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NUTRITION AND COMPOSITION OF THE DEGLET NOOR PALM IN RELATION TO THE DECLINE DISEASE[1]

A. R. C. HAAS[2] AND L. J. KLOTZ[3]

The Deglet Noor is the most important variety of the date palm grown in the Coachella Valley. This variety, however, is very susceptible to a decline disease to which the small number of individual palms of other varieties which happen to be in the same gardens, thus far appear to be less susceptible. As the malady may rapidly become of considerable economic importance it was thought desirable to record at this time these preliminary observations and data.

SYMPTOMS OF THE DECLINE DISEASE

The symptoms of the decline disease are: a greatly retarded growth of the stem buds, a lack of the normal dark-green color, and a reduction in the quality and quantity of the fruit. Some diseased palms may continue to produce marketable, although inferior fruit, for long periods. Ultimately, the palms fail to produce fruit. The area including the diseased palms enlarges gradually from year to year. Among the larger, highly productive and apparently unaffected palms in the better areas of a garden occasional individuals are found to suddenly

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decline and in time adjacent palms become affected. No recovery of an untreated palm has been found to occur once the disease has made perceptible progress. Of the few trials conducted thus far, only a soil treatment with copper sulfate has shown promise. This and other treatments are now being tested on a large scale in several gardens.

When the soil is dug away from affected palms many of the roots are found to have deteriorated. This partial destruction of the root system limits the feeding area of the palm and enables one to treat the soil about a diseased palm with but little likelihood of affecting the neighboring palms.

Affected palms are susceptible to the *Diplodia* disease described by Fawcett[1] The *Diplodia* disease and the decline disease are apparently two distinct maladies. In fact, commercially productive palms frequently have *Diplodia*-affected fronds and offshoots and show no symptoms of decline disease. Investigations have as yet given but few clues to the probable cause of this decline disease. The problem has been approached simultaneously from several angles and this preliminary paper deals chiefly with the changes in the composition of the Deglet Noor palm in relation to the decline disease.

CITRUS AS AN INDICATOR PLANT

Since there is considerable information at hand concerning the pathological symptoms and physiological responses of citrus in relation to chemical composition, it was thought that interplanted citrus would more quickly reveal the causal factors of the decline disease. Accordingly, grapefruit trees were set out as indicator plants between the rows of diseased palms in several gardens. In all instances the citrus interplants thrived while the palms continued to retrograde. The results suggest that a plant to be most useful as an indicator should have a nutrient requirement and root habit similar to the plant being studied.

These antithetical responses of the two classes of plants is understandable, in part at least, when the composition of the leaves and pinnae are compared. Contrasted with citrus, which is dicotyledonous and usually has a relatively shallow root system, the palm is monocotyledonous and has a very deep root system. The growth habits of the two classes of plants differ enormously. The mineral nutrition of the palm as will be shown later corresponds more closely with other monocotyledonous plants such as asparagus or corn, the latter being well known for its relatively large requirements for nitrogen, phosphorus and potassium, but not for calcium. The presence of fresh-water calcium carbonate shells in the Valley is taken as an encouraging sign of good soil. The increased formation of carbon dioxide in the soil following the turning under of covercrops has been utilized as a means of increasing the solubility of this source of calcium. The data presented later show that the calcium requirement of date pinnae is considerably smaller than that of citrus leaves. To illustrate, the ash of normal citrus leaves has a relatively high calcium and a low potassium content while that of mottled leaves is deficient in calcium and relatively too high in potassium. Later it will be shown that the composition of pinnae of normal and diseased Deglet Noor fronds bear an inverse relationship to that of normal and mottled citrus leaves.

SOIL FERTILIZATION IN RELATION TO THE DECLINE DISEASE

The view has been expressed that the decline disease is a result of inadequate fertilization. That it is difficult to defend such a position, if we use our experience with citrus as a guide, is seen when one considers the extensive fertilization of the garden in which we have carried on experiments. In this garden in 1928 the diseased palms each received 700 pounds of manure and 25 pounds of superphosphate. The same year each of the healthy and diseased palms received amounts of 'Ammo-Phos,' superphosphate, and sulfate of potash, equivalent to 1 pound of N, 2.6 pounds of P_2O_5, and 3 pounds of K_2O. In April, 1929, each of the healthy and diseased palms was given amounts of 'Ammo-Phos,' superphosphate, and sulfate of potash, equivalent to 1 pound of N, 3 pounds of P_2O_5, and 3 pounds of K_2O. In October, 1929, all healthy palms received dairy manure equivalent to 3 pounds of N, 1.5 pounds of P_2O_5, and 3 pounds of K_2O, per palm. In December, 1929, the healthy palms were given 4–10–10 fertilizer equivalent to 1.1 pounds of N, 2.8 pounds of P_2O_5, and 2.8 pounds of K_2O, per palm. During 1929 the healthy palms therefore each received fertilizers equivalent to 5.1 pounds of N, 7.3 pounds of P_2O_5, and 8.8 pounds of K_2O. During 1928 and 1930 covercrops of Hubam clover were turned under. Notwithstanding this apparently liberal application of fertilizer to these palms, which are about 14 years of age, some palms in the better portion of the garden are beginning to show symptoms of decline while the diseased palms have not improved but have steadily become worse. If the fertilizer applications have been too small because of the large quantities of irrigation water applied, the open texture of the soil and the nutrient requirements of rapid growth, the following cases will make it clear that the diseased palms may not respond even to somewhat heavier applications of fertilizer. For example, two diseased palms received in addition to the previously mentioned amount of fertilizer the equivalent of 25 tons of manure per acre in trenches 2½ feet deep, and 2000 pounds of 4–10–10 fertilizer per acre, but showed no sign of recovery in 18 months. Iron sulfate applied to two palms at the rate of 40 pounds per palm (10 pounds in each of four pits 1 to 2 feet deep at a 4-foot radius from the palm) had, at the end of one year, brought about no recovery. However, it is not impossible that the palms may require considerably heavier applications and more time. Treatments with other chemicals such as $Zn(NO_3)_2$, NaCl, KCl, K_2SO_4, $MnCl_2$, S, $Ca(NO_3)_2$, H_3BO_3, etc., have not been given sufficient time to produce effects.

A marked improvement, however, of one badly diseased palm which had ceased bearing fruit was brought about by the application of a copper sulfate solution to the soil in a square about the palm. In this case 16 pounds of copper sulfate were applied in solution on November 30, 1929, and likewise 34 pounds on January 4, 1930. The analysis of pinnae collected from this palm one month later showed a composition similar to that of pinnae of healthy palms. Measurements six months later of the bud elongation and fruit production (fig. 1) confirmed these analytical results. During this period the diseased palm that served as a control (fig. 2) steadily became worse. More recent and extensive applications of copper sulfate to other diseased palms are being made by disking the material into the soil and following this by basin irrigation. It will be of great interest and importance if these treated palms show the same rapidity in recovering from the disease. Experiments are also being conducted in which much larger quantities of certain salts than are normally used in the fertilization practice are being added to the soil, in the hope that all of a given element will not be fixed before coming in contact with some of the roots.

Samples of soil obtained from 2-foot depths in locations where the palms are diseased and in other locations in the same garden where they are healthy, show that the soil areas having diseased palms fix phosphorus and potassium more readily than the soil of the better locations.[4] The water extract of the soil samples from the

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[4] The soil analyses were conducted independently by Professor P. L. Hibbard, the detailed data being omitted in this paper.

affected areas shows more calcium and less potassium than that of samples from the healthy areas. This is also true of the relative amounts of these bases replaced from the two soil samples by normal

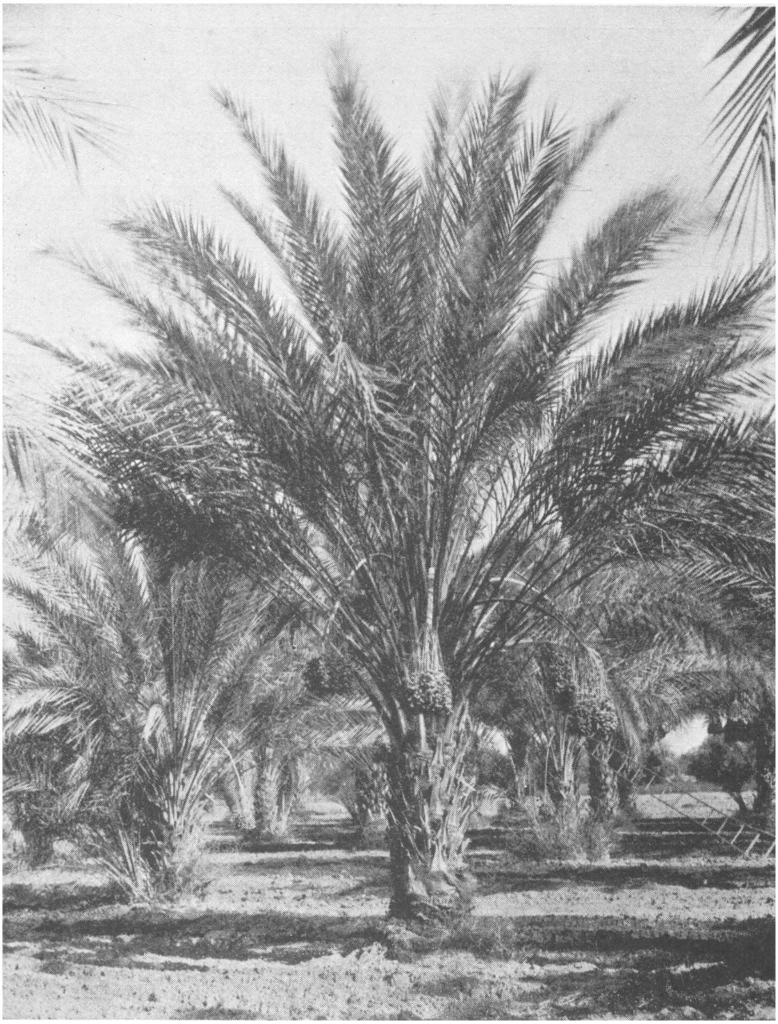

Fig. 1. Deglet Noor date palm recovering from decline disease after applications of copper sulfate to the soil.

ammonium acetate. Our analyses of the pinnae (table 1) of diseased and healthy palms parallel the results shown by the analyses of the soil samples.

TABLE 1

Composition of Deglet Noor Date Pinnae Expressed as Percentages

Sample number*	Condition of palm**	Grouped by color of powdered leaves	Total ash in dry matter	Acid (HCl) soluble ash		Acid (HCl) insol. residue		Silica in acid (HCl) insoluble residue	Calcium			Potassium			Sodium in dry matter	Magnesium in dry matter	Total chlorine in dry matter	Total sulfur in dry matter	Total phosphorus in dry matter	Total nitrogen in dry matter	Total nitrogen in silica-free dry matter
				In dry matter	In silica-free dry matter	In dry matter	In total ash		In dry matter	In silica-free dry matter	In acid-soluble ash	In dry matter	In silica-free dry matter	In acid-soluble ash							
5	g	Dark green	19.84	3.22	3.86	16.62	83.77	95.86	0.62	0.74	19.25	0.65	0.78	20.12	0.27	0.11	0.58	0.25	0.11	1.85	2.22
16	†r	Dark green	12.72	3.08	3.41	9.64	75.77	94.62	0.61	0.67	19.82	.50	.55	16.13	.27	.12	.43	.21	.12	1.53	1.69
19	g	Dark green	21.63	2.68	3.31	18.94	87.59	97.08	0.64	0.79	23.81	.34	.42	12.67	.31	.11	.30	.22	.11	1.42	1.73
2	g	Dark green	19.05	2.77	3.31	16.28	85.44	94.93	0.62	0.73	22.25	.49	.59	17.74	.22	.12	.48	.22	.11	1.42	1.70
22	g	Dark green	15.08	3.35	3.79	11.74	77.81	95.94	0.74	0.84	22.12	.50	.57	14.91	.31	.13	.26	.19	.14	1.38	1.55
9	g	Dark green	17.21	3.36	3.90	13.85	80.47	96.69	0.67	0.77	19.82	.41	.47	12.17	.31	.09	.29	.28	.15	1.31	1.52
12	g	Intermediate	19.50	3.22	3.84	16.28	83.50	95.94	0.86	1.02	26.61	.40	.47	12.34	.25	.17	.45	.21	.10	1.26	1.51
24	b	Yellowish	20.32	3.04	3.68	17.28	85.02	98.39	0.94	1.13	30.81	.23	.28	7.49	.26	.15	.20	.15	.13	1.20	1.43
20	b	Yellowish	13.82	2.89	3.24	10.93	79.10	97.03	0.67	0.75	23.09	.30	.33	10.21	.22	.10	.21	.17	.13	1.19	1.34
6	b	Intermediate	14.17	3.49	3.91	10.69	75.38	97.33	0.83	0.93	23.73	.40	.44	11.38	.35	.26	.35	.28	.13	1.17	1.31
11	gb	Intermediate	21.64	3.02	3.71	18.62	86.05	97.29	0.91	1.12	30.13	.28	.35	9.34	.30	.12	.24	.21	.10	1.15	1.41
3	b	Yellowish	13.18	3.10	3.45	10.08	76.49	95.96	0.71	0.79	22.85	.38	.43	12.33	.25	.23	.39	.23	.11	1.15	1.28
4	gb	Intermediate	19.66	3.22	3.85	16.44	83.63	97.77	0.89	1.07	27.73	.28	.34	8.79	.27	.14	.25	.20	.06	1.13	1.35
14	b	Yellowish	17.24	2.96	3.45	14.28	82.82	97.07	0.77	0.90	26.11	.31	.36	10.54	.32	.20	.35	.27	.09	1.09	1.27
7	gb	Intermediate	22.20	3.20	3.95	19.00	85.59	....	1.09	1.34	34.07	.23	.28	7.05	.25	.12	.29	.24	.08	1.09	1.34
8	b	Intermediate	16.54	3.51	4.03	13.04	78.80	97.92	1.01	1.16	28.88	.26	.30	7.47	.25	.26	.45	.24	.07	1.05	1.21
23	b	Yellowish	19.50	3.63	4.32	15.86	81.36	97.13	1.20	1.43	33.13	.17	.20	4.65	.31	.19	.17	.23	.07	1.04	1.22
13	gb	Yellowish	21.54	2.88	3.54	18.65	86.61	98.65	0.95	1.16	32.81	.21	.26	7.37	.27	.11	.24	.27	.07	1.02	1.26
15	gb	Yellowish	20.75	3.18	3.85	17.57	84.70	96.59	1.03	1.25	32.55	.20	.24	6.30	.37	.22	.33	.22	.09	0.92	1.12
10	gb	Yellowish	22.13	2.68	3.33	19.44	87.88	98.22	0.82	1.02	30.54	.14	.18	5.34	.25	.13	.19	.22	.08	0.92	1.14
21	b	Yellowish	15.01	3.18	3.61	11.83	78.82	98.60	0.94	1.07	29.60	.19	.21	5.94	.26	.24	.31	.22	.07	0.89	1.00
1	b	Yellowish	24.65	3.33	4.23	21.32	86.48	98.73	1.04	1.33	31.30	.20	.26	6.03	.20	.12	.37	.23	.06	0.82	1.03
25	b	Yellowish	22.65	3.70	4.56	18.95	83.67	99.00	1.41	1.74	38.08	.13	.17	3.62	.24	.22	.31	.25	.08	0.82	1.01
17	b	Yellowish	22.52	2.74	3.41	19.79	87.85	98.22	0.86	1.07	31.51	.17	.22	6.36	.31	.13	.44	.27	.05	0.81	1.01
18	b	Yellowish	28.79	3.65	4.88	25.13	87.35	98.91	1.21	1.61	33.03	0.16	0.21	4.38	0.29	0.14	0.58	0.30	0.04	0.70	0.93

* All samples collected, December 14, 1929.

** Key to symbols: g = good in decline-disease-free garden; b = bad in diseased garden; r = recovering from disease; gb = good in diseased garden.

† Soil treated with copper sulfate.

Fig. 2. Deglet Noor date palm affected with decline disease and bearing no fruit; this is the control for the palm shown in figure 1.

COMPOSITION OF THE PINNAE

All healthy and diseased fronds were collected in date palm gardens of the Coachella Valley, the apparently healthy leaves being secured both from gardens in which the disease was present and in those where there was no evidence of the malady. In all cases collection of the material was made subsequent to the pruning of the palms and removal of the old desiccated leaves. All of the pinnae of two green fronds of the lowermost whorl furnished the sample in each case. The pinnae were cut off at their base, the halves spread apart and all sand and dust carefully wiped off. They were then dried in an electric oven at 70° C.

The inorganic composition of the pinnae is given in table 1. The samples analyzed are arranged in a descending order determined by the nitrogen content of their dry matter. The diseased pinnae are low in total nitrogen, potassium, and phosphorus but high in calcium as compared with healthy pinnae.

When the finely ground pinnae were placed in white porcelain dishes, the samples from healthy palms showed a dark green color, while those from severely diseased palms were yellow. Several disinterested people placed the samples in the same order as given by the authors in table 1. It may be mentioned that it was impossible to guess by examining fronds detached from healthy and diseased palms as to the group from which they were secured. All samples consequently were labeled on a cut surface at the base of the frond.

Table 1 shows that the chemical analyses of pinnae from apparently healthy palms growing in close proximity to diseased palms may not show any appreciable difference from those of the diseased palms. This suggests that the decline disease may affect palms by degrees and that the better looking palms may decline very abruptly after they have the composition of diseased palms. As a consequence the control fronds were secured from gardens that apparently were free of the disease.

It should be mentioned that the analyses of the pinnae were carried on in two ways: (1) in which the iron, aluminum, and phosphorus were removed prior to the determination of calcium; (2) in which they were not removed. Although the results were not very different, the former method appeared to be preferable, due in some cases to the interference of iron, when using the latter method.

Table 1 shows the ash in the dry matter to range from about 12 to 29 per cent. The acid-soluble ash as a percentage of the dry matter varied from 2.68 to 3.70 per cent, and the acid-insoluble residue from 9.64 to 25.13 per cent. This acid-insoluble residue is not a result of soil adhering in the pocket at the base of the pinnae, as these pockets were opened and thoroughly cleaned during the preparation of the samples.

The acid-insoluble residue was 75 to 88 per cent of the total ash. From 95 to 99 per cent of this acid-insoluble residue in the ash consisted of silica as was determined by volatilizing the silica with hydrofluoric acid. These analyses showed, therefore, that about four-fifths of the ash of the pinnae of Deglet Noor palms is silica. Perhaps these palms approach in composition as closely as it is possible in nature, to the world famous handmade glass plants that are exhibited at the Harvard University Museum. Water culture experiments may make it possible to determine whether large amounts of silica are essential for the successful growth of the date palm.

Table 1 indicates higher percentages of total nitrogen in the dry matter of healthy than in diseased pinnae. Considering the relatively large applications of nitrogen applied in some diseased gardens in the Coachella Valley as compared to the meager applications of animal manure in the Old World plantings, the low values for total nitrogen in diseased pinnae can hardly be associated with inadequate nitrogen fertilization. The total nitrogen content of the dry matter of date pinnae is less than that of normal mature citrus leaves which usually contain 2 to 2.5 per cent.

The per cent of calcium in the dry matter is very low as compared with that of citrus, which contains 5 per cent or more. When citrus leaves are mottled they contain less calcium than normal leaves, while table 1 shows that the reverse is true for health in date pinnae, namely, that when the pinnae contain the least calcium they are more nearly normal. However, if the ash of the pinnae is considered as a basis then the per cent of calcium is not as low as one might at first glance take it to be. Because of the large quantities of silica present the acid-soluble ash is only about one-fifth of the total ash. Calculation of the calcium on the basis of the acid-soluble ash shows the healthy pinnae to contain about 20 per cent and the diseased in some samples nearly 40 per cent. In the acid-soluble ash of normal mature citrus leaves the calcium is about 35 per cent and in that of mottled leaves about 25 per cent, the reverse of the order found in diseased date pinnae.

The low percentage of calcium in the dry matter of healthy pinnae is associated with a high percentage of potassium. Conversely the diseased pinnae have the higher percentages of calcium and the lower percentages of potassium. The potassium values for the dry matter of the pinnae are in most cases much below those of calcium. It may be of interest here to mention that the ash of the leaves of corn plants, which like palms are monocotyledonous, has been shown by Schweitzer[7] to contain about 4 per cent lime and 31 per cent potash. In the diseased date pinnae the potassium in the acid-soluble ash ranged as low as 3.62 per cent and in the healthy pinnae as high as 20.12 per cent. If the calcium and potassium percentages were based on the total instead of on the acid-soluble ash, the values would all be considerably lower. In the sample having the highest percentage of nitrogen the percentages of calcium and potassium are approximately equal. The inverse relationship of calcium and potassium is the opposite of that found in the case of mottle-leaf of citrus. Very little, if any, mottling of citrus has been found to occur in the close proximity of decline-diseased palms. The excessive calcium and the deficient potassium in the diseased pinnae agree very well with the limited results of soil studies previously mentioned. It is too early as yet to say which is cause and which is effect, whether the composition of the pinnae is the result of the decline or the decline a result of the composition. It suffices for us at present to learn the facts in the case.

A deficiency of potassium in the diseased pinnae coupled with the high fixation of potassium in the affected soils, may tempt individuals to fertilize their soils rather heavily with potassium. It should be noted at this point that should a deficiency of available potassium prove to be an important factor in this decline disease, even many times the amounts considered to be heavy fertilizer applications may prove inadequate because of the rapid fixation by the soil. Unusually large, commercially impracticable amounts may have to be applied before an effect on the palms becomes evident. On the other hand, if we add large amounts of potassium to a soil, the fixation of much of the applied potassium may mean a considerable increase in soluble calcium, an excess of which already is present. Temporarily at least such applications might even be looked upon as possibly producing an initial set-back rather than a recovery, while the application of other salts, such as calcium compounds, that set free potassium and other cations into the soil solution may prove effective earlier. Considering the present lack of knowledge as to the effect of large applications of potassium to the soil, the trials now being conducted by the Experiment Station should be adequate for the time being.

Table 1 shows no difference in the sodium, magnesium, total sulfur, and total chlorine content of diseased and normal pinnae. In view of the great tolerance of date palms for white alkali salts as reported by Swingle[8] it is rather surprising to find such a condition. He has pointed out that the date palm is able to grow in soils containing 3 per cent of the alkali salts (30,000 parts per million) and irrigated with brackish water containing 0.6 per cent of alkali salts (6000 parts per million). Under such conditions growth is no doubt retarded and when the alkali salt concentration becomes excessive the disease called "Meznoon" makes its appearance. The results in table 1 do not show that the better pinnae contain more salts than the diseased. This would indicate, therefore, that soil or irrigation water suitable for commercial date culture need not be heavily charged with salts. Soil adaptation has been given only a secondary consideration in the planting of date palms, the essential factors for successful date culture being considered largely as consisting of an ample supply of irrigation water, a low humidity throughout most of the year, and adequate heat units. The fact that the date palm in the Old World has in many cases been found by Popenoe[5] and others to be growing under extremely saline soil conditions, has given the impression that the sandy loam soils with a small percentage of clay and slightly charged with salts may be preferable to the richer, heavier soils. Rudolfs[6] has reported a beneficial effect of common rock salt upon the growth of asparagus which is a monocotyledonous plant. The absence of a large alkali salt content in the pinnae of date palms grown in the Coachella Valley confirms the fact that the Valley has unusually pure irrigation water and that the soil solution is not heavily charged with salts. On the contrary the application in large quantities of this water of high quality may over a period of years impoverish the soil solution.

In table 1 the results for total phosphorus show in general that the badly diseased pinnae contain lower percentages than healthy pinnae. This is also in agreement with the results obtained for the phosphorus-fixation power of the soil areas bearing healthy and diseased palms, although the differences are much smaller than those of calcium and potassium.

Water solubility studies made on eight samples of finely ground pinnae show that practically all of the ash of the water-soluble fraction of the dry matter dissolves in nitric acid. The acid-insoluble ash, which was shown to be largely silica, constituted 92 to 95 per cent of the ash of the water-insoluble fraction of the dry matter. The ash of the water-soluble dry matter is about 72 to 80 per cent of the total ash soluble in nitric acid. Seventy-four to 80 per cent of the total calcium, 87 to 99 per cent of the total potassium, 74 to 85 per cent of the total magnesium, and 54 to 64 per cent of the total sodium were water-soluble. For calcium the values obtained by Haas[2] for citrus were considerably lower.

It should be mentioned at this time that the pinnae of three healthy and three diseased *Cocos plumosa* palms obtained from a nursery near San Diego showed essentially the same type of results as were found for the Deglet Noor date pinnae, so that it would not be surprising to find cases of the disease occurring in other varieties of date palms grown on a commercial scale. In fact several palms of the Thoory variety have already been found showing the symptoms and composition of decline-diseased pinnae.

COMPOSITION OF THE FRUIT

In one garden it was possible to secure Deglet Noor dates from healthy and diseased palms. Calculated on a dry matter basis, the pulp of the dates of healthy palms showed 1.04 per cent of potassium, 0.10 per cent of calcium, 0.08 per cent of magnesium, 0.38 per cent of chlorine, and 3.34 per cent of acid-soluble ash, while the values for the pulp of dates of diseased palms were 0.89, 0.09, 0.10, 0.23, and 2.54 per cent respectively. Over 90 per cent of the inorganic constituents of the dry matter of date pulp is water-soluble.

Calculated on a dry matter basis the seed of the dates from healthy palms showed 0.28 per cent of potassium, 0.04 per cent of calcium, 0.14 per cent of magnesium, and 1.03 per cent of acid-soluble ash, while the seed of the dates of diseased palms showed 0.37, 0.05, 0.11, and 1.36 per cent respectively. The pulp of the fruit of healthy and diseased palms show small differences in composition the order of which is reversed in case of the seed of the two groups. Further analyses including phosphorus are being made as fruit becomes available. These limited data on the composition of fruit make it evident that the Deglet Noor palm in order to mature a crop of fruit requires considerably more potassium than calcium. For the pulp nearly ten times as much potassium as calcium is required and for the seed seven times as much. If we assume 200 pounds of seeded dates per palm, which represents about 150 pounds of dry matter, as a commercial yield, the fruit alone would require nearly 1½ pounds of actual potassium (nearly 2 pounds K_2O), not considering the additional potassium requirement of the new growth produced each year by the palm.

Obviously with soil applications of potash (K_2O) equal to 2 or 3 pounds per palm, which is a liberal application in the case of citrus, it seems inevitable that sooner or later a deficiency of available potassium must occur. The soils of the Coachella Valley contain considerable mica which may serve as a potential source of potassium. However, as previously referred to, the potassium-fixation power of many of these soils is considerable, in which case great difficulties might be encountered by the palms in obtaining potassium adequate for commercial date production. It should be stated here that the soils in the Coachella Valley may be adequately fertilized from the standpoint of citrus but perhaps far inadequately as regards the Deglet Noor palm. A fertilization practice to make certain elements available at a sufficiently rapid rate may not be economically feasible. As has already been mentioned, field trials for this distinct purpose are now being conducted. Haywood[3] has reported the beneficial effects of heavy applications of fertilizer rich in potash on the yield of dates in his garden. Analysis of dates obtained from palms that have received large applications of potash should be of interest from the standpoint of fruit quality.

TABLE 2

COMPOSITION OF ROOTS OF HEALTHY AND DISEASED DEGLET NOOR DATE PALMS EXPRESSED AS PERCENTAGES

	Old palms		Young palms	
	Healthy	Diseased	Healthy	Diseased
Ash of water-soluble dry matter, soluble in HNO_3	5.20	6.61	4.01	3.36
Ash of water-insoluble dry matter, soluble in HNO_3	1.40	1.21	0.71	0.98
Total ash in dry matter	11.72	10.68	7.72	7.29
Chlorine in dry matter	1.52	....	....	0.93
Water-soluble calcium in total calcium	53.02	58.46	52.48	38.72
Total calcium in dry matter	0.68	0.54	0.28	0.47
Total calcium in total ash	5.79	5.09	3.65	6.45
Total phosphorus in dry matter	0.14	0.12	0.15	0.07
Total sulfur in dry matter	0.41	....	0.29	0.22
Water-soluble potassium in total potassium	96.59	96.58	94.15	94.73
Total potassium in dry matter	1.79	2.63	1.52	1.33
Total potassium in total ash	15.28	24.64	19.72	18.23
Water-soluble magnesium in total magnesium	61.01	64.72	57.21	54.22
Total magnesium in dry matter	0.32	0.33	0.22	0.17
Total magnesium in total ash	2.71	3.05	2.88	2.28
Water-soluble sodium in total sodium	80.44	84.19	86.92	73.22
Total sodium in dry matter	0.50	0.86	0.75	0.42
Total sodium in total ash	4.23	8.05	9.70	5.79

COMPOSITION OF THE ROOTS

Analyses were made of roots (about ⅜ to ¼ inch in diameter) obtained from healthy and diseased Deglet Noor palms. The difficulty of removing adhering material from the roots even though they were allowed to dry and were thoroughly scrubbed with a fine brass-wire brush, makes their analyses of doubtful value. Furthermore, there is no known way of choosing roots of comparable age and consequently the results in table 2 should be considered only as being suggestive. In both cases total phosphorus is higher in the roots of healthy than in diseased palms. Table 2 also shows the percentage of potassium in the dry matter of healthy and diseased roots greatly to exceed that of calcium. The potassium content of the roots is about 95 per cent water-soluble and is considerably higher than that of the pinnae, fruit pulp, or seed.

INORGANIC COMPOSITION IN RELATION TO CARBOHYDRATE CONTENT

The relatively high potassium content of various portions of the Deglet Noor date palm is of interest from the standpoint of the carbohydrate nutrition. It has been shown by Janssen and Bartholomew[4] that there is a relation between the concentration of potassium and carbohydrate metabolism in tomato plants. Determinations were made of the total sugars plus starch in date pinnae containing high and low percentages of potassium. The results are given as total reducing sugars calculated as percentages of the dry matter. Table 3 compares the values obtained with those of total potassium, nitrogen, calcium, and phosphorus in the dry matter.

TABLE 3

RELATION OF PERCENTAGES OF TOTAL SUGARS PLUS STARCH TO INORGANIC CONSTITUENTS IN DRY MATTER OF DEGLET NOOR DATE PINNAE

Sample number	Total sugars plus starch as dextrose (C)	Potassium (K)	Total nitrogen (N)	Calcium	Total phosphorus	C/K	C/N
Healthy							
19	4.374	0.34	1.42	0.64	0.11	12.9	3.08
22	4.1804	0.50	1.38	0.74	0.14	8.4	3.03
12	4.1496	0.40	1.26	0.86	0.10	10.4	3.29
Diseased							
21	3.4837	0.19	0.89	0.94	0.07	18.3	3.91
1	3.3586	0.20	0.82	1.04	0.06	16.8	4.10
25	3.231	0.13	0.82	1.41	0.08	24.8	3.94

In the healthy pinnae the higher percentages of carbohydrates are in general associated with the higher percentages of potassium, nitrogen, and phosphorus but with the lower percentages of calcium; whereas the diseased pinnae are characterized by a lower carbohydrate, potassium, nitrogen and phosphorus content, but a higher percentage of calcium. It appears, therefore, that in the decline-diseased palms the metabolism of both the organic and the inorganic constituents is seriously interfered with and as a consequence the quality and composition of the fruit undergo considerable change. The last two columns of table 3 which are designated carbohydrate-potassium $\left(\frac{C}{K}\right)$ and carbohydrate-nitrogen $\left(\frac{C}{N}\right)$ ratios, show that the carbohydrate content in relation to either potassium or nitrogen is greater in the diseased than in the healthy pinnae.

GROWTH OF DATE SEEDLINGS IN CONTROLLED CULTURES

To learn more about the nutrition of date palms, Deglet Noor seedlings are now being grown in sand and water cultures. The seeds were germinated in a deep container of pure sand and when the tops had grown several inches in length it was found that the roots had grown from one to two feet in length. By inserting a glass rod into the sand close to the plant to be removed it was possible by shifting the rod back and forth to remove the greater portion of the root system intact. The other method employed was to remove the side of the container and wash away the sand. In the first method the sand can be kept clean and used over again for the same purpose; the plants can be selected and removed without disturbing the others and the smaller ones left to grow for a time before being transplanted. The roots were washed with distilled water and some of the seedlings transferred to deep enamelware pails and others to deep battery jars.

It is of interest to note that in most cases the secondary roots are negatively geotropic for a distance from the primary root and then become positively geotropic. Thickenings, the structure and function of which have not as yet been investigated, occur on the roots at intervals as shown in figure 3. Even though the culture vessels were deep and the solutions unchanged during long intervals, the roots remained a healthy white color and showed no signs of a lack of aeration.

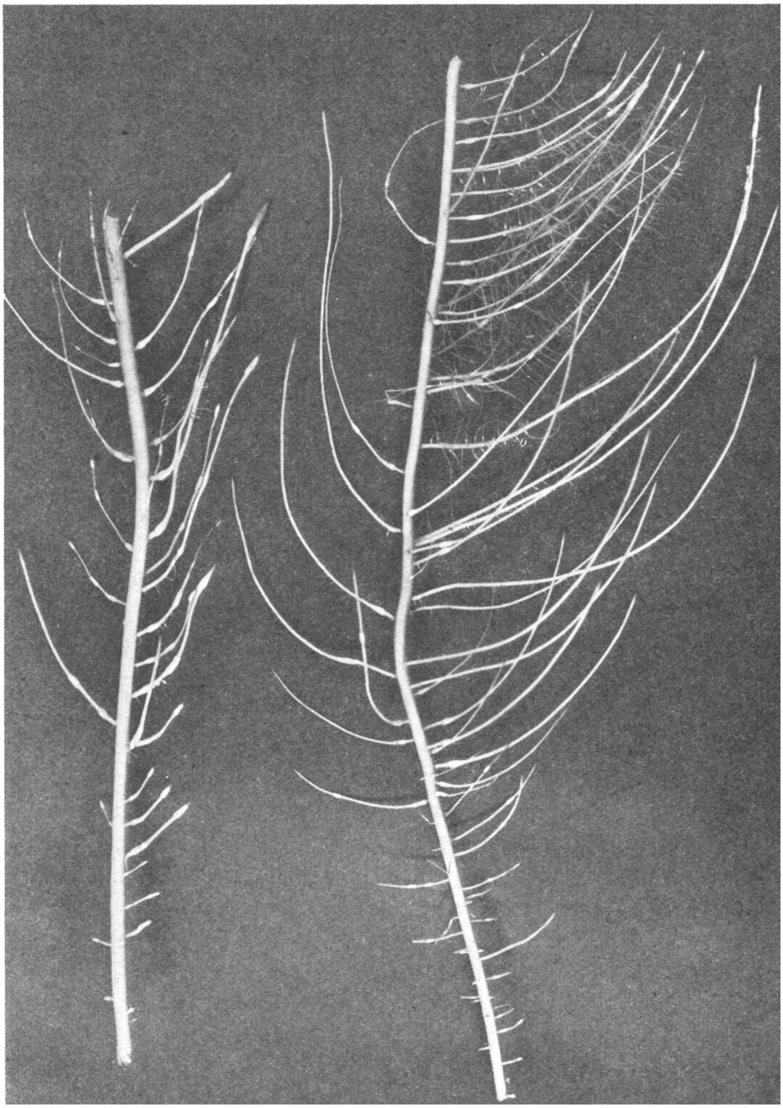

Fig. 3. Growth habit of date seedling roots when grown in water culture. Note direction of lateral roots.

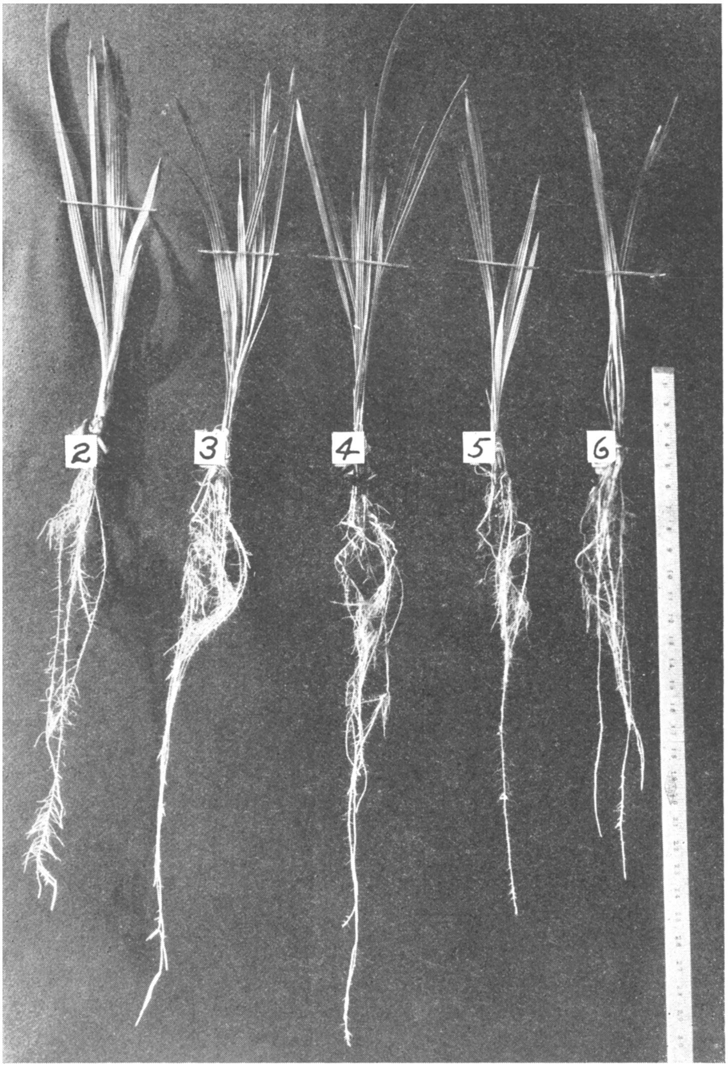

Fig. 4. Tolerance of date seedlings (Thoory variety) for large concentrations of sodium chloride in culture solution. The figures represent the thousands parts per million of sodium chloride.

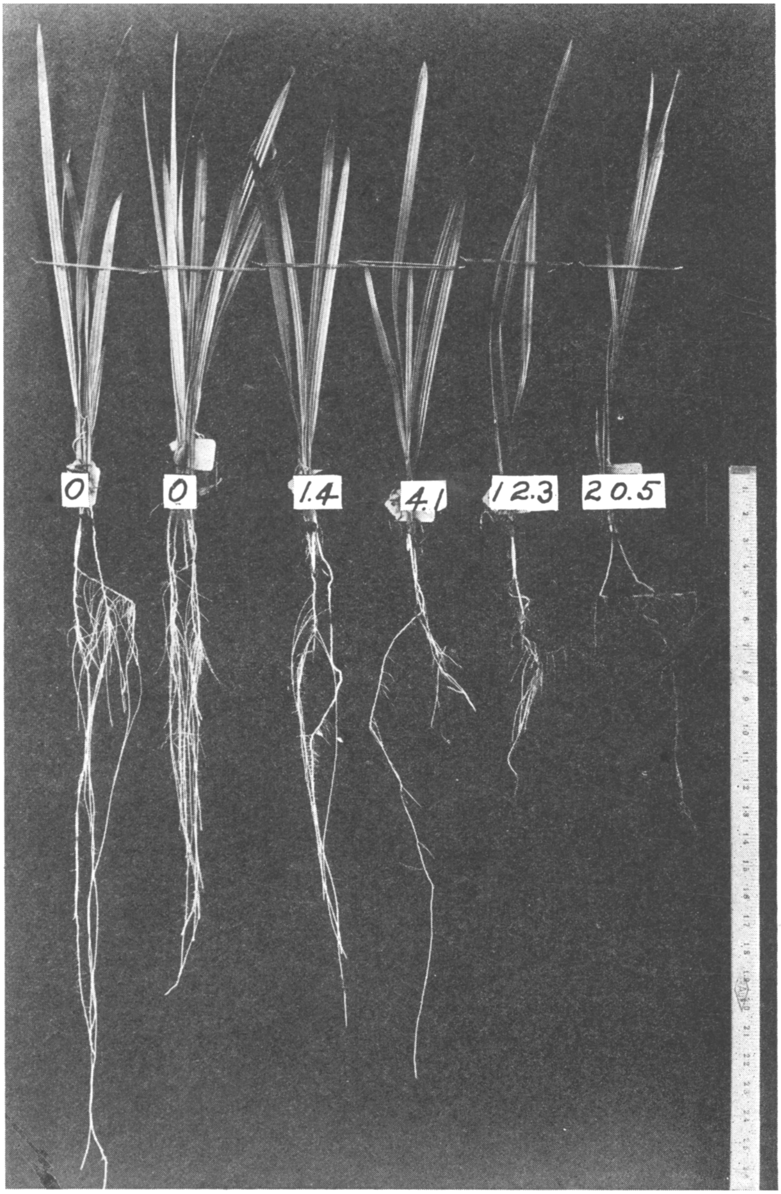

Fig. 5. Toxicity of beryllium to Deglet Noor date seedlings in water cultures. The concentrations of beryllium are shown in parts per million.

Date seedlings of the Thoory variety were placed in Hoagland's solution containing from 0 to 6000 p.p.m. of sodium chloride. Very little effect was to be found up to 4000 p.p.m., but beyond this concentration the leaves were inclined to tip burn and the roots were somewhat retarded although of a healthy appearance (fig. 4). This great tolerance of date palm seedlings for salts is in harmony with observations on date culture in the Old World where the palms are found tolerating large concentrations of alkali salts in the soil and irrigation water. The successful culture of date palms in the Coachella Valley indicates that saline conditions are unnecessary and possibly undesirable.

Although date palm seedlings are uninjured in culture solutions containing excessive concentrations of certain salts, they may be extremely susceptible to injury when grown in culture solutions containing small concentrations of certain toxic elements. This is shown by the fact that Deglet Noor date seedlings were seriously injured when the concentration of beryllium in the culture solution exceeded 4 p.p.m. (fig. 5).

Very little is known regarding the importance of traces of certain elements such as copper and silicon for the healthy growth of the date palm. The large silica content of pinnae and roots of the date palm makes it desirable to study the relation of silica to the nutrition of the plant. Likewise in the soil treatments mentioned, we do not know whether copper acts as an essential element or whether its usefulness depends on its interaction with the other elements of the soil setting more potassium or phosphorus, etc. free into the soil solution, whether it acts as a germicidal or antiseptic agent, or as a toxin precipitant.

SUMMARY

A serious malady, 'decline disease,' has appeared in the date gardens of the Southwest. It is characterized by retardation and eventual cessation of growth, destruction of roots, and gradual reduction in quality and quantity of fruit produced. The *Diplodia* disease is frequently associated with the decline.

Comparative analyses show that the diseased pinnae are lower in carbohydrates, total nitrogen, potassium, and phosphorus, but higher in calcium than the healthy pinnae. There were no appreciable differences in the sodium, magnesium, total sulfur, and total chlorine of diseased and normal pinnae.

Copper sulfate applied to the soil about one badly diseased palm has in three months effected a great improvement as shown by new growth and by the composition of the pinnae. Subsequent fruitfulness also indicated further improvement. No control palms have been known to recover.

There is a great variation in the ash of the dry matter of date pinnae, ranging from about 12 to 29 per cent. Date pinnae are highly siliceous, containing from 9 to 25 per cent of silica in the dry matter. About 80 per cent of the ash is silica. Seventy-four to 80 per cent of the total calcium and 87 to 99 per cent of the total potassium of the pinnae are water-soluble.

The pulp of dates dried at 70° C contained about 1.0 per cent of potassium and about 0.1 per cent of calcium. Over 90 per cent of the inorganic constituents of the dry matter of date pulp is water-soluble.

The potassium content of the dry matter of the roots is three to four times as large as the calcium and is considerably higher than the potassium found in the pinnae or fruit.

Date seedlings (Thoory variety) in culture solutions were apparently uninjured by concentrations of sodium chloride below 4000 p.p.m. Certain elements such as beryllium may be extremely toxic to Deglet Noor date seedlings.

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The titles of the Technical Papers of the California Agricultural Experiment Station, Nos. 1 to 20, which HILGARDIA replaces, and copies of which may be had on application to the Publication Secretary, Agricultural Experiment Station, Berkeley, are as follows:

4. Effect of Sodium Chlorid and Calcium Chlorid upon the Growth and Composition of Young Orange Trees, by H. S. Reed and A. R. C. Haas. April, 1923.
5. Citrus Blast and Black Pit, by H. S. Fawcett, W. T. Horne, and A. F. Camp. May, 1923.
6. A Study of Deciduous Fruit Tree Rootstocks with Special Reference to Their Identification, by Myer J. Heppner. June, 1923.
7. A Study of the Darkening of Apple Tissue, by E. L. Overholser and W. V. Cruess. June, 1923.
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11. Studies on the Effects of Sodium, Potassium, and Calcium on Young Orange Trees, by H. S. Reed and A. R. C. Haas. October, 1923.
12. The Effect of the Plant on the Reaction of the Culture Solution, by D. R. Hoagland. November, 1923.
14. The Respiration of Potato Tubers in Relation to the Occurrence of Blackheart, by J. P. Bennett and E. T. Bartholomew. January, 1924.
16. The Moisture Equivalent as Influenced by the Amount of Soil Used in its Determination, by F. J. Veihmeyer, O. W. Israelsen and J. P. Conrad. September, 1924.
17. Nutrient and Toxic Effects of Certain Ions on Citrus and Walnut Trees with Especial Reference to the Concentration and Ph of the Medium, by H. S. Reed and A. R. C. Haas. October, 1924.
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20. A Study of the Conductive Tissues in Shoots of the Bartlett Pear and the Relationship of Food Movement to Dominance of the Apical Buds, by Frank E. Gardner. April, 1925.