Table 1. Results of fungicide test for control of avocado scab on Lula fruit.

Fungicide* and amount/100 gallons	Yield No. fruit per plot	Free of scab (%)	Severe Scab (%)
Tribasic copper sulfate, 3 lbs. + Volck oil, 1 qt.	400	98.1	0.6
Captan, 3 lbs.	399	86.3	5.1
Ferbam, 3 lbs. + Volck oil, 1 qt.	440	98.8	0.3
Dodine, 0.5 lb.	476	74.2	9.9
Dodine, 0.25 lb. + captan, 2 lbs.	350	89.4	3.8

* Applications made on February 28, April 3, and May 9-11.

EFFECTS OF NITROGEN, POTASSIUM AND CALCIUM FERTILIZATION ON KENT MANGOS ON DEEP, ACID, SANDY SOIL

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Substantial increases in yield with increasing nitrogen fertilization have been reported (6) for Kent mangos growing on deep, acid, sandy (Lakewood) soil. However, incidence of "soft-nose," a physiological breakdown in the flesh of mango fruits (8), also increased greatly with increasing nitrogen fertilization on such soil. On calcareous rock soil (Rockdale), increased yields with increased nitrogen fertilization were somewhat questionable (8), and incidence of soft-nose remained insignificantly low, although nitrogen level in trees, as measured by leaf analysis, was comparable to that on the sandy soil. The calcium level of trees on calcareous rock soil, however, was two or three times that of trees on sandy soil. This suggested an inter-relationship in Kent mango trees between nitrogen and calcium in which calcium at relatively high levels tended to prevent or retard soft-nose, which evidently was aggravated by high nitrogen levels in the tree.

Somewhat analogous conditions have been reported for other crops. Garman and Mathis (2) observed that low levels of calcium, as compared with potassium and magnesium, in apple fruits resulted in an increase in bitter pit, and that heavy nitrogen fertilization aggravated this unbalanced condition. Evans and Troxler (1) demonstrated that blossom-end rot of tomatoes, a physiological disorder, was associated with low levels of calcium in the plant. Geraldson (3) was able to show a similar association for celery blackheart and Hamilton and Ogle (4) for blossom-end rot of peppers, both physiological disorders.

An experiment, designed to investigate further the influence of nitrogen on yield of Kent

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mangos on sandy soil and to explore the possibility of reducing soft-nose by increasing calcium level in the tree, was started at Boynton in August 1960. Some attention also was given to potassium fertilization in this experiment because of the rather common, but unsubstantiated, belief among growers that soft-nose was controlled and better yields obtained through heavy potash fertilization.

The present paper covers results from the first two years with this experiment.

Materials and Methods

The soil in the experimental grove was a Lakewood fine sand, with orange colored sand at a depth of about 42 inches. Immediately before these experimental treatments were started, the 0 to 6-inch depth had a pH of 5.1 to 5.6 and an extractable calcium[1] content of 437 pounds per acre. The 6 to 12-inch depth had a pH of 5.1 to 5.4 with 93 pounds of extractable calcium. The grove was not cultivated.

The trees were ten years old at initiation of this investigation and, as buffer trees in a former experiment, had been fertilized for the previous six years with 2-6-8-3, 4-6-8-3 and 8-6-8-3 (N-P_2O_5-K_2O-MgO) commercial mixtures. In selecting trees for the present experiment, care was taken, by measuring tree height and spread, to have uniform size trees among the various treatments. Sixty buffered, completely randomized, single-tree plots were used. All trees in the experimental block were fertilized with 4-6-8-3 at 14 pounds per tree once a year immediately after harvest in both seasons considered here. This basic over-all treatment was supplemented with calcium nitrate, ammonium nitrate (or nitrate of soda), muriate of potash, high calcium limestone and gypsum, each alone and in various combinations on different trees at rates and according to plan shown in Table 1. With this arrangement, each material was applied to 18 trees, either alone or in combination, except for potash, which was applied to 24 trees as a "cross-treatment" on the other supplemental fertilizer treatments.

Calcium nitrate and ammonium nitrate (or nitrate of soda) treatments were at rates supplying 1 pound of nitrogen per tree each application and were made each crop year in August, November and February. Thus, trees under supplemental nitrogen treatments each received a total of 3.56 pounds of nitrogen a year, as compared with 0.56 pound for other trees in the experiment, including controls. For reasons to be discussed later, nitrate of soda was substituted for ammonium nitrate as a non-calcium bearing source of nitrogen in these treatments for the 1961-62 crop year.

Limestone was applied once a year in early fall at 500 pounds per tree. This was spread in a 50-foot diameter circle about the tree so as to reach trunks of adjacent trees and thus was equivalent to 4½ tons per acre.

Gypsum was applied at 1000 pounds per tree at same time and in same manner as limestone. This rate, equivalent to 9 tons per acre, supplied approximately the same amount of calcium per tree as the limestone.

Extra potassium was supplied as muriate of potash on three trees from each of the calcium nitrate, ammonium nitrate (or nitrate of soda), limestone, gypsum and combination treatments. Trees selected to receive this extra potassium averaged the same size in each treatment as those receiving potassium only from the N-P-K-Mg fertilizer. These potash treatments were made three times a year, along with supplemental nitrogen treatments, at rate which supplied 1.4 pounds of potash per tree each application, or a total of 4.2 pounds of supplemental potash a year. This, combined with 1.12 pounds of potash from the N-P-K-Mg fertilizer, supplied 5.32 pounds of potash annually to these trees, as compared with 1.12 pounds for remainder of trees in experiment.

Yields and incidence of soft-nose were obtained by counting fruits from individual trees at harvest, which occurred from late June to early August in both seasons. Each fruit was examined for soft-nose, and unless unquestionably firm and free of external symptoms of the breakdown, it was cut for inspection. The error in determining incidence of soft-nose was negligible by this method.

Leaf samples for nitrogen and mineral analyses were taken from all trees in each treatment just before harvest in 1961 and 1962. Leaves in these samples were from near the terminal of the last mature flush and distributed evenly between fruiting and non-fruiting shoots. Soil samples from all trees in each treatment were taken from 0 to 6-inch and 6 to 12-inch depth in mid-July each year for pH, calcium and potassium determinations.

Results

Average yield per tree and incidence of soft nose under each of the 17 different treatments

[1]Extractable with 1 N ammonium acetate, pH 7.0.

Table 1. Supplemental fertilizer treatments in N-K-Ca experiment with Kent mangos on acid, sandy soil for crop years 1960-61 and 1961-62.

Treatment symbol	No. of trees	Material	Lbs./tree each application	Number of applications per year
CN	3	Calcium nitrate	6.45	3
CNK[1]	3			
AN[2]	3	(Ammonium nitrate (or Nitrate of soda	3.00) 6.25)	3
ANK[1,2]	3			
L	3	High Ca limestone	500.00	1
LK[1]	3			
G	3	Gypsum	1000.00	1
GK[1]	3			
CNL	3	(Calcium nitrate (High Ca limestone	6.45 500.00	3 1
CNLK[1]	3			
CNG	3	(Calcium nitrate (Gypsum	6.45 1000.00	3 1
CNGK[1]	3			
ANL[2]	3	(Ammonium nitrate (or Nitrate of soda (High Ca limestone	3.00) 6.25) 500.00	3 1
ANLK[1,2]	3			
ANG[2]	3	(Ammonium nitrate (or Nitrate of soda (Gypsum	3.00) 6.25) 1000.00	3 1
ANGK[1,2]	3			
Control	12	None	--	-

1 Indicates duplication of preceding treatment, plus 2.3 pounds of muriate of potash per tree in each of 3 applications a year.

2 Ammonium nitrate used in 1960-61 and nitrate of soda in 1961-62.

are shown for both seasons in Table 2. Nitrogen, potassium and calcium contents of leaves from the various treatments are given in Table 3. Over-all yields and soft-nose incidence are summarized, together with pertinent data on over-all leaf and soil composition, in Table 4.

The nitrogen content of leaves from trees receiving supplemental nitrogen fertilization rather consistently was greater than from other treatments, and with no important difference between nitrogen sources either season. Increased nitrogent content of leaves generally was accompanied by increased yields, as shown in Fig. 1, and generally by an increased incidence of soft-nose, as shown in Fig. 2.

The correlation between treatment and calcium content of leaves was poor in 1961, but fairly good in 1962. At rates used in this experiment, gypsum seemed to be slightly more effective than limestone in increasing calcium level in tree, and calcium nitrate appeared to be about as effective as limestone. As shown in Fig. 3, as calcium content of leaves increased, incidence of soft-nose decreased. At calcium levels above about 2.4 percent, incidence of soft-nose dropped to around 5 percent or less, regardless of nitrogen level in leaves.

Table 2. Yield and incidence of soft-nose - 1961 and 1962.

Treatment[1/] symbol	Yield - No. fruits/tree			Percentage soft-nose		
	1961	1962	Average	1961	1962	Average
CN	200	443	322	23.5	4.3	13.90
CNK	282	424	353	15.3	1.4	8.35
AN	220	361	296	40.0	4.7	22.35
ANK	144	431	288	49.3	4.4	26.85
L	98	247	173	4.1	0.4	2.25
LK	202	361	287	5.9	1.1	3.50
G	94	295	195	10.6	1.4	6.00
GK	109	177	143	3.7	0.6	2.15
CNL	241	407	324	30.7	2.7	16.70
CNLK	173	455	314	23.1	5.1	14.10
CNG	231	389	310	21.7	3.1	12.40
CNGK	242	447	345	14.5	2.5	8.50
ANL	138	404	271	34.1	3.7	18.90
ANLK	220	562	391	35.9	3.6	19.75
ANG	278	467	373	21.2	2.8	12.00
ANGK	157	420	289	32.5	3.4	17.95
Cont.	151	279	215	6.0	1.4	3.70
Statistical significance						
Treatment			**			**
Year			**			**

*F values indicating significance at 5% level.
**F " " " " 1% " .

1/ See Table 1.

Leaves from trees receiving supplemental potash fertilizer generally contained substantially more potassium, and slightly less calcium, than leaves from corresponding treatments without the extra potash. Although the increased potassium in leaves was reflected by a slight trend towards increased yields and a decrease in incidence of soft-nose, the differences were not significant.

Discussion

The differences in yield and incidence of soft-nose, regardless of fertilizer treatment, between the 1960-61 and 1961-62 season were striking. Over-all average yield in 1962 was over twice that in 1961 and incidence of soft-nose in 1962 about 12 percent of that in 1961 (Table 4). Also, broad differences, which could not be explained by treatments, occurred in leaf (Table 3) and soil composition (Table 4) between 1961 and 1962. Nitrogen, potassium and especially calcium content of leaves increased in 1962 over that of 1961 more than could be accounted for readily by fertilizers that had been applied. The soil pH and calcium increase recorded for most of these treatments from 1961 to 1962 could not be accounted for entirely on basis of materials applied to soil. The limestone and calcium nitrate would tend to raise both the pH and calcium, but gypsum would raise

Table 3. Nitrogen, potassium and calcium content of Kent mango leaves collected just before harvest in 1961 and 1962.

Treatment[1/] Symbol	Percentage Dry Weight					
	1961			1962		
	N	K	Ca	N	K	Ca
CN	1.18	0.15	1.75	1.19	0.32	3.06
CNK	1.15	0.27	1.75	1.36	0.54	2.81
AN	1.33	0.16	1.68	1.42	0.42	2.44
ANK	1.18	0.22	1.55	1.16	0.54	2.12
L	0.91	0.29	2.00	1.00	0.50	3.38
LK	1.15	0.35	1.68	1.07	0.65	2.94
G	0.91	0.35	1.82	0.89	0.49	3.50
GK	0.91	0.17	2.22	1.00	0.65	4.12
CNL	1.24	0.11	1.80	1.42	0.26	2.88
CNLK	1.18	0.26	1.75	1.24	0.54	2.75
CNG	1.21	0.22	2.25	1.51	0.35	3.12
CNGK	1.27	0.17	1.50	1.16	0.59	3.06
ANL	1.27	0.15	2.12	1.21	0.34	2.62
ANLK	1.27	0.15	1.62	1.24	0.50	2.44
ANG	1.24	0.11	1.52	1.24	0.32	3.25
ANGK	1.21	0.25	1.52	1.24	0.64	2.81
Cont.	0.97	0.12	1.82	1.18	0.44	2.50

1/ See Table 1.

Table 4. Over-all yields, incidence of soft-nose, leaf and soil composition.

	All (60) trees					
	1961			1962		
	Min.	Max.	Avg.	Min.	Max.	Avg.
Yield - Number of fruits per tree	5	448	187	30	643	386
Percent soft-nose	0.91	100.00	21.92	0.36	9.48	2.71
Percent N in leaves	0.91	1.33	1.15	0.89	1.51	1.21
Percent Ca in leaves	1.50	2.25	1.78	2.12	4.12	2.93
Soil Ca, 0-6", lbs./A.	340	620	466	456	2875	1266
" " , 6-12", lbs./A.	75	255	142	249	747	447
Soil pH 0-6" depth	4.8	5.9	5.3[1/]	5.5	6.9	6.1[1/]
" " 6-12" "	4.9	5.7	5.3[1/]	5.3	6.7	5.9[1/]

1/ Arithmetical averages.

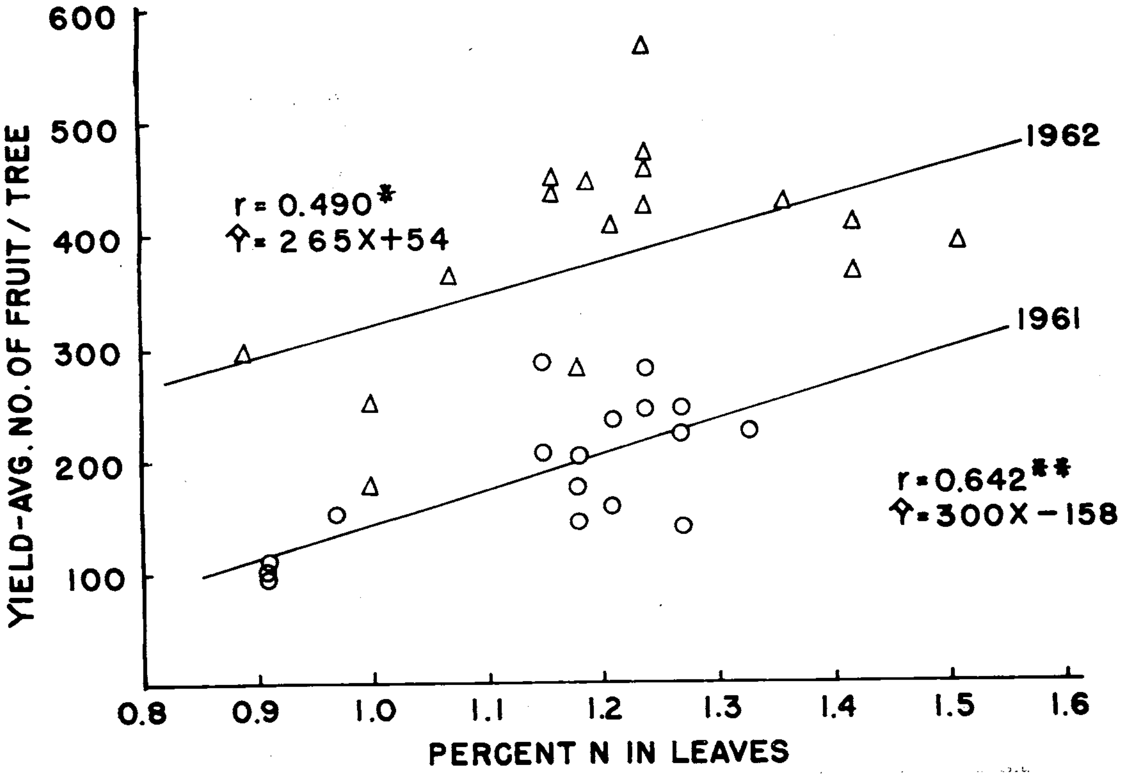

Figure 1. Relationship between yield and percentage nitrogen in leaves.

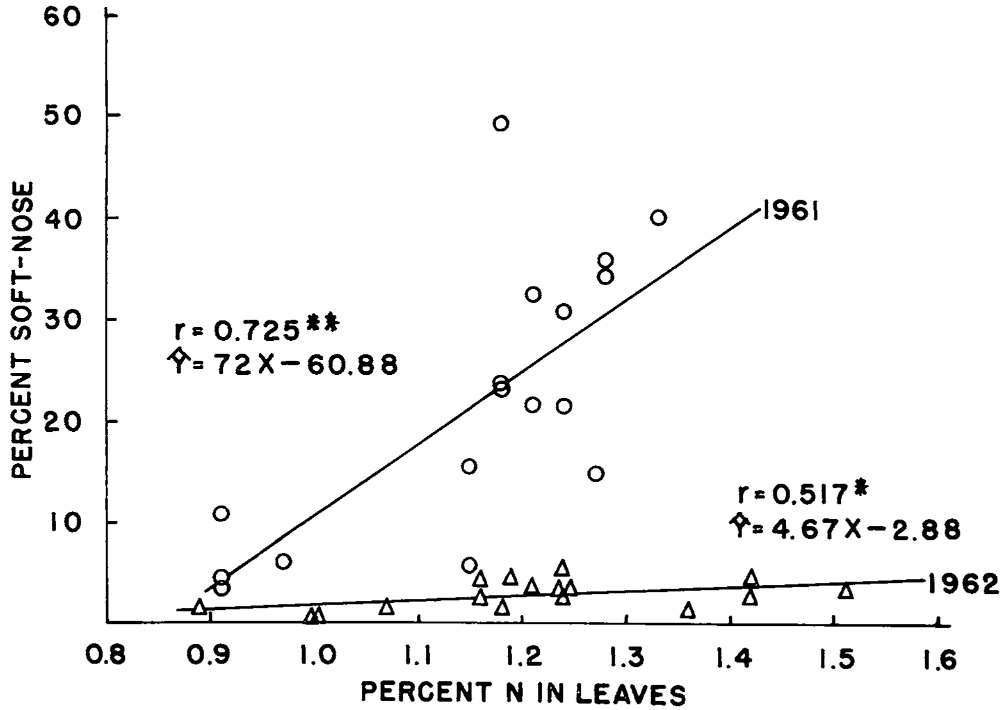

Figure 2. Relationship between percentage soft-nose and percentage nitrogen in leaves.

only the calcium and nitrate of soda only the pH of the soil. Moreover, from 1961 to 1962, the pH of the soil in the control plots at the 0 to 6-inch depth increased from 5.3 to 6.0 and at 6 to 12-inch depth from 5.4 to 5.6, and calcium from 340 to 622 and 90 to 290 pounds per acre at the two depths, respectively, without treatment with calcium. It appeared that there was a seasonal effect concerned, at least to some extent in these differences. Temperatures were fairly comparable for the two seasons, with 1960-61 being slightly warmer, but it was much drier, especially until about harvest, in 1961-62 than in 1960-61, and no irrigation was used. Available information on weather factors is not sufficient, however, to explain how these could have been responsible for the differences observed, if such was the case, or to even isolate the factor (or factors) involved. Regardless, the bloom and crop in 1962 was the best in the history of the grove.

Incidence of soft-nose in 1961 from supplemental ammonium nitrate treatments averaged considerably more (34%) than in the calcium nitrate treatments (21%). The probability that the ammonium ion could be antagonistic to the absorption of calcium was pointed out by van der Merwe (5), and he demonstrated that as the proportion of ammonium nitrogen in nutrient solution increased, the absorption of calcium decreased. Because of the possibility that the ammonium ion was in this way responsible for the high incidence of soft-nose from the ammonium nitrate treatments, nitrate of soda was substituted for ammonium nitrate, beginning with the post-harvest treatments in 1961.

With the exception of the high incidence of soft-nose from the ammonium nitrate treatments in 1961, there was no important difference between the supplemental nitrogen treatments each year in the average yield or soft-nose incidence. The two-year average yield for all treatments with extra nitrogen, including those combined with limestone and gypsum, was 322 fruits per tree per year, with 36 soft-nose fruits per tree (11.2%), or 286 sound fruits per tree. If the ammonium nitrate and nitrate of soda treatments which were not combined with limestone or gypsum treatments are excluded, incidence of soft-nose was somewhat less and the trees averaged 296 sound fruits each season. The controls aver-

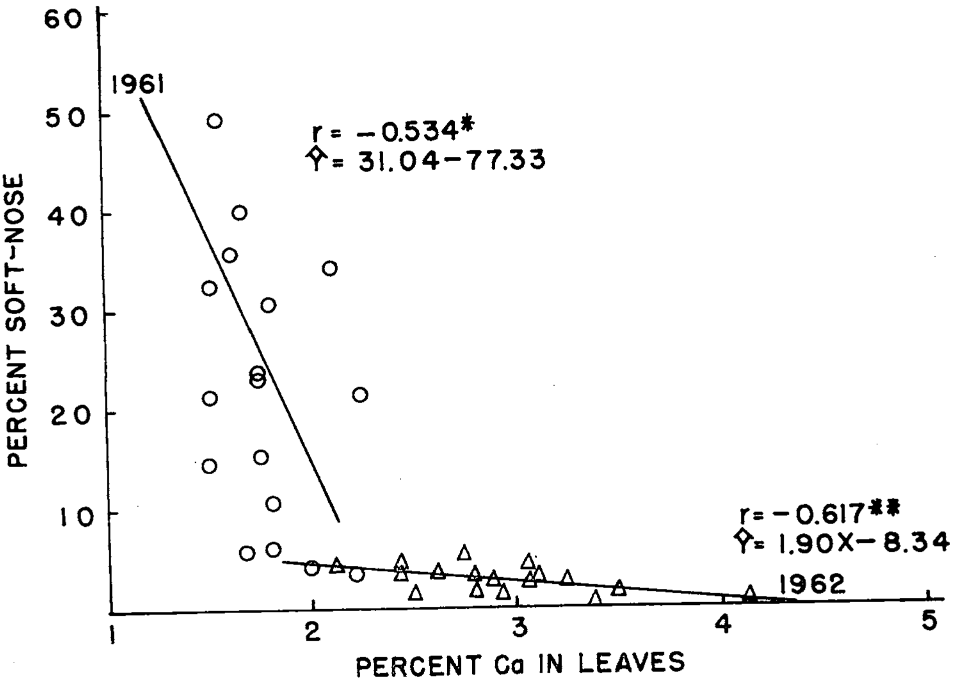

Figure 3. Relationship between percentage soft-nose and percentage calcium in leaves.

aged 215 fruits, with 7 soft-nose fruits per tree (3.2%), or 208 sound fruits per tree. This is a gain of about 2 bushels of sound marketable, fruits per tree each year, which was obtained by increasing nitrogen from 0.56 pound per tree per year to 3.56 pounds per tree and maintaining a relatively high calcium level in the tree. It was mentioned that increased potassium fertilization resulted in no measurable benefit to yields or soft-nose incidence.

When used in combination with calcium nitrate treatments, neither limestone nor gypsum caused a measurable reduction in incidence of soft-nose below that occurring where calcium nitrate was used alone. With ammonium nitrate treatments, incidence of soft-nose in 1961 was reduced from an average of about 45 percent for ammonium nitrate alone, to 35 percent where limestone also was used and to about 27 percent with gypsum. On the same plots in 1962, when nitrate of soda was substituted for ammonium nitrate, the amount of soft-nose was almost insignificant in all cases, ranging from an average of 4.6 percent for nitrate of soda alone to 3.7 and 3.1 percent for nitrate of soda in combination with limestone and gypsum, respectively.

On the limestone and gypsum plots where no supplemental nitrogen was used, incidence of soft-nose was not measurably different between the two treatments either season and was comparable to that on controls.

The positive influence of the nitrogen level in the tree on incidence of soft-nose was somewhat greater than the negative influence of the calcium level, as indicated in the multiple regression equation $\widehat{Y} = 17.047X_1 - 13.339X_2 - 30.679$, where X_1 represents nitrogen percentage and X_2 calcium percentage in leaves. The multiple regression coefficient ($R = 0.725^{**}$) was highly significant. Indications are, however, that if the calcium level in the tree was maintained around 2.5 percent, or somewhat higher, incidence of soft-nose probably would level off at somewhere near that of controls, even with relatively heavy nitrogen fertilization. Evidence thus far suggests that this probably could be accomplished by using calcium nitrate as principal source of nitrogen, plus perhaps reasonably heavy maintenance applications of materials such as limestone or gypsum, once calcium in the soil was brought to the necessary level. Such a program would be entirely feasible economically.

The question arises as to whether varieties of mangos other than Kent would respond to nitrogen and calcium treatments in the manner described here. A partial answer was obtained for the Haden variety on acid, sandy soil by some tests with ammonium nitrate at heavy rates of application (7). Yields did not increase with increased nitrogen fertilization, but soft-nose incidence was around 50 percent, as compared with 12 percent on controls. In this connection, it should be pointed out that the Kent mango normally sheds large numbers of immature fruits with developing seeds, whereas most of immature fruits shed by the Haden variety, often in large numbers also, are with aborted seeds. Most of these Haden fruits with aborted seeds would shed regardless of nutritional factors, but with Kent the fruit-shed apparently is due to crop strain and is alleviated by extra nitrogen.

This paper is in the nature of a progress report only. With such nutritional work on tree crops, especially on mangos, definite and final conclusions cannot be justified without several additional years' data.

Summary

Yields on Kent mangos growing on deep, acid, sandy soil were increased substantially by heavy nitrogen fertilization. Incidence of *soft-nose*, a physiological disorder in the fruit, also increased with increased nitrogen fertilization, but was alleviated to a great extent by increasing the calcium level in tree through heavy soil applications of limestone or gypsum, or by using calcium nitrate almost exclusively as a source of nitrogen. The combination of heavy nitrogen and calcium fertilization resulted in an average increase in yield of about 2 bushels of sound, marketable, fruits per tree each year for the two years this test has been conducted.

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DISTRIBUTION OF PEACH ROOTS IN LAKELAND FINE SAND AND THE INFLUENCE OF FERTILITY LEVELS

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Peaches have not been grown to any extent in Florida for two reasons. First, the damage caused by root-knot nematodes, particularly on deep, sandy soils, has been severe. Second, standard peach varieties developed in areas farther north require more winter cold for proper growth and fruiting than normally occurs in Florida.

The nematode problem has recently been solved by the introduction of the nematode-resistant Okinawa peach rootstock (13). Even more recently, another nematode-resistant rootstock, Nemaguard, has been made available (2).

The development of varieties adapted to Florida's mild winters has been slower. However, recent introductions, such as the Flordawon from Florida (12) and Tejon from California (1), have made commercial peach production feasible as far south as Tampa.

Because large acreages of low-income land are available and because of the off-season production due to Florida's long growing season, there is much interest in peach production. Numerous small commercial acreages of Flordawon and Tejon have been planted, and over 100,000 trees of these varieties were budded in Florida in 1962.

Despite the fact that rootstocks and varieties suitable for Florida are now available, successful commercial peach production is not a certainty. With the development of a crop in a new area,

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