THE VALUE AND USE OF FERTILIZERS

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Fertilizers are of value only when their use results in a profitable incraese in yield or quality. Like many good things, their unnecessary use may result in injury, or at best, in a waste of valuable materials. In order to choose fertilizer materials which will give the greatest return for the money spent, a grower needs to understand the nature of soils and the way plants are nourished by soil. But the final choice should be based on observation of results on his own land and with each of the crops grown.

The major portion of most soils is composed of particles of rock in various stages of decomposition, ranging in size from pebbles to particles too small to see.

This material has usually been laid down by wind and water and is extremely variable in its make-up. It is derived from different rocks from different locations and laid down by different storms at different times. For this reason soils differ at various depths and from one another, even in small tracts.

Organic matter is another constituent of soils. The amount varies widely but it is usually a very small part of the soil. Nevertheless it is very important in determining its various physical qualities. Organic matter as found in soils is also extremely variable. It varies in quantity, quality, and state of decomposition. Organic matter is most important because it helps maintain soil in good tilth, but it is also an important carrier of fertilizer elements.

Another part of the soil which is important is the very fine or colloidal material. This finely divided portion of the soil is composed of both mineral and organic substances. The amount of colloidal material present in a soil is an important factor in determining fertility. This is true because of the large amount of surface exposed to root action. It has been calculated that a pound of coarse sand has a surface area of about 11 square feet, and that a pound of cloidal material from soil would expose a surface of about 5 acres.

Another portion of the soil which is important, but about which we know relatively little, is the living part, composed of bacteria, fungi, algae, yeasts, protozoans, worms, animals and plants. This living material is exceedingly variable and is in a continuous state of change. It may be beneficial or it may be harmful to the plants which grow in the soil. It changes from season to season, and for the most part is not subject to any sort of control.

In addition, soils contain both air and water, and if either is lacking, the most fertile soil will be unproductive.

The foregoing discussion emphasizes the variability and changeability of soils. Climate is another factor determining the nature of soils and since it affects all soils of a given area in more or less the same way, it tends to produce uniformity. In areas of heavy rainfall soluble materials are leached from the soil, and as a result, numerous mineral deficiencies develop. In the Southeast, for example, 9 elements are necessary in the fertilizer program on some soils. In the arid southwest, on the other hand, the content of soluble minerals is high, so much so that alkali is a serious problem, but the intense heat to which these soils are exposed causes volatile materials to be burned out, and as a result, the most prominent deficiencies of this area are nitrogen and organic matter.

The ability of a soil to feed plants is determined by many factors, some of the most prominent ones are as follows:

1. Variety and composition of minerals.
2. Size of soil particles.
3. Organic matter content.
4. Kind of organisms living in the soil.
5. Degree of acidity or alkalinity.
6. Physical condition of the soil.
7. Supply of moisture and air.
8. Feeding habit of the crop.

These factors cannot be discussed here, but they are listed to emphasize the fact that the productivity of a soil is determined by many features, and the mere adding of a few minerals will not make a good soil out of a poor one, nor will it compensate for poor farming.

In considering the problem of fertilization, a soil may be regarded as a storehouse which contains all of the 15 or more elements required for plant growth. Some of the materials in this storehouse may be reduced to such a low level that plants do not secure enough for their most profitable development. In such cases, it is desirable to add the elements which are lacking so the storehouse will again be supplied with the proper food elements to produce the desired crop. It is not necessary or desirable to add all of the elements needed by the plant. It is only necessary to restore those which have been depleted.

In California nitrogen gives profitable responses on practically all soils and with most crops. In some soil areas phosporous is also necessary for the production of many crops, but in other areas of the state the supply in the soil is ample. Potassium is deficient in certain soils, but profitable responses to its use are rare. In the central and nothern part of the state legumes on some soils respond to the use of sulfur and in one area of northern California borax is necessary for olive production. In addition, tree crops may require zinc, copper or manganese, but these materials are used as dusts or sprays and need not be considered here. Fortunately it is very unusual to find more than two of these elements lacking in any particular soil.

Because of the great variability of soils it is obviously impossible to prepare a fertilizer which will complete the store of food elements in all soils and it is equally impossible to prepare a fertilizer which is suited to all crops, because different crops have different requirements and different abilities to take materials from the soil. It is necessary, therefore, to develop a fertilizer program which is suited to the particular soil and crop which are to be fertilized.

There are many sources of fertilizer elements, but first consideration should be given to maures and other organic materials which are ordinarily available at low cost.

Organic materials have a very important place in fertilization, chiefly because of their favorable effect on the physical properties of the soil. Organic matter increase the permeability of soil to water and thus improves the efficiency of irrigation. It counteracts the tendency of tillage to cause soils to run together or puddle and form plow sole. It also counteracts the tendency of certain chemical fertilizers to seal the soil surface and prevent proper penetratin of irrigation water.

In addition to improving the physical properties of the soil, organic matter, such as manure, which is brought onto the land carries important amounts of nitrogen and minerals. These are released slowly as decay takes place and are made available over a considerable period of time. This results in a sustained effect which is especially desirable on sandy lands susceptible to leaching.

Cover crops may be used to produce a very desirable kind of organic matter at a minimum of cost, but they grow on the land, and therefore add no mineral to the soil. Leguminous cover crops are to be preferred where they can be grown, because they tend to increase the nitrogen supply in the soil.

The fertilizer value of manure is exceedingly variable, but representative analyses are given in Table I to indicate the usual content of various elements and especially to emphasize the fact that plant residues contain large amounts of phosphorous and potash in addition to the organic matter, and nitrogen for which they are usually purchased.

If current prices for the various fertilizer elements required are applied to these typical analyses, it will indicate whether it is best to buy manures or chemical fertilizers.

Potassium is available in manures which usually carry from 1 to 3% potash, or in chemical form as muriate and sulfate potash. The sulfate (48% potash) is the best chemical form to use in California.

Phosphorous is available in manures which contain ½ to 3% phosphoric acid and in chemical form as super phosphate, phosphoric acid, and in combination with nitrogen. The choice of materials should be based on price per unit of phosphoric acid and convenience in use.

Nitrogen is available in manures and in chemical form as nitrate of soda, sulfate of ammonia, ammonium nitrate and anhydrous ammonia. These materials act differently when applied to the soil, but they are all good sources of nitrogen and are more readily available to plants than organic forms of nitrogen.

TABLE I
BULKY ORGANIC FERTILIZERS

Kind	Nitrogen	Phosphate	Potash	Organic Matter	Water
Dairy Manure	.8%	.45%	1.37%	30.5%	32.7 %
Steer Manure (Cotton seed fed)	2.00%	.55%	1.92%	58.0%	14.5 %
Steer Manure (Alfalfa fed)	1.35%	.65%	2.70%	48.0%	16.8 %
Poultry Droppings	4.15%	3.15%	1.58%	74.0%	8.27%
Poultry Manure	2.00%	1.85%	1.16%	52.0%	12.5 %
Rabbit Manure	2.25%	1.35%	.83%	60.0%	5.5 %
Hog Manure	2.20%	2.10%	1.00%	62.0%	10.0 %
Sheep Manure	1.40%	.95%	2.10%	52.5%	9.0 %
Lima Bean Straw	1.2 %	.25%	1.28%	82.0%	8.5 %
Blackeye Bean Straw	1.0%	.25%	1.90%	82.0%	8.6 %
Grain Straw	.6 %	.30%	1.38%	86.0%	5.79%

NOTE: Manures vary in weight with the time of year. When high in moisture, buy by the cubicfoot; when low in moisture, buy by the ton.

Nitrogen in the nitrate form penetrates soil readily and is carried with the water in which it is dissolved. Nitrate of soda is therefore a good nitrogen fertilizer for use in irrigation water and is especially desirable where quick penetration is important. It has been very effective for winter use on vegetables.

Nitrogen in the ammonia form becomes insoluble on contact with soil and remains fixed in the surface until it is transformed into the soluble nitrate form by soil organisms. When it is applied in irrigation water, it becomes fixed in the soil of the furrow and does not penetrate far below the surface. There is also a tendency for more nitrogen to be fixed in the upper end of the furrow than in the lower end. This tendency is greater in heavy clay soil than in light sandy soil, and it is greater when the stream carries soil particles than when the water runs clear. Because of this characteristic, furrows longer than 300 feet should be avoided whenever possible when any form of ammonia is used. In the interval between irrigations, the nitrogen which has been fixed by the soil is made soluble by the action of soil organisms and is carried into the root area by subsequent irrigations. For best results it is necessary to use the same furrows one or more times after the fertilizer has been applied.

Ammonium sulfate and liquid ammonia give good results under a wide variety of conditions. The slower penetration which results from the use of this form of nitrogen is often desirable, especially with shallow rooted crops and on open sandy soils where the fertilizer is apt to be carried below the root zone before it can be utilized by plants.

Liquid ammonia is a gas which has been reduced to the liquid form by pressure and is sold in steel cylinders. It dissolves very rapidly in water and is well suited to use in irrigation water. However, it is a gas and there is a certain amount of loss to the air during the time the solution is exposed in the irrigation furrows.

Ammonium nitrate contains half of its nitrogen in ammonia form and half in the nitrate form. Therefore, when this material is used, half of the nitrogen is carried into the soil by the water and half becomes fixed on the surface to be changed to the nitrate form and later to be carried down by subsequent rains or irrigations. This material has an advantage where both a quick and sustained effort are desired.

Nitrogen should be bought on the basis of cost per unit because for most crops one form is as good as another. There is wide variation in nitrogen content of chemical fertilizers and price per ton is not important—it is the price per unit of nitrogen that is important. (A unit is 1% of a ton, or 20 lbs.). Table II gives the value per ton of several

TABLE II
COMPARATIVE VALUES OF NITROGENOUS FERTILIZERS

Sodium Nitrate	16% Nitrogen at $2.50	$ 40.00	per ton
Ammonium Sulfate	20½% Nitrogen at $2.50	51.25	per ton
Ammonium Nitrate	23½% Nitrogen at $2.50	81.25	per ton
Liquid Ammonia	81% Nitrogen at $2.50	202.50	per ton

materials when nitrogen is selling at $2.50 per unit.

SUMMARY

Soils are exceedingly complex and variable. They may be regarded as a storehouse where the many elements required for plant growth are kept. Plants differ in their requirements and in their ability to take plant food elements from the soil.

Because of differences in soil and plant requirements no set formula can be laid down as a guide to fertilization.

A fertilizer program must finally be developed on the basis of individual experience. With few exceptions, fertilizer elements should be purchased on the basis of price per unit.

THE RESPONSE OF KHADRAWY DATE PALMS IN OMPHALIA-INFESTED SOIL

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Omphalia-infested soil presents a difficult problem to the date grower. In areas where many palms have been infected, complete eradication of the causal fungi, **Omphalia pigmentata** Bliss and **O. tralucida** Bliss, is not always practicable. Soil in such areas is sometimes abandoned or used for crops that are not affected by omphalia root rot. The use of disease-resistant varieties of dates offers a possible solution to this problem. Whereas the commercially important Deglet Noor variety is especially susceptible to omphalia root rot, there is observational evidence that certain other desirable varieties, such as Khadrawy, Halawy, and Zahidi, are relatively less susceptible (2). Experimental evidence on varietal susceptibility is incomplete, but I can report some rather encouraging observations on the growth and fruitfulness of Khadrawy palms in omphalia-infested soil where Deglet Noor palms have declined since 1922.

There are at least 13 date gardens in the Coachella Valley of California having omphalia - infested areas of more than ten tree spaces (1). One of these gardens near Thermal [designated in this and previous papers (1, 2) as garden **T**] was originally planted with offshoots of several varieties of dates imported from the Old World. Sixty-one Deglet Noor offshoots were imported by Popenoe from Algeria in 1913, planted in a nursery for two years, and finally set in four rows in the orchard in 1915. Adjoining this planting on two sides were date palms of the following varieties: Khustawy, Zahidi, Khalasa, Tafazwin, Deglet Beida, and Halawy. The weak, stunted condition of a Deglet Noor palm near the center of the planting was first noticed in 1922. From it, the disease spread in an ever-widening circle, affecting all palms of the Deglet Noor variety but producing no secondary or above-ground symptoms of omphalia root rot on the adjoining palms of other varieties. Between 1922 and 1935, the disease spread from 1 to 60 palms and finally prompted the owners of the garden to destroy this entire planting of the Deglet Noor variety.

In May, 1933, an experiment was initiated in which offshoots of Deglet Noor and Khadrawy varieties were planted in three separate areas. Two of these areas were in garden **T** near Thermal; the other, in garden **I** west of Indio. The soil in one of the areas in garden **T** was infested with omphalia; that in the other two experimental areas was not infested. Records of trunk growth, production of fruit bunches, and the appearance of disease symptoms have been taken on the experimental palms during a period of nearly eleven years. The present paper is a progress report intended to summarize these data and to call attention to differences in the response of the Deglet Noor and Khadrawy varieties when planted in omphalia-infested soil. Special emphasis is placed on the response of the Khadrawy variety because at the present time Khadrawy palms seem to be showing considerable resistance to the omphalia root rot.

Experimental Method

Fifty nursery-rooted offshoots of Deglet Noor variety (palms 1-50, inclusive) from garden **I**, and 50 nursery-rooted offshoots of Khadrawy variety (palms 51-100, inclusive) from garden **T**, were planted May 30, 1933, in three experimental areas. Equal numbers of offshoots of the two varieties were planted in each area. Forty offshoots (Deglet Noor palms 31-50 and Khadrawy palms 81-100) were interplanted between the rows of diseased Deglet Noor palms in that part of garden **T** where omphalia root rot had been spreading with disastrous effect since 1922. A similar lot of 40 offshoots (Deglet Noor palms 11-30 and Khadrawy palms 61-80) was planted in noninfested soil in another part of garden **T**, ½ mile from the nearest known area of infestation. The 20 remaining offshoots (Deglet Noor palms 1-10 and Khadrawy palms 51-60) were planted in garden **I**, where no trace of omphalia root rot had been found.

The offshoots in the different lots were reasonably uniform in size and vigor when planted, but the environmental conditions in gardens **T** and **I** were somewhat different. The soil in garden **T** was relatively heavier, less permeable, and more saline than that in garden **I**. The southeastern part of the Coachella Valley, including garden **T**, seemed to excel in the quality of Khadrawy dates produced, but was less favorable to the Deglet Noor than the district west of Indio where garden **I** was situated.

All the offshoots survived the transplanting operation except one Khadrawy (palm 72). Four of the palms were later removed from garden **I**. Deglet Noor palm 5 died suddenly from undetermined causes, and Khadrawy palms 53, 57, and 59 were destroyed, together with their offshoots, because they were infected with omphalia. All other palms of the original planting are alive at the present writing.

Cultural operations in the three experimental areas were carried on in a reasonably satisfactory manner. Whereas all the palms in garden I were planted at intervals of 30 feet (the usual orchard spacing), some of the palms in garden **T** were crowded because of interplanting between the 30-foot rows. This crowded condition was partially compensated in garden I by interplanted citrus trees. Irrigation practice was usually adequate, although the soil moisture content in garden **T** was sometimes low in early summer, and, in garden I, the soil about Khadrawy palms 57-60, inclusive, was often dry. Special applications of commercial fertilizers were made to the soil each year during five years of the experiment. Ammonium sulfate (3¾ pounds per palm) was applied in 1937, 1938, and 1939; ammonium phosphate (5 pounds per palm) was applied in 1940 and 1941.

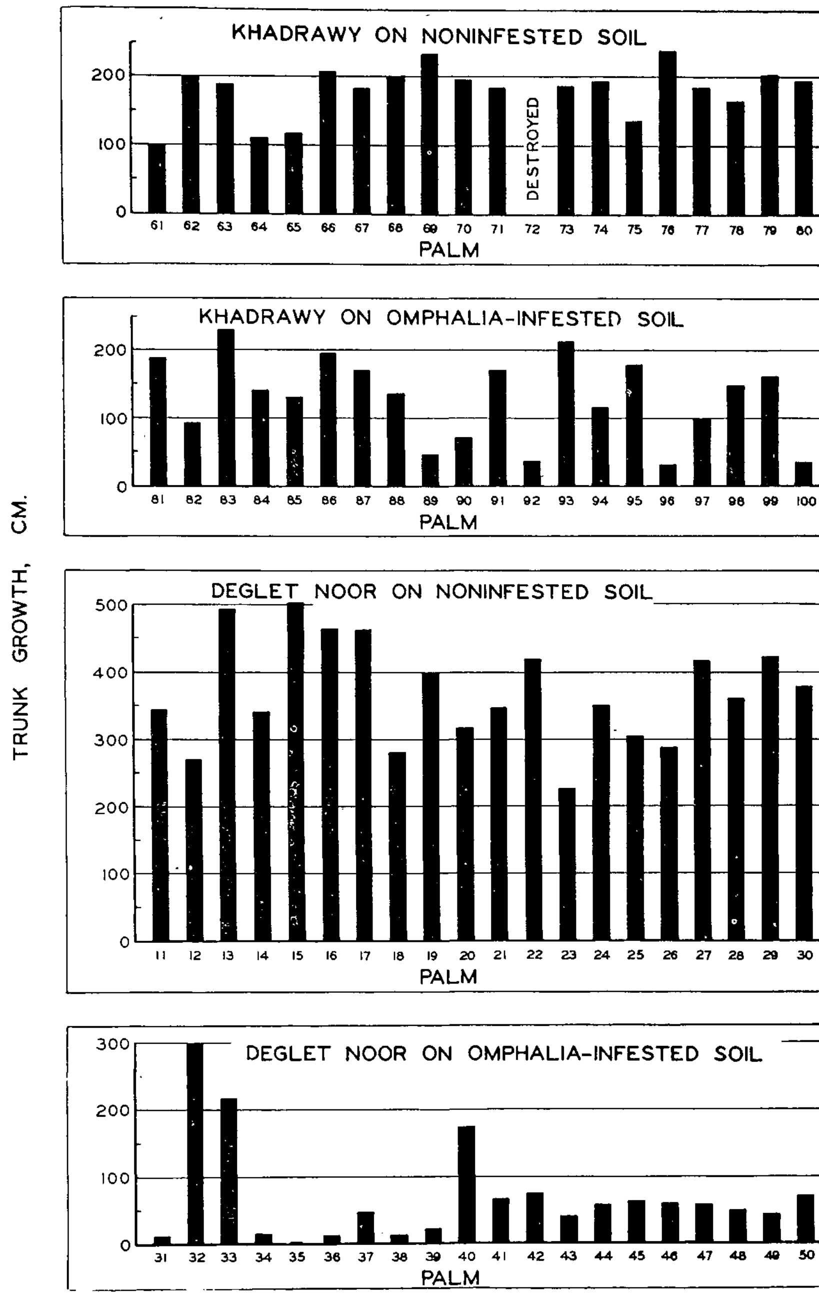

Fig. 1—Trunk growth (elongation) of Khadrawy and Deglet Noor date palms in areas of noninfested and omphalia-infested soil in garden **T** during the period May 23, 1935, to March 30, 1944, inclusive.

Records of the individual palms were taken on or about June 1 of each year, beginning with 1935. These records included the height of the trunk (measured from the soil line to the fiber line), the appearance of the palm in relation to the secondary symptoms of omphalia root rot, and the number and relatize size of both the pollinated fruit bunches and the offshoots. Because of variations in the elevation of the soil line, the measurements of the trunks were subject to error. The readings are believed to be relatively correct, however. Samples of roots were taken from various palms and at different times to test the presence of omphalia and to observe the progress of the disease.

Experimental Data

The mean growth (elongation) of trunks of the experimental palms during the period May 23, 1935, to March 30, 1944, inclusive, was as follows:

Khadrawy variety
  Garden **T**
    Noninfested soil .... 181.8 cm.
    Omphalia-infested soil .. 129.1 cm.
  Garden **I**
    Noninfested soil .... 183.4 cm.
Deglet Noor variety
  Garden **T**
    Noninfested soil .... 339.3 cm.
    Omphalia-infested soil .. 68.7 cm.
  Garden **I**
    Noninfested soil .... 429.3 cm.

Considerable variation in trunk growth was found among individual palms within certain groups of the same variety. These variations in the four groups of palms in garden **T**, as calculated at the end of the above-mentioned period, are indicated in figure 1. Khadrawy palms in noninfested soil showed greater uniformity in trunk growth than did those in omphalia-infested soil. The Deglet Noor palms in noninfested soil grew normally but most of those in the omphalia-root-rot area became stunted. Whereas the average growth of Deglet Noor palms in noninfested soil was twice as great as that of Khadrawy palms, the average growth of Khadrawy palms in omphalia-infested soil was twice as great as that of Deglet Noor.

Growth curves of representative palms from each of the four groups in garden **T** are shown in figure 2.

These palms represented, within their particular groups, the maximum, minimum, and mean trunk growth, respectively, in the period May 23, 1933, to March 30, 1944, inclusive. The growth curve of palm 33 was also included in figure 2 to illustrate the effect of omphalia root rot on trunk elongation in a growing Deglet Noor palm.

The growth rates of normal palms increased perceptibly after an initial lag phase. Deglet Noor palms grew twice as rapidly as Khadrawy palms. About five years after the palms were planted, the growth

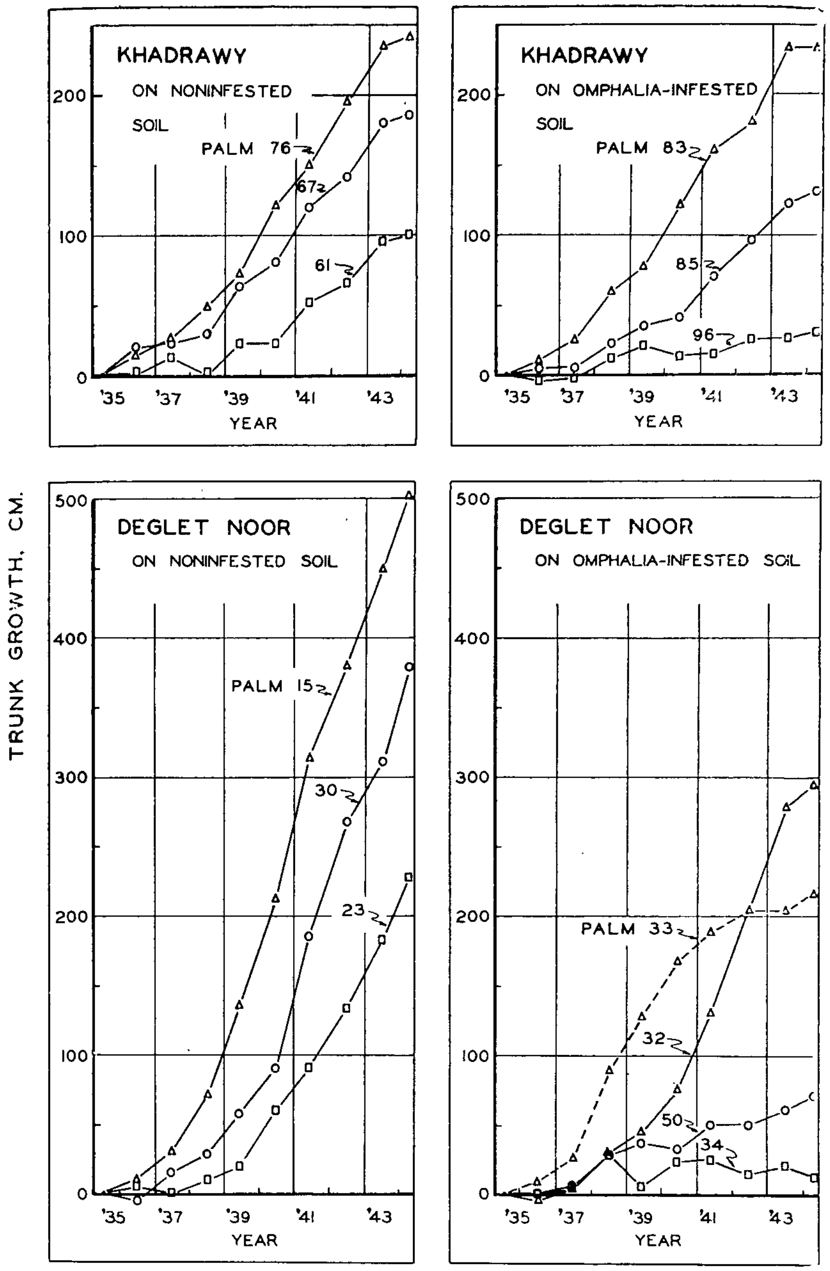

Fig. 2—Growth curves of Khadrawy and Deglet Noor date palms in areas of noninfested and omphalia-infested soil in garden **T**. Trunk measurements of 3 palms in each group are given to show the maximum, minimum, and mean trunk growth, respectively, in the period May 23, 1935, to March 30, 1944, inclusive. Palms 76, 83, 15, and 32 show the maximum trunk growth in their respective groups; palms 61, 96, 23, and 34 show the minimum trunk growth; and palms 67, 85, 30, and 50 show the mean trunk growth. The growth curve of palm 33 illustrates the effect of omphalia root rot on trunk elongation in a growing Deglet Noor palm.

rates of many Deglet Noor and of a few Khadrawy palms in the root-rot area fell far behind those of palms in the noninfested soil of the control areas. This change in palms of the Deglet Noor variety coincided with the appearance of the secondary symptoms of omphalia root rot, such as small, weak leaves and fruit bunches, a yellowish color, and a general decline in vigor. The stunted Khadrawy palms retained a fairly normal green color but they lacked vigor.

Fruit production began in 1937. The weight of fruit was not recorded, but counts of pollinated fruit bunches were made in 1937 and in each year thereafter. The fruit bunches on all palms were relatively small at first; small bunches in other years were found on diseased palms. Although the fruit bunches were not all alike in size and quality, the mean number of pollinated bunches per palm per year gives indirect evidence of the relative vigor of the various groups of experimental palms (table 1). The fruit load increased more or less regularly from year to year until 1943, when the Khadrawy palms bore 8.0 to 8.8 fruit bunches in noninfested soil and 6.3 fruit bunches in omphalia-infested soil. Averages of 10.9 to 12.1 fruit bunches were retained on Deglet Noor palms in the control areas, but the average was only 2.0 bunches in the root-rot area. This very significant difference in the number of Deglet Noor fruit bunches would probably seem greater if records had been obtained on the relative quantity and quality of fruit produced.

No differences of such magnitude were observed between groups of Khadrawy palms. The palms in the omphalia-infested area had three-fourths as many fruit bunches as those in the controls. Furthermore, one of the ranch foremen reported, in conversation, that in 1943 the Khadrawy fruit from the infested area was satisfactory from the commercial standpoint.

The value of this experiment was altered somewhat by the discovery, in 1940, that a few of the Khadrawy palms in noninfested soil, both in garden **I** and in garden **T**, were infected with omphalia. All the offshoots used in this experiment had been selected for their uniformity, vigor, and apparent freedom from omphalia. Root examination of all these palms had not been practicable at the time of transplanting from the nursery rows to the orchard. Judgment on the health of these offshoots had been based on the apparent condition of the parent palms, where known, and also on the results of direct examination of, and tissue cultures from, a few representative offshoots. Since in 1933 there was no knowledge of infection in the parent palms or in their rooted offshoots, it was assumed that all the experimental offshoots were free of omphalia. The discovery, in 1940, of infected Khadrawy palms in both of the control areas, cast some suspicion on the condition of these palms at the beginning of the experiment. Omphalia was unknown in the Deglet Noor palms of the control areas until 1944, when one palm in garden **T**, standing 30 feet from an infected Khadrawy palm, was found to be infected.

TABLE 1
Mean Number of Pollinated Fruit Bunches per Palm, 1937-1943, inclusive

Variety and location of palms; condition of soil	Crop						
	1937	1938	1939	1940	1941	1942	1943
Khadrawy							
Garden **T**							
Noninfested soil	0.5	1.8	4.2	5.6	7.4	7.8	8.8
Omphalia-infested soil	0.0	1.5	3.2	4.6	6.4	4.5	6.3
Garden **I**							
Noninfested soil	2.1	0.0	1.0	5.0	6.6	4.3	8.0
Deglet Noor							
Garden **T**							
Noninfested soil	0.9	2.9	7.8	7.4	11.1	11.3	10.9
Omphalia-infested soil	0.0	2.4	2.9	2.3	2.0	1.8	2.0
Garden **I**							
Noninfested soil	3.6	1.7	4.1	5.5	10.1	6.2	12.1

Omphalia had been known since 1939 in palms of both Deglet Noor and Khadrawy varieties in the omphalia-infested area of garden **T**. In this area, secondary symptoms of the disease appeared in 1938 in 4 Deglet Noor palms. In succeeding years the number of visibly affected palms of this variety increased as follows: 5, 13, 14, 16, 17, and 17, respectively. Five of the Khadrawy palms in this area had a trunk growth of less than 75 cm. between 1933 and 1944 (fig. 1). Of these, palms 89 and 96 are known to be infected with omphalia. The secondary symptoms of omphalia root rot have not been recognized with certainty in the Khadrawy variety. It is possible, however, that the stunting of these 5 Khadrawy palms is due, at least in part, to omphalia root rot.

In the two control areas, no evidence of secondary symptoms of disease has been found in palms of either variety.

Discussion and Summary

The comparatively favorable response of Khadrawy palms in omphalia-infested soil is the principal point of interest in this experiment. In an environment where most of the Deglet Noor palms became worthless, many palms of Khadrawy variety grew and fruited normally. Whereas the difference between the two varieties is very striking at present, only time will tell whether the Khadrawy variety is sufficiently disease-resistant to remain commercially profitable when grown under such circumstances for longer periods.

While reporting progress on this experiment, I wish also to call attention to certain implications which should be discussed. Palms of the Khadrawy variety are somewhat susceptible to omphalia root rot and are therefore potential carriers of the disease. Many Khadrawy palms in the Coachella Valley are thought to be free from omphalia, but there is an element of danger in transplanting palms of this variety because the disease is not easily recognized in them.

There are two possibilities regarding the origin of omphalia in the two control areas of this experiment. Omphalia was either introduced on the offshoots or it was present in the soil at the time of planting. The first possibility seems more likely than the second. There is no evidence that omphalia is indigenous in soils where dates have not been grown, but omphalia is known to be carried on infected offshoots. Infected Khadrawy palms were detected in both control areas in 1940, but the disease was not discovered in any Deglet Noor palm in the control areas until 1944. In the case of the one infected Deglet Noor palm in the control area of garden **T**, the fungus could have spread from an adjoining infected Khadrawy palm during this interval of four years.

Further knowledge of disease resistance among commercial date varieties is of importance in the control of omphalia root rot. The Khadrawy variety may be sufficiently resistant to be grown in omphalia-infested soil.

Literature Cited

(1) Bliss, Donald E.
1943 The spread of omphalia root rot by offshoots of the date palm. Date Growers' Instit. Ann. Rept. 20:3-5.

(2) Bliss, Donald E.
1944 Omphalia root rot of the date palm. Hilgardia 16 (2):15-124.

RESPONSE OF DEGLET NOOR DATE PALMS TO IRRIGATION ON A DEEP SANDY SOIL

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Plan of Experiment

In 1935 a four-acre block of Deglet Noor offshoots was set out on an exceedingly variable piece of soil at the U. S. Date Garden. The upper twelve to fifteen inches of soil is quite uniform throughout the block, and is a very fine sand in texture. From the very outset it was apparent that there was a marked effect on the nature of the subsoil on the vigor of the palms. In areas where palms grow vigorously, there is a deep silt layer from three to six feet in thickness immediately below the upper twelve- or fifteen-inch layer. In areas where palms are low in vigor, no silty textured soil is to be found until a depth of nine to sixteen feet is reached. The entire nine to sixteen feet of the profile is sandy in texture. There are several of these deep sandy spots in this block, the largest being ¾ of an acre in extent. In the middle of this largest deep sandy spot 24 representative palms were selected for special study. These palms were only about half as large as normal vigorous Deglet Noor palms should be. In January, 1944, these eight-year-old palms averaged 7½ feet in height, and had an average

Table 1. Moisture content of soil in relation to soil texture and date palm vigor. Experimental Block 7, U. S. Date Garden

	Deep sandy soil; low-vigor palms		Silty subsoil; vigorous palms	
Depth feet	Moisture* (percent)	Soil Texture	Moisture* (percent)	Soil Texture
0-1	5.8	very fine sand	7.6	very fine sand
1-2	10.9	very fine sand	31.1	silty clay loam
2-3	6.5	fine sand	41.7	silty clay loam
3-4	6.3	fine sand	33.2	silty clay loam
4-5	10.0	fine sand with minute silt layers	36.3	silty clay loam
5-6	9.4	fine sand with minute silt layers	35.9	silty clay loam
6-8	3.8	coarse sand	10.7	fine sand with minute silt layers
8-10	7.4	fine sand	4.9	fine sand
10-12	5.9	fine sand	5.2	fine sand
12-14	5.3	fine sand	7.3	fine sand
14-16	22.4	silt loam	9.0	fine sand with minute silt layers

*Moisture samples obtained 12/16/42, 3 weeks after last previous irrigation. Moisture expressed as per cent of oven dry soil.

of 67 leaves per palm, while the adjacent ½ acre block of normal, vigorous, eight-year-old palms, growing in an area having a silty subsoil,, averaged 15½ feet in height, and had an average of 116 leaves per palm (figure 1). The data presented in table 1 indicate the marked contrast in soil makeup and moisture content between the areas supporting low- and high-vigor palms. The data presented in table 2 emphasize that the silty textured layers in this block will hold 1½ to 2½ times as much available water as the sandy portion of the soil.

During the summer of 1941 a water pipe system was installed in the deep sandy area so that each of the 24 palms selected for study received a continuous trickle of water in a small basin constructed around each palm in which differential mineral nutrient treatments were applied in liquid form. The continuous trickle of water, amounting to around 25 cubic feet of water per palm per day, was supplementary to the regular irrigation program. This supplied between 10 and 11 acre-feet of water annually to this block, which also amounts to about 25 cubic feet of water per palm per day.

Palm Growth and Fruit Quality

This mineral nutrient experiment was continued until the fall of 1942, when it became obvious that the additional water was having a profound effect on the growth of all of the experimental palms without relation to fertilizer treatment. There was marked increase in vigor, number of inflorescences produced, and earliness of blooming with these experimental palms after about 18 months of supplementary trickle irrigation, while adjacent untreated low-vigor palms in deep sandy soil remained at the same low level of vigor as before. In April, 1943, the trickle of water was turned off on 12 of these palms, while the remaining 12 palms continued to receive supplementary water. Growth records obtained from these palms indicated that between May and October of 1943, leaf growth rates on the 12 palms receiving normal irrigation flucuated between 2.8 and 3.8 centimeters per day (1.1 and 1.5 inches per day), while the 12 receiving supplementary irrigation fluctuated between 3.2 and 4.3 centimeters per day (1.3 and 1.7 inches per day). During this period, vigorous palms in an adjacent block growing in an area having a silty subsoil grew at a rate fluctuating between 4.2 and 5.3 centimeters per day (1.6 and 2.1 inches per day). Through the hottest period from June 15 through September 30, the rate of leaf growth of the palms receiving supplementary water was from 10 to 25 per cent greater than those receiving normal irrigation. In cooler months, the difference in growth was less pronounced, and at times entirely absent (figure 2). Throughout the year the moisture content of the soil in the vicinity of the palms receiving normal irrigation only, would never, by ordinary standards, have been considered deficient. In fact, it remained very close to field capacity throughout the entire season (figure 2).

One of the most striking results of the supplementary water was the effect on the quality of the 1943 crop. About 86 percent of the fruit produced by the palms receiving normal irrigation was substandard, while only 51 percent of the fruit from those receiving supplementary water was substandard. These grade data are summarized in table 3. Another very striking result was the effect on the number of inflorescences produced, and the earliness of emergence. The palms irrigated in the customary way produced fewer and later inflorescences (table 4) than those receiving additional water.

Discussion

The results obtained so far from this experiment may have certain practical applications. However, it should be emphasized that any conclusions drawn are tentative in nature, and that more definite conclusions and recommendations will require at least two more seasons'

Table 2. The relation of soil texture to certain moisture holding characteristics. Experimental Block 7, U. S. Date Garden

		Approximate range of moisture characteristics expressed in acre-inches of water per acre-foot of dry soil		
Texture range of soil	Range of weight in pounds of an acre-foot of dry soil	Field moisture-holding capacity	Unavailable water	Available water (theoretical)
Silt loam to very fine sand	4,200,000 to 4,000,000	1.5 to 2.2	0.3 to 0.5	1.2 to 1.7
Mean	4,100,000	1.85	0.4	1.45
Fine sand to silty clay loam	3,300,000 to 2,700,000	2.6 to 4.5	0.6 to 1.3	2.0 to 3.2
Mean	3,000,000	3.55	0.95	2.6

Table 3. Effect of supplementary irrigation on date fruit quality

1943 Season

Irrigation Treatment	Percentages (by weight) of fruit graded as: Choice	Standard and No. 1 Dry	Substandard	Culls
Normal	0.5	12.1	85.8	1.6
Normal plus supplementary water	5.3	42.9	50.8	1.0

data, and will possibly require a larger scale irrigation experiment on a larger block of palms in deep sandy soil containing virtually no silt layers in the principal root zone. These data suggest that insufficient water, rather than inadequate soil fertility, is the primary factor responsible for the low vigor of palms in deep sandy soils. Many growers have sandy spots in their date gardens which produce weak palms and low grade fruit. Where these spots are fairly large, it is suggested that it might be worth while to try irrigating such areas much more frequently than the rest of the planting, and cutting down somewhat on the amount applied at each irrigation.

A program of very frequent irrigation might be particularly beneficial to young non-bearing, or young bearing palms planted in deep sandy soils, which have not yet established extensive rooting in silt layers located five to six feet or more below the surface. In other words, when plantings are on soils having no extensive silt layers in the first five or six feet of soil, it may be beneficial to continue for several years the frequent irrigation program usually given offshoots the first summer after planting. In very deep, sandy soils, having no appreciable silt in the first 10 or 12 feet, it may be necessary to continue frequent irrigation indefinitely in order to obtain palms having satisfactory vigor, yields, and fruit quality. It should not be concluded from this study that water is the only factor limiting the growth of palms in deep sandy soils, but it does appear to be a primary factor. When adequate water is applied, it would be quite reasonable to expect good response from the application of farm manure or chemical fertilizer materials.

The question naturally arising after reviewing the results of this experiment is, how is it possible that palms whose root systems are lo-

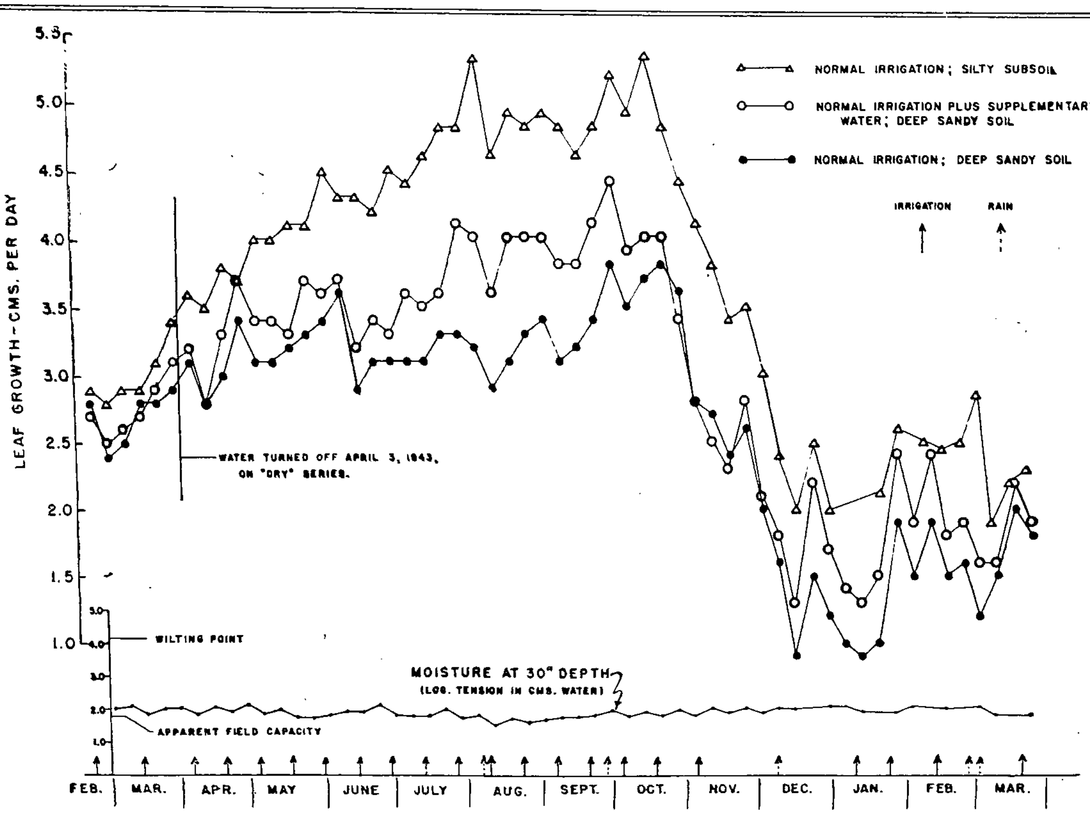

Figure 2. The effect of supplementary water and soil type on the rate of leaf elongation of Deglet Noor palms. The moisture data presented was obtained from a plot receiving normal irrigation in deep sandy soil.

Table 4. Effect of supplementary irrigation on earliness and total number of inflorescenes

1943-1944 Season

Description	Normal	Normal plus supplement
Average* No. of inflorescences pollinated or open 3/17/44	1.5	4.3
Average* No. of inflorescences pollinated or open on 3/28/44	4.0	7.8
Average* total No. of inflorescenes produced per palm	11.25	14.0

* Average of 12 palms in each treatment.

cated in soil which is kept quite moist at all times respond to additional water? We have no adequate answer for this question at present. It seems contrary to certain long-established theories of soil-moisture availability. It is suggested that the date palm is relatively coarse-rooted compared with most tree crops, and that the rate of moisture loss by the palm is often so great that sandy soils cannot transmit water to the absorbing root surface fast enough to supply the requirements for maximum vigor. Other workers with other crops have obtained evidence which tends to support this suggestion.

Figure 1. The Deglet Noor palm on the left is located in an area having a silty subsoil, and the palm on the right in an area having a sandy subsoil. Both palms planted in June, 1936, photo taken January, 1942, Block 7, U. S. Date Garden.

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Prepared by G. L. Rygg

based on index for Numbers 1-10 by W. R. Barger

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