Table 6. Yields, Costs and Returns for the Three Settings, 1940-57

	Trees per Acre					
	Under 50 Single Set		90 to 99 Double Set		Combination	
Yield in boxes per acre	229		274		310	
	Per Acre	Per Box	Per Acre	Per Box	Per Acre	Per Box
Operating cost	$102.56	$ .45	$177.68	$ .65	$159.43	$ .51
Returns from fruit	265.90	1.16	317.32	1.16	360.12	1.16
Net above operating cost	163.34	.71	139.64	.51	200.69	.65

tional to those here considered when under comparable treatment at similar ages. However, the most favorable results would be obtained in close spacings only when provisions were made to prevent trees from crowding each other, and thus maintaining the maximum leaf or bearing surface.

Some growers have recently double-set young groves with the idea of carrying out the combination method in their management of such groves. Other growers have stated they expect to make new plantings within the near future and will use the combination idea. However, the long productive life of citrus trees will mean that several years will elapse before conclusions can be drawn as to the results obtained.

The success of the combination method hinges very largely on attaining the maximum leaf surface on the trees to be left permanently and at the same time leaving as much leaf surface as possible on the trees that are to be removed without permitting these trees to interfere with the permanent trees.

KEEPING QUALITY OF MARSH GRAPEFRUIT AFTER NITROGEN AND POTASH FERTILIZATION

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Considerable variation has been found in keeping qualities of fruit from different groves and from different packing-houses (3). Accordingly, a study of the effect of soil fertilization on the keeping qualities of grapefruit was begun in 1955 by Harding, Soule, and Sunday (2). They found no consistent relation between levels of nitrogen and potash fertilization and pitting or decay of grapefruit stored for 8 weeks at 32°, 40°, and 50° F. When stored this long, however, practically all fruit stored at 40° was pitted on removal. This study is a continuation of that investigation, using shorter storage periods in order to avoid complete pitting of fruit in 40° storage.

MATERIALS AND METHODS

Marsh grapefruit grown on rough lemon rootstock were obtained from an experimental grove near Groveland, Florida. A general description of the arrangement of plots was recently reported by Smith and Reuther (6). The trees received extremes of high and low nitrogen levels, and high and low potash levels of soil fertilization[1]. The nitrogen fertilization plots received 2 or 9 pounds of nitrogen per tree per year as ammonium nitrate and ammonium sulfate. The potash fertilization plots received 0.5 or 5.0 pounds of K_2O from sulfate of potash-magnesia per tree per year. These extreme variations were chosen to determine the maximum effects of fertilization on pitting and decay of the fruit during storage. All nitrogen fertilization plots received 2 pounds of K_2O per tree per year and all potash fertilization plots received 3.5 pounds of ni-

[1] Acknowledgment is made to Paul F. Smith, Agricultural Research Service, Orlando, Fla., for supplying the grapefruit used in these experiments.

trogen per tree per year. Borax and lead arsenate sprays were applied each year and each tree received about 4 pounds of sulfur yearly for mite control. Copper and manganese were used consistently in the fertilizers during the first 10 years of the life of the grove and further application was not deemed necessary after the beginning of the present experiment.

In the first test, fruit was picked in November 1957; in the second, in October 1958; and in the third in January 1959. The fruit was packed in regular 1⅘-bushel wirebound Bruce boxes, without washing or other treatment, and stored within 2 days after picking. In each test 4 boxes from each plot were stored at 32°, 40°, and 50° F. for 6 weeks. Shelf life of the fruit after storage was tested by a holding period of 7 days at 70°.

Inspections of the fruit were made at the time the boxes were removed from storage and after 3 and 7 days at 70° F. The fruit was scored for slight and severe aging, slight, moderate and severe pitting, and for type of decay. Data for severe aging and moderate and severe pitting are combined into a single grouping, termed pitting, for the purpose of this report. These forms of rind breakdown

Table 1.--Effect of nitrogen and potash fertilization on pitting and decay of Marsh grapefruit stored 6 weeks at 32°, 40°, and 50° plus 3 and 7 days at 70° F. Fruit stored November 22, 1957

Fertilizer used on plot; level at which applied	Storage temperature	Number of fruit	Fruit pitted after 6 weeks' storage + indicated period at 70° F.1/			Fruit decayed after 6 weeks' storage + indicated period at 70° F. 2/		
			0 day	3 days	7 days	0 day	3 days	7 days
	F.		Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Nitrogen								
High.....	32°	301	0	0	0	0	0	7
Low.....		304	0	2	0	0	0	6
Potash								
High.....		304	0	3	2	0	0	9
Low.....		302	0	0	0	0	0	8
Nitrogen								
High.....	40°	224	17	16	15	0	3	10
Low.....		304	8	9	9	1	3	11
Potash								
High.....		303	8	9	10	1	3	10
Low.....		304	9	9	13	1	3	12
Nitrogen								
High.....	50°	224	1	1	4	8	13	16
Low.....		296	1	1	0	7	10	14
Potash								
High.....		304	0	0	0	3	5	8
Low.....		304	0	2	2	8	13	18

1/ Data not cumulative; includes moderate and severe pitting and severe aging.

2/ Data cumulative; includes stem-end rot, Penicillium rot, and miscellaneous decay.

are considered of commercial importance. Data for pitting are not cumulative as they are based on counts made at the particular inspection. Data for decay are cumulative as the decayed fruit of the first and second inspection were discarded before the fruit was repacked.

Results

Marsh grapefruit, regardless of the kind of fertilization, developed little or no pitting during 6 weeks storage at 32° or 50° F., or during the 7 days at 70° following these temperatures (tables 1, 2, 3).

Pitting developed in all samples stored at 40° F. for 6 weeks, but there was no clear-cut indication that one kind of fertilization treatment was more conducive than another to pitting. In the first test, fruit which had received high nitrogen fertilization developed the most pitting during storage, while fruit from low nitrogen and high and low potash fertilization plots developed about half as much pitting. In the second test, fruit from the low potash plots had the most pitting

Table 2.--Effect of nitrogen and potash fertilization on pitting and decay of Marsh grapefruit stored 6 weeks at 32°, 40°, and 50° plus 3 and 7 days at 70° F. Fruit stored October 23, 1958

Fertilizer used on plot; level at which applied	Storage temperature	Number of fruit	Fruit pitted after 6 weeks' storage + indicated period at 70° F. 1/			Fruit decayed after 6 weeks' storage + indicated period at 70° F. 2/		
			0 day	3 days	7 days	0 day	3 days	7 days
	F.		Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Nitrogen								
High	32°	320	0	0	1	0	0	0
Low		319	0	0	0	0	0	0
Potash								
High		318	0	1	2	0	0	1
Low		320	0	0	3	0	0	0
Nitrogen								
High	40°	318	27	34	39	0	0	1
Low		320	27	33	37	0	1	3
Potash								
High		319	13	15	23	1	1	2
Low		320	50	54	55	0	0	5
Nitrogen								
High	50°	319	0	1	0	10	14	19
Low		320	0	2	2	3	8	9
Potash								
High		320	0	2	0	3	6	9
Low		320	2	3	2	9	15	18

1/ Data not cumulative; includes moderate and severe pitting and severe aging.

2/ Data cumulative; includes stem-end rot, Penicillium rot, and miscellaneous decay.

while that from high potash plots had the least, with both nitrogen plots intermediate. In the final test, fruit from the low nitrogen plots developed the most pitting and that from high potash plots the least, with high nitrogen and low potash plots intermediate. In two of the three tests, fruit receiving high potash fertilization had the least pitting, indicating that potassium may have had some protective value. However, the effect of these fertilization treatments is minor compared to the effect of storage temperature.

More decay developed during storage at 50° than at 32° or 40° F. (tables 1, 2, 3). During the holding period decay developed in fruit which had been stored at all three temperatures. In two of the three tests fruit stored at 32° had less total decay after the holding period than that stored at 40° or 50°. As with pitting, no obvious relation was found between fertilization treatment and development of decay. Pitting did not necessarily lead to decay, as evidenced by one instance in which 50 percent of the low potash level

Table 3.--Effect of nitrogen and potash fertilization on pitting and decay of Marsh grapefruit stored 6 weeks at 32°, 40°, and 50° . plus 3 and 7 days at 70° F. Fruit stored January 27 and 29, 1959

Fertilizer used on plot; level at which applied	Storage temperature	Number of fruit	Fruit pitted after 6 weeks' storage + indicated period at 70° F. 1/			Fruit decayed after 6 weeks' storage + indicated period at 70° F. 2/		
			0 day	3 days	7 days	0 day	3 days	7 days
	F.		Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Nitrogen								
High.....	32°	254	0	0	0	0	1	15
Low.....		272	0	1	0	0	1	16
Potash								
High.....		286	0	0	0	0	0	17
Low.....		287	0	1	0	0	1	23
Nitrogen								
High.....	40°	256	13	21	14	2	4	14
Low.....		271	21	24	20	3	6	16
Potash								
High.....		288	5	8	5	5	10	16
Low.....		288	10	14	11	6	14	24
Nitrogen.								
High.....	50°	256	0	0	0	6	9	15
Low.....		272	0	0	0	5	10	17
Potash.								
High.....		288	0	0	0	13	17	28
Low.....		288	0	0	0	8	15	23

1/ Data not cumulative; includes moderate and severe pitting and severe aging.

2/ Data cumulative; includes stem-end rot, Penicillium rot, and miscellaneous decay.

fruit had moderate to severe pitting on removal from storage and a total of only 5 percent decay after the 7-day holding period.

These results are in general agreement with several reports, including those of Hawkins and Magness (4), and Brooks and McColloch (1), who found pitting most serious at about 40° F. storage, and Stahl and Camp (7) who reported little decay in grapefruit held at 32° and 37.5° but severe decay when stored at warmer temperatures. In Texas, Johnson, Buford, and Ryall (5) reported their best results were obtained from storage of Marsh grapefruit at 52° in that pitting and surface browning were of minor importance and less Penicillium decay developed during the post-storage holding period.

SUMMARY

Marsh grapefruit which had received high nitrogen level, low nitrogen level, high potash level, and low potash level soil fertilization developed little or no pitting when stored at 32° or 50° F. for 6 weeks and held at 70° for 1 week. When stored at 40° for 6 weeks, all samples developed pitting, regardless of fertilization treatment. Fruit stored at 50° had more decay when removed from 6 weeks storage than that stored at 32° or 40°, but decay developed fairly rapidly during the holding period in most samples.

The development of pitting and decay is more closely related to storage temperature than to fertilization practices.

LITERATURE CITED

(1) Brooks, C., and McColloch, L. P. 1936. Some Storage Diseases of Grapefruit. Jour. Agr. Res. 52: 319-351.

(2) Harding, P. L., Soule, M. J., and Sunday, M. B. 1957. Storage Studies on Marsh Grapefruit — 1955-56 Season: I Effect of Nitrogen and Potash Fertilization on Keeping Quality, II Effect of Different Temperature Combinations on Keeping Quality. U. S. Dept. Agr. AMS - 202.

(3) Harding, P. L., Wiant, J. S., Hruschka, H. W., Sunday, M. B., and Kaufman, J. 1952. Control of Decay of Florida Oranges During Storage. The Citrus Ind. 33: 5-7, 11-12.

(4) Hawkins, L. A., and Magness, J. R. 1920. Some Changes in Florida Grapefruit in Storage. Jour. Agr. Res. 20: 357-373.

(5) Johnson, H. B., Buford, W. R., and Ryall, A. L. 1951. Storage Tests on Florida and Texas Grapefruit, 1950. U. S. Dept. Agr. H. T. and S. Office Rpt. No. 237. 17 pp.

(6) Smith, P. F., and Reuther, W. 1955. Preliminary Report on the Effect of Nitrogen Source and Rate and Lime Level on pH, Root Growth, and Soil Constituents in a Marsh Grapefruit Grove. Soil Sci. Soc. Fla. 15: 108-116.

(7) Stahl, A. L., and Camp, A. F. 1936. Cold Storage of Florida Citrus Fruits. I—Effect of Temperature and Maturity on the Changes in Composition and Keeping Quality of Oranges and Grapefruit in Cold Storage. Univ. Fla. Agr. Expt. Sta. Bul. 303. 67 pp.

FIELD TRIALS ON THE LONG-TERM EFFECT OF SINGLE APPLICATIONS OF COPPER, ZINC, AND MANGANESE ON FLORIDA SANDY CITRUS SOIL

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Beginning about 1938 copper (Cu), zinc (Zn) and manganese (Mn) were applied to most commercial citrus groves in Florida. The use of these metal elements in addition to the overcoming of magnesium deficiency spectacularly improved tree condition and increased yields, enabling the development of a major horticultural industry on light sandy soils that were once thought to be practically worthless for agriculture.

These 3 metals were used rather lavishly and the recommendations (3) called for their use in foliage sprays in addition to inclusion of Cu and Mn in the mixed fertilizer applications to the soil. Zn was thought to be ineffective when applied to the soil because of inconsistent responses in short-term trials (2). The accumulation of these metals in the soil was not fully appreciated until Cu toxicity became rather commonplace in many older groves (8). In recent years Cu and Mn have been either omitted in the cultural program or used in greatly reduced amounts except for the first few years on young trees on virgin land. Nutritional Zn sprays are used much less routinely than was the custom prior to 1952 and the current recommendations to the industry (7) call for its use only as

[1] The authors wish to express their gratitude to the following for assistance in this study: Werner Husmann, General Manager of Apshewa groves, Minneola, Florida, for providing the experimental site and diligently maintaining it in line with experimental objectives; Walter Reuther for help in planning and starting the test; and G. K. Scudder, Jr. and Gus Hrnciar for competent technical assistance in carrying on the sampling and analytical work involved.