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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production problems usually arise that were not anticipated. New or modified cultural methods must frequently be developed.

Of immediate concern was the dearth of information relative to the extent and density of rooting of the commercially untested Okinawa rootstock and the influence of mineral nutrition on root development. It was the purpose of the experiment reported herein to obtain information about these factors.

PROCEDURE

This work was conducted in an orchard of the Flordawon variety on Okinawa peach roots. Root samples were obtained during parts of May and June of the third growing season.

The method of obtaining root samples was essentially that of Ford (5) for sampling citrus roots. Using a hand well-drilling auger, soil cores 4 inches deep and 8 inches in diameter were taken. Each core was screened through quarter-inch hardware cloth in the field. Peach roots estimated to be larger than 2 mm in diameter, weed roots, and foreign material were discarded, and the remaining peach roots placed in labeled paper bags.

The bagged samples were dried at 70° C. for 24 hours and cooled to room temperature in a desiccator. The roots were then transferred to a screen-wire basket, shaken to remove adhering sand, and weighed. The root density or concentration was calculated as grams (dry weight) of roots per cubic foot of soil.

The fertilizer sources used in this experiment were ammonium nitrate, potassium sulfate and magnesium sulfate; however, in order to conform with grower usage, all fertilizers are reported in this paper as ounces of N, K_2O, and MgO.

General Extent and Density of Roots. Four trees were used from plots receiving 4, 4, and 2 ounces of N, K^2O, and MgO per tree, respectively.

Density of rooting was determined from samples taken around the tree at the following points: halfway between the trunk and outer extremity of the branches (1.5 to 2.5 feet from the trunk), at the outer extremity of the branches, 6 feet from the trunk, and 9 feet from the trunk. Four equidistant borings were taken between the trunk and branch extremity, and 8 borings were taken at each of the other locations. Four-inch cores were used as samples in the top 2 feet of soil. Below that, 1-foot cores were used.

Depth of rooting was determined by boring until no roots were found in a 1-foot core. The lateral extent of the roots was determined by taking 18-inch borings at 1-foot intervals out from the 9-foot radius until no roots were found.

Influence of N, K, and Mg. The effect of nitrogen on density of rooting was determined by sampling from plots in which potassium and magnesium levels were kept constant and N levels were 2, 4, or 6 ounces per tree per year. The effects of potassium and magnesium were determined similarly. Trees receiving 2, 4, or 6 ounces of K_2O and 0, 2, or 4 ounces of MgO per year, respectively, were used. The fertilizer experiment has been replicated only 4 times; therefore, it was necessary to use trees at the 2 K_2O-2 MgO, and 3 K^2O-2 MgO levels in order to get 8 trees at each nitrogen level. Likewise, trees were used at the 2 N-2 MgO, and 2 N-3 MgO levels for potassium and 2 K_2O-2 N, and 3 K^2O-2 N levels for magnesium.

Samples were taken in 4-inch increments to a depth of 2 feet at 8 equidistant points around the tree at the outer branch extremities

A split-block design, using depths of sampling as main plots and treatments as subplots, was used. Statistical significance for differences between means was determined by Duncan's multiple-range test.

Calcium content of the soil was determined from 9 samples taken at each of 3 depths, as indicated in Table 4, in an X pattern across the entire block of trees. The samples were analyzed on the flame spectrophotometer.

RESULTS AND DISCUSSION

General Extent and Density of Roots. The roots penetrated deepest at the sampling radius nearest the trunk, i.e., halfway in from the outer extremities of the branches. As indicated in Table I, the rooting depth at this radius ranged from 9.5 to 12.5 feet with a mean depth of 11 feet.

The lateral root extent ranged from a radius of 9.0 to 12.5 feet. Due to the fact that the trees were spaced 25 by 25 feet, some overlapping may have occurred with the adjacent trees. The mean lateral radius, assuming that the roots extended no farther than 12.5 feet, was 10.5 feet (Table 1).

Figure 1, which was constructed from the data in Table 2, diagramatically portrays several zones distinguished by differences in density or concentration of roots. Generally, the concentration of roots diminished both with increased distance from the trunk and with depth (Figures 1, and 2). This is in general agreement with work of Cowart (3) in Georgia.

Table 1.--The extent of the Okinawa peach root system.

	Depth (feet)	Lateral rooting radius (feet)
Mean	11.0	10.5
Range	9.5 - 12.5	9.0 - 12.5

Table 2.--Average feeder root density[1] of Okinawa peach rootstock. Flordawon top in Lakeland fine sand.

Depth (Inches)	Distance from trunk			
	1.5 - 2.5 ft.	3 - 5 ft.	6 ft.	9 ft.
0-4	13.24	2.22	0.65	0.35
4-8	9.06	2.22	1.42	0.96
8-12	6.41	1.75	1.58	0.66
12-16	3.22	1.17	1.11	0.87
16-20	1.77	0.59	0.29	0.28
20-24	1.40	0.56	0.29	0.15
24-26	1.41	0.37	0.22	0.11
26-48	1.14	0.37	0.15	0.10
48-60	1.16	0.31	0.05	0.05
60-72	0.44	0.16	0.01	
72-84	0.48	0.14		
84-96	0.38	0.06		
96-108	0.20	0.01		
108-120	0.09	0.01		
120-132	0.06			

[1] Expressed as grams of feeder roots (dry weight) per cubic foot of soil and the mean of 4 trees sampled.

By far the greatest concentration of roots was in the top foot, with 68.0 percent occurring there (Figure 2). The second foot contained 19.5 percent of the roots, and only 12.5 percent was found below 2 feet.

Undoubtedly, the great depth of *penetration* and lateral extent of the roots found in this study was due largely to the nature of the soil profile, which was very well drained and had a clay layer at 11 feet. Hinrichs and Cross (7), working with heavy soils in Oklahoma, planted peaches in holes only deep enough to accommodate the roots and in holes 4 feet deep and 5 feet square. Roots of trees planted in the large holes extended a maximum of 11 feet from the trunk and some were 10 feet deep at the end of 2 years. The others had a lateral extent of only 8 feet, 3 inches, and a depth of 4 feet.

There has been very little work relative to the density or concentration of peach roots with which this work can be compared. Savage and Cowart (11), in Georgia, reported that 5-year-old peach trees had roots that extended laterally 13 feet from the trunk and roots as deep as 10 feet, but that 90 percent of the roots were in the top foot of soil.

Thus, a high concentration of roots in the top portion of the soil, despite deep and extensive lateral rooting, may be common to peaches in both Georgia and Florida.

Contrary to this concept, Proebsting (10), in California, reported the maximum concentration

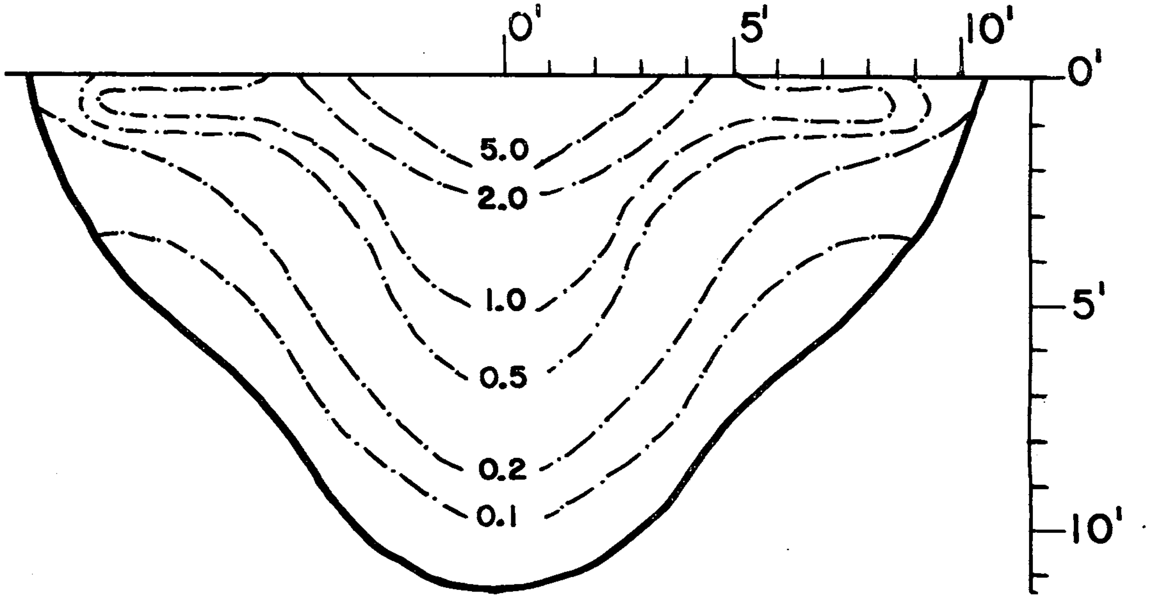

Figure 1. Diagramatic portrayal of density of feeder roots of an Okinawa peach root system (Flordawon top) in grams per cubic foot.

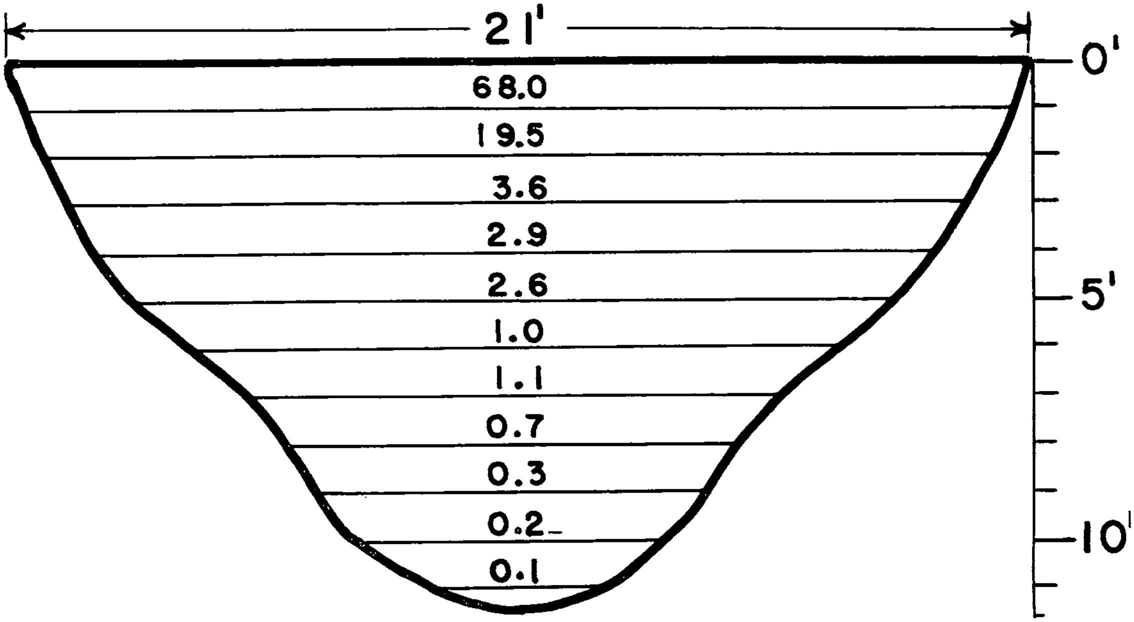

Figure 2. Mean percentage of peach feeder roots contained in each foot of soil below Flordawon peach trees on Okinawa rootstocks.

of peach roots was not in the top foot but between 1 and 5 feet deep. However, this was in a dry, irrigated area that is quite different from the southeastern United States. Proebsting postulated that the scarcity of roots in the upper foot was due to high soil temperatures. Nightingale (8) has pointed out that little root growth occurs at temperatures above 95° F.

It was noted in this work (Table 2) that in a zone 6 to 9 feet from the trunk there were fewer roots in the top 4 inches of soil than in 4 inches immediately below. This was not true closer to the trunk, where the top 4 inches had the greatest concentration of roots. This could have been due to one or more of several factors. Soil temperatures may have been lower under the canopy (no temperature measurements were taken), or competition from weeds in the middles may have been greater. Also, fertilizer applications were all made close to the tree, and the trees were tank-watered the first year. However, it is probably more pertinent that the middles were disked while areas under the trees were kept free of weeds by shallow hand-hoeing.

Whether the small concentration of roots found below 2 feet was due to the genetic constitution of the peach or to a more unfavorable environment below the 2-foot level was not determined.

An aggregate soil sample taken from several points in the orchard and at several depths indicated that there was a much lower calcium content in the lower soil zones. A more extensive group of soil samples (Table 4) showed that the top 4-8 inches had a mean Ca-content of 1600 pounds of Ca per acre-6-inches. Samples from the 12-16-inch depth had 150 pounds of Ca per acre-6-inches; below 2 feet it was only 35 pounds. Thus, the calcium content decreased with depth, roughly parallelling the decreases in root concentration. This is by no means conclusive evidence that the root concentration was limited by the Ca-content of the soil. However, substance is given to this hypothesis by Gammon (6). He reported that the roots of several species of plants did not penetrate layers of soil that contained no Ca, even though the pH of the no-Ca layers had been adjusted to that of layers containing Ca and in which roots did grow satisfactorily.

The extensive lateral rooting suggests the

Table 3.--The effect of three levels of N, K and Mg on feeder root density[1] of young peach trees at various soil depths.

	Feeder roots in indicated depth zones						
Oz N/Year	0-4 (in)	4-8 (in)	8-12 (in)	12-16 (in)	16-20 (in)	20-24 (in)	0-24 (in)
2........	2.66 a	2.75 ab	2.40 a	0.99 a	0.49 a	0.62 a	9.91 a
4........	3.87 b	3.46 b	2.09 a	1.10 a	0.75 a	0.97 a	12.24 b
6........	2.03 a	2.34 a	1.85 a	0.90 a	0.65 a	0.61 a	8.38 a
Oz K_2O/Year							
2........	2.06 a	2.63 a	2.02 a	1.08 a	0.91 a	0.83 a	9.53 a
4........	4.14 b	2.95 a	2.38 a	1.40 a	1.24 a	0.84 a	12.95 b
6........	2.15 a	2.22 a	1.42 a	0.74 a	0.43 a	0.55 a	7.51 a
Oz MgO/Year							
0........	1.68 a	2.58 ab	2.01 a	1.22 a	0.82 a	0.65 a	8.96 a
2........	3.87 b	3.46 b	2.09 a	1.10 a	0.75 a	0.97 a	12.24 a
4........	2.12 a	2.15 a	1.58 a	1.05 a	0.65 a	0.83 a	8.38 a

Means in the same column not followed by any letter in common differ significantly at the 1 percent level, except in the last column, where they differ at the 5 percent level.

[1] Expressed as grams (dry weight) per cubic foot of soil.

feasibility of broadcasting fertilizer with a mechanical distributor during the third growing season. On the other hand, the heavy concentration of roots under the tree canopy is undoubtedly more than adequate to take up the needed mineral elements if fertilizer is applied in that area.

The fact that 68.0 percent of the roots were in the upper foot points out the need for frequent, shallow cultivation to control weeds. Also, the high concentration of small roots in the top foot of soil, coupled with the fact that the peach develops to maturity during Florida's dry season (March, April, May), strongly indicates that irrigation may be an annual requirement.

Ford (5), in Florida, has reported that, with sweet orange tops, over 50 percent of rough lemon feeder roots may be below 30 inches and 15 percent below 9 feet. This suggests that closer attention to cultivation and irrigation will be necessary with peaches than with citrus.

However, the deep rooting of peaches, as indicated in this study, should not be discounted. The exact value of the deep roots is not known. However, Oskamp (9), working with apples and peaches in New York, reported that the deeper rooted trees were almost invariably the more productive trees.

Table 4.--Calcium at 3 different depth-zones in a Lakeland fine sand in a young peach orchard.

Depth (Inches)	Calcium content (pounds per acre-6-inches)	
	Mean	Range
4-8	1600	500-1800
12-16	150	50-300
Below 24	35	5-60

Influence of N, K, and Mg. The highest densities or concentrations of roots were obtained from plots receiving the medium levels of N, K, and Mg.

When the densities of roots for the entire 24-inch cores were compared, only the means from the N and K experiments differed significantly. However, when the mean densities from the 4-inch cores were used, only the 0-4 and 4-8 inch increments from the medium N and Mg plots and only the 0-4 inch increments from the medium K plots were significantly higher than those at the high and low levels. No statistically significant differences were found below 8 inches; however, the density of roots did tend to be highest in the plots receiving the medium levels of the 3 elements.

There are no field studies with peaches with which the above results can be compared. Results of work with peaches grown in solution cultures indicate that N, K, and Mg all may influence the root production.

Cullinan *et al.* (4) found that, with peaches grown in nutrient solutions, the size of both the root system and the top increased with additions of N up to 60 ppm and with K up to 10 ppm. Weinberger and Cullinan (15) reported that peaches grown in nutrient solutions without N had many decayed roots, but the root system was not greatly reduced; and, in comparison with trees receiving either no-K or no-Mg, these trees had the largest root system in proportion to the top. Where Mg was excluded, roots were small and scarce, but apparently healthy. Where K was eliminated, the root system was small in comparison with the top, as was the case when a complete nutrient solution was used, but the roots showed no deficiency of growth. Waltman (14), working with peaches grown in sand cultures, found that 448 ppm of N seriously retarded root growth and the fibrous growth was very poor. At 56 ppm a very good, fibrous root system was developed, and at 0 ppm a moderately good root system with dense fibrous growth occurred.

Results of the experiment reported herein are somewhat clouded by the fact that relatively high rates of fertilizer had been applied during the first year of growth. The rates per tree were as follows: 4, 8, or 16 ounces of N; 2, 4, or 8 ounces of K_2O; and 1, 2, or 4 ounces of MgO. The fertilizer was applied in 4 equal applications during the growing season. In the second year the fertilizer rates were reduced to those indicated in the section on Procedure.

The high concentrations of salts applied during the first year may have damaged the root system to such an extent that it had not recovered by the time the root samples were taken. Of course, the current high level could still be excessive.

It may be that the lack of treatment differences of root concentration was due simply to the inherent nature of the peach root system. On the other hand, the large decrease in Ca below the 4-8-inch-depth zone suggests that Ca may have been limiting and thus precluded any response to N, K, or Mg. However, further work is needed to substantiate or refute this assumption.

Summary and Conclusion

1. Young peach trees growing in a Lakeland soil with a clay layer at 11.0 feet had a mean rooting depth of 11.0 feet at a point halfway between the trunk and the outer extremities of the branches. The mean lateral rooting radius was 10.5 feet.
2. Sixty-eight percent of the roots were found in the top foot of soil, 19.5 percent in the second foot, and only 12.5 percent below 2 feet.
3. The extensive lateral spread of roots suggested that fertilizers might be efficiently broadcast with a mechanical fertilizer distributor as early as the third growing season.
4. The high percentage of roots found in the upper foot of soil suggests that cultivations should be shallow and frequent enough to maintain good weed control. In view of the heavy concentration of roots reportedly found below 30 inches for citrus, it appears that cultivation and irrigation practices for peaches will need to receive much closer attention than they will with citrus.
5. Coupled with the fact that the Fordawon and Tejon peach varieties ripen during the dry season, the high percentage of roots near the surface also suggests that irrigation may be an annual requirement.
6. The highest densities or concentrations of roots were found in plots receiving the medium levels of N, K, and Mg; however, statistical significance was obtained only in the top few inches.
7. Soil analyses for Ca indicated that Ca decreased sharply with an increase in depth.
8. It is postulated that the sharp decrease in roots in the 1-2-foot depth-zone and the scarcity of roots below 2 feet may have been due at least in part, to insufficient Ca at these depths.
9. It is also postulated that the low soil Ca may have precluded any influence of N, K, or Mg on root density below the top few inches.

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THE PERFORMANCE OF PEACH VARIETIES AT QUINCY, FLORIDA[1]

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In 1954 Sharpe (1) discussed the commercial potential of peaches in northwest Florida. Since that time approximately 600 acres, mainly the Maygold variety, have been planted in the area. The small volume of fruit produced has been readily accepted by buyers. Production in the area must precede Georgia harvest for maximum profits; therefore, growers are interested in obtaining earlier varieties to supplement Maygold plantings.

Table 1: Hours of temperature at or below 45 degrees at the North Florida Experiment Station, Quincy, Florida.

Year	Feb. 15	Feb. 28	Mar. 15
1959-60	650	772	918
1960-61	864	878	912
1961-62	666	668	760

Table 2: Peach variety bloom, foliage break and ripening at North Florida Experiment Station, Quincy, Florida

Variety	Chilling Hours	Full Bloom			Foliage Break			First Ripe Fruit		
		60	61	62	60	61	62	60	61	62
Earligold	600	3-5	3-23	2-22	3-9	2-20	2-26	5-20	5-2	5-8
Flordahome	400	2-29	2-24	2-23	2-29	2-20	2-19	-	6-2	-
Junegold	650	3-18	3-1	2-26	3-29	2-25	3-2	6-7	5-14	5-31
Hiland	750	3-23	3-2	3-5	3-29	3-5	3-15	6-8	5-22	6-8
Meadowlark	650	3-27	2-28	2-26	3-26	2-24	2-26	6-20	6-1	6-11
Maygold	650	3-30	3-5	3-8	3-29	3-1	3-8	6-8	5-22	6-11
Flordaqueen	550	2-29	2-27	2-26	3-9	3-2	2-28	6-24	5-31	6-11
Robin	660	3-29	3-1	2-26	4-4	3-5	2-28	6-6	5-15	6-12
Suwannee	560	3-16	2-28	2-26	3-23	2-28	2-28	6-26	6-9	6-20
Saturn	650	3-13	3-1	2-26	3-26	2-23	2-28	7-6	6-5	6-25
Valigold	660	4-1	3-1	3-19	4-1	3-7	3-26	6-17	6-9	6-25
Sunhigh	750	3-29	3-5	3-8	3-29	3-5	3-5	6-29	6-20	6-25
Fortyniner	650	3-29	3-5	3-5	3-30	3-5	3-17	7-12	6-29	6-28
Goldrush	600	3-29	3-3	3-5	3-29	3-2	3-23	6-29	6-16	6-29

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