Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

FERTILIZER EXPERIMENTS WITH CANTALOUPES

J. C. Lingle
and
J. R. Wight

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FERTILIZER EXPERIMENTS WITH CANTALOUPES[1]

PMR 45 cantaloupes were grown at Davis and at the West Side Field Station with different rates and combinations of N, P, and K fertilization. Yield increases of 25 to 300 per cent were observed after the application of N, depending on the soil and the season. Smaller increases in yield were observed after the use of P. P fertilization hastened fruit maturity, especially when heavy N applications were made. Banding the P fertilizer increased its efficiency several times. K had no detectable effect on yield at either location.

In very N-deficient soils, the application of this element increased the soluble solids content and the size of the fruit, as well as the per cent of the fruit that were marketable. P or K fertilization did not have much effect on these quality characteristics. Tissue analysis changes resulting from fertilizer variables were related to yield and quality responses, with a view of using tissue analysis as a diagnostic tool in the fertilization of this crop.

NOTE: Applications of P and K are given in this bulletin as amounts of P_2O_5 (phosphorus pentoxide) and K_2O (potassium oxide). To find the actual amounts of P and K applied, see the conversion table on page 21.

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THE AUTHORS: John C. Lingle is Associate Professor of Vegetable Crops and Associate Olericulturist in the Experiment Station, Davis; J. R. Wight, formerly Laboratory Technician in the Vegetable Crops Department, Davis, is now with the Department of Agronomy, University of Wyoming, Laramie.

J. C. Lingle and J. R. Wight

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INTRODUCTION

Commercial fertilization practices on California's 45,000-acre muskmelon crop have developed without benefit of much experimental data. Recommendations to growers have been based mostly on experience with other crops grown in the immediate vicinity, or on the characteristics of the particular soil involved. Surveys of fertilizer practices indicate that many commercial cantaloupe growers ignore basic fertilizer principles, preferring to rely on their own judgment in supplying fertilizer needs.

With costs rising in relation to prices, fruit quality factors influenced by management practices are becoming increasingly important. For example, cantaloupe grades are based partially on soluble solids content, which may be greatly affected by fertilizer management. Other quality factors, such as storage life, netting, "green sutures" (persistence of chlorophyll in sutures near stem end), sunburn, etc., may also be affected by fertilizer practices. Economically, the effect of fertilizer on the time required to reach maturity is very important, particularly on crops which sell for less as the season progresses.

The experiments reported in this paper were designed to study some of the basic principles of fertilization affecting various responses of muskmelons. The cantaloupe is grown more extensively than other muskmelons, and principles developed with this crop would be applicable to similar cucurbits. When the cantaloupe is physiologically mature, it abscises from the vine, thus providing a more accurate indication of maturity than is found in other melons.

Little literature can be found describing fertilizer experiments on melons in the western United States. Zink and Davis (1951)[2] indicated that 60 pounds of nitrogen (N) per acre in the Imperial Valley were sufficient to obtain maximum yields of melons, but they did not study the value of applying phosphorus (P) or potassium (K). Davis *et al.* (1953) stated that barnyard or feedlot manures were especially desirable in the interior valleys of California, especially on soils of low organic matter content. Animal manures have long been used as a source of plant nutrients for vine crops, and Lorenz (1962) indicates that their main value lies in their nitrogen-supplying power. Vine growth is usually more vigorous in rotations which include manure dressings.

Pew *et al.* (1956) state that N is the plant nutrient most needed for cantaloupe production in Arizona and recommended two applications—one-third before or at time of planting, and the balance side-dressed about thinning time. They seemed to feel that excessive N fertilization might be detrimental to fruit set and fruit development, but did not offer a reason for this; they suggested that P was beneficial for early-planted crops and that it should be a preplant application. K fertilization was of little value for melons in Arizona soils.

Melon fertilizer research in acid soils of the eastern United States has been adequately reviewed by Stark and Haut (1958); it was found that N was the most critical nutrient needed. In acid sandy soils a critical balance between calcium (Ca), magnesium (Mg), potassium (K), and boron (B) was needed for maximum production and highest quality. This balance would not seem to be important in the western United States, because most of the melons in California and Arizona are produced on alkaline soils having enough of these nutrients.

[2] See "Literature Cited" for publications referred to in the text by author and date.

Masui *et al.* (1960), studying the nutrient needs of greenhouse-grown muskmelons in Japan, found that the balance between the N and P supply was critical. Heavy P fertilization hastened early growth, but its effect was not detectable in later stages of growth. N fertilization was beneficial to vine growth up to a point, after which it became deleterious. Both nutrients tended to lower soluble solids of the fruit. Many indirect effects of nitrogen fertilization on nutrient composition (N, P, K, Ca, and Mg) of the leaves were noted. The concentration of these nutrients in the leaves was generally lowered, apparently because N fertilization stimulated leaf growth and diluted the concentrations of other ions.

MATERIALS & METHODS

The cultural methods used in the present study were as nearly commercial as possible. Crops were direct seeded in 6-foot rows on the north shoulder of an irrigation furrow, fields were irrigated immediately after seeding and approximately every 2 weeks throughout the growing season, and plants were thinned to approximately 15 inches apart in the row when they had eight true leaves.

N, P, and K were the nutrients studied. Sources of N and P were ammonium sulphate or ammonium phosphate-sulphate (16-20-0) and treble superphosphate; potassium sulphate was the source of K. At planting, part of the N and all of the P or K were applied approximately 6 inches below and 6 inches to each side of the seed. When N was applied at rates in excess of 60 pounds per acre, applications were split—60 pounds at planting, and the balance side-dressed immediately after thinning.

The fruit was harvested twice or thrice weekly, weighed, counted, and graded into U. S. No. 1's or culls. If a fruit showed injury not due to fertilizer treatment but was otherwise a No. 1, it was included with No. 1 fruit. From these data, yields were calculated on a crates-per-acre basis. Throughout the harvest season uniformly mature melons from each lot were selected, stored at 55°F for 24 hours, and analyzed for soluble solids. Fruits were cut through the middle and three 1-cc cubes of flesh removed from the interplacental areas. These were squeezed with a small hand press and the solids concentration determined by hand refractometer. Readings were converted to soluble solids from suitable tables. Notes were taken on internal flesh color, texture, and size of the cavity. On one occasion, representative fruits of each treatment were stored at 55°F for a 14-day period and scored daily to determine differences in storage ability.

Tissue Analysis Methods

To determine the effect of fertilization on the nutrient composition of the tissue, plant samples were taken two or four times during the growth period. At Davis, samples were taken at thinning time (eight true leaves) and at the time of initial fruit set. At the West Side Field Station, samples were taken at the four- and six-leaf stages in addition to the above sampling stages. Petioles of the youngest fully-matured leaves were selected in the 1958 Davis test. In the 1959 and 1960 tests, the youngest fully-matured leaves were selected.

After washing the samples to remove surface contamination, the tissue was handled and analyzed according to methods outlined by Johnson and Ulrich (1959).

RESULTS

1958 Experiment

The object of this experiment was to determine the response by cantaloupes to an application of each individual element, N, P, and K, and to obtain information on responses which should be observed more closely in future experiments.

At planting, N, P_2O_5, or K_2O were applied in all possible combinations at 0 or 120 pounds per acre. Each plot was a single row 100 feet long, and a guard row was left between each treatment. Seeds were planted May 1, and plants emerged on May 7.

Results. Table 1 summarizes yields, fruit weights, and per cent of soluble solids as influenced by fertilizer treatment. Data in the first column illustrate effects of different fertilizer combinations on early maturity. N alone increased first harvest yields sharply, with lesser responses to P alone. However, when the two elements were used together, early yields were increased almost threefold over plots not receiving fertilizer. K fertilization had no effect on yields, either total or early.

The data in the third column of table 1 show total yields for four harvests and are similar to those of the first harvest yields, with the exception that yields from plots receiving N alone or N with K were proportionately greater than in the first harvest. This demonstrates the delaying effect on maturity of N used alone.

Fruit size was not affected by fertilizer

Table 1

INFLUENCE OF NITROGEN, PHOSPHORUS, AND/OR POTASSIUM FERTILIZATION ON EARLY AND TOTAL YIELDS, FRUIT SIZE, AND SOLUBLE SOLIDS CONTENT OF CANTALOUPES
(Davis, 1958)

Plot	N	P_2O_5	K_2O	Yields: First harvest		Yields: Total harvest	Fruit size	Soluble solids
	pounds per acre			crates per acre	per cent of total yield	crates per acre	pounds	per cent
8	0	0	0	120.6	41	293.3	2.45	8.82
1	120	0	0	219.1	48	459.5	2.33	9.59
2	0	120	0	163.7	48	337.1	2.36	8.93
3	0	0	120	97.6	36	269.1	2.35	8.85
4	120	120	0	335.8	59	565.1	2.36	9.84
5	120	0	120	205.5	45	458.2	2.37	9.55
6	0	120	120	116.6	38	306.1	2.40	8.65
7	120	120	120	300.1	58	519.4	2.36	10.05
LSD 5%				49.6		26.5	NS	0.64
1%				69.7		37.0	NS	0.87
		+ N		265.1**		500.5**	2.39	9.76**
		0 N		124.6		301.4	2.35	8.77
		+ P		229.0**		431.9**	2.36	9.34
		0 P		160.7		370.0	2.38	9.16
		+ K		180.0		388.2	2.37	9.28
		0 K		209.8		413.8	2.37	9.25

** Indicates 1% level of significance.

treatment; therefore, yield differences must be accounted for in terms of greater fruit numbers. Data in the last column show that N increased soluble solids by about 1 per cent. This is contrary to the popular belief that N increases the succulence of plant growth and hence tends to reduce soluble solids. This increase was probably due to the large increase in leaf area in response to N fertilization. P and K did not have a detectable effect on the soluble solids.

Table 2 shows the per cent dry weight and plant nutrient composition of cantaloupe petioles at thinning time (eight-leaf stage) as influenced by fertilizer treatment. These data indicate that N applications significantly increase the nitrate-nitrogen content of the petioles. P and K had no effect on the nitrate-nitrogen content of the petioles. Application of P significantly increased the acid soluble P in the tissue, but neither N nor K fertilization had any effect on this constituent.

In an experiment of this design (complete factorial) any interactions between treatment variables should be readily detectable. Table 2 indicates that the effect of fertilizer treatments on total P in cantaloupe tissue is similar to their effect on acid soluble P content; no difference in P content except in response to P application could be found. Curiously, N fertilization had a greater effect than K fertilization on the K concentration in the tissue. Table 2 also shows that the Ca and Mg concentration in the petioles was sharply reduced by N application. This may have been the result of dilution through increased plant growth produced by N fertilization. Sodium (Na) concentration was increased by N application, an effect which may have been due to the N carrier. Ammoniacal nitrogen may have replaced Na from the colloidal exchange complex of the soil, raising the Na concentration in the soil solution, and thus increasing the uptake of Na by the plant. Inasmuch as the am-

Table 2

EFFECTS OF FERTILIZATION WITH NITROGEN, PHOSPHORUS, AND/OR POTASSIUM ON PER CENT DRY WEIGHT AND NUTRIENT COMPOSITION OF CANTALOUPE PETIOLES AT THE EIGHT-LEAF STAGE (Davis, 1958)

Treatment			Dry weight	2% Acetic acid soluble		Total				
N	P_2O_5	K_2O		NO_3–N	PO_4–P	P	K	Na	Ca	Mg
pounds per acre			per cent	ppm	ppm	per cent of dry weight				
0	0	0	4.80	5840a*	1590a	0.321a	11.40b	0.39a	1.47b	1.13b
120	0	0	4.68	22320b	1570a	0.300a	10.50a	0.55b	1.03a	0.83a
0	120	0	4.79	4500a	2820b	0.477b	11.60b	0.39a	1.49b	1.18b
0	0	120	4.62	3975a	1500a	0.290a	11.70b	0.35a	1.65b	1.25b
120	120	0	4.47	21760b	3280b	0.480b	10.00a	0.78c	0.94a	0.92a
120	0	120	4.46	23800b	1440a	0.265a	11.20b	0.56b	1.16a	0.92a
0	120	120	4.66	3440a	2870b	0.468b	11.30b	0.38a	1.68b	1.28b
120	120	120	4.80	21090b	3210b	0.519b	11.20b	0.56b	0.84a	0.70a
+ N			4.60	22242†	2375	0.391	10.72	0.61†	0.99	0.84
0 N			4.72	4439	2195	0.389	11.50†	0.38	1.57†	1.21†
+ P_2O_5			4.65	12697	3045†	0.486†	11.02	0.53	1.24	1.02
0 P_2O_5			4.68	13984	1525	0.294	11.20	0.47	1.32	1.03
+ K_2O			4.56	13076	2255	0.385	11.35	0.46	1.33	1.04
0 K_2O			4.76	13605	2315	0.395	10.87	0.53	1.23	1.01

* Values in any given column followed by a common letter are not significantly different (5% level).
† Indicates significant differences between mean effects.

Table 3

EFFECTS OF FERTILIZATION WITH NITROGEN, PHOSPHORUS, AND/OR POTASSIUM ON PER CENT DRY WEIGHT AND NUTRIENT COMPOSITION OF CANTALOUPE PETIOLES AT INITIAL FRUIT SET (Davis, 1958)

Treatment			Dry weight	2% Acetic acid soluble		Total				
N	P_2O_5	K_2O		NO_3–N	PO_4–P	P	K	Na	Ca	Mg
pounds per acre			per cent	ppm	ppm	per cent of dry weight				
0	0	0	5.13	1730a*	3030b	0.478b	11.40a	0.24a	1.61b	1.32b
120	0	0	5.13	12210d	2200a	0.387a	10.30a	0.39b	1.19a	1.02a
0	120	0	5.14	1500a	3250b	0.513c	11.60a	0.25a	1.62b	1.32b
0	0	120	5.20	3650b	2900b	0.486b	11.60a	0.24a	1.62b	1.26b
120	120	0	5.30	6900c	2540a	0.427b	10.50a	0.37b	1.20a	1.06a
120	0	120	4.95	10660d	2250a	0.384a	11.30a	0.31b	1.25a	1.08a
0	120	120	5.01	3500b	3340b	0.507c	11.20a	0.23a	1.55b	1.31b
120	120	120	5.28	8200c	2390a	0.396a	11.20a	0.28ab	1.17a	0.98a
+ N			5.16	9492†	2345	0.398	10.82	0.34†	1.20	1.03
0 N			5.12	2595	3130†	0.496†	11.45†	0.24	1.60†	1.30†
+ P_2O_5			5.18	5025	2880	0.461	11.12	0.28	1.38	1.17
0 P_2O_5			5.10	7062	2595	0.434	11.15	0.29	1.42	1.17
+ K_2O			5.11	6502	2720	0.443	11.32	0.26	1.40	1.16
0 K_2O			5.17	5585	2755	0.451	10.95	0.31	1.40	1.18

* Values in any given column followed by a common letter are not significantly different (5% level).
† Indicates significant differences between mean effects.

monium ion is held less strongly than Ca, Mg, or K on the exchange complex, the ammoniacal nitrogen probably did not increase the concentration of the latter cations in the soil solution.

Table 3 shows the effect of N, P, and K fertilization on the nutrient content of petiole samples taken at initial fruit set (about 4 weeks after thinning). These data are similar to those in table 2, except that plots receiving certain treatments show the effect of fruit on the vines. It has been frequently observed with other annual fruit crops that the acid soluble fraction of plant nutrients in the petioles (particularly nitrates and phosphates) drops sharply soon after fruit set is initiated. Plots receiving both N and P were more heavily set with fruit than other plots at this sampling, and the nitrate-nitrogen content of leaves from these plots was much lower than from plots receiving N alone. The same was true of the soluble P content of petioles from plots receiving P alone and from those receiving N and P. It has been frequently observed that the developing seeds in the fruit mobilize all the reserve N and P in the plant and thus the fruit acts as a "sink" for the acid soluble fractions. The effect of N on the cation content of the petioles was similar to the earlier sampling, except that Ca and Mg concentrations were higher and total P concentration was lower.

1959 Studies

The objective of the 1959 study was to determine the effect of a relative balance of N and P on yield and maturity of the crop.

The 1959 cultural techniques were similar to those of 1958. Treatments included N at 0, 60, 120, or 240 pounds per acre, and P_2O_5 at 0, 25, or 125 pounds per acre in all possible combinations. Plots were two rows 5 feet apart and 66

Table 4

EFFECT OF DIFFERENT RATES OF NITROGEN AND PHOSPHORUS FERTILIZERS ON YIELD OF U. S. NO. 1 CANTALOUPES, CRATES SIZE 36 PER ACRE
(Davis, 1959)

Nitrogen	Pounds P_2O_5 per acre			
	0	25	125	Mean*
pounds per acre	crates per acre			
0	94.6	132.8	112.0	112.9a
60	346.1	385.9	385.1	371.8b
120	410.8	459.0	477.2	448.2c
240	461.5	495.5	537.0	497.1d
Mean	328.7y	368.5z	378.5z	

* Means followed by a common letter are not significantly different (5% level).

feet long; a single guard row was left between each plot. All P was band-applied at planting. Plant tissue was sampled from each plot at the same stages of growth as in the 1958 test.

Harvesting began on July 20 and continued until August 17 on a thrice-weekly basis. Fruits were graded according to USDA standards, and concentration of soluble solids in the fruit was determined on three occasions during the harvest season.

Results. Table 4 summarizes the yield of No. 1 cantaloupes as influenced by different rates of N and P fertilization. Each 60-pound increment of N increased yields significantly over lower rates of application. Application of 25 pounds of P_2O_5 per acre increased yields by 40 crates per acre; application of 125 pounds per acre increased yields only 50 crates per acre.

Phosphorus fertilization was of little value without N fertilization, and the application of 125 pounds of P_2O_5 per acre did not increase total yields over the 25-pound rate save where N was applied at 240 pounds per acre. This is in close agreement with previous data: research with many other irrigated row crops has shown that P fertilization is ineffective if a severe N deficiency exists.

Figure 1 illustrates the effect of different combinations of fertilizer on the cumulative yields (yield with time) throughout the season. Graphs A, B, and C of figure 1 show that yields were highest during the first third of the season on plots receiving 60 pounds of N per acre. However, as the harvest sea-

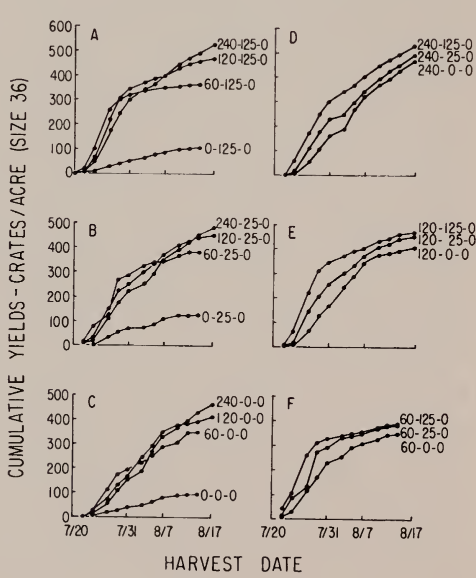


Fig. 1. Effect of nitrogen and phosphorus fertilization on cumulative yield of cantaloupes (Davis, 1959). Numbers on each treatment refer to pounds per acre of N, P_2O_5, and K_2O, respectively.

son progressed plots receiving 120 pounds of N per acre became the highest yielders, and these plots were eventually exceeded by those receiving the 240-pound rate. Graph C in the figure indicates that N without P gave an essentially linear (straight-line) yield pattern; the higher the N application the more nearly linear the yield pattern. However, comparison of graph C with A and B shows that, as P and N fertilization was increased, the yield pattern became more concentrated in the early part of the season. This becomes evident if a comparison is made of the yield pattern of plots fertilized with 240 pounds of N and 25 pounds P_2O_5 per acre, and of plots receiving the same amount of N but 125 pounds P_2O_5 per acre.

N on a crop often induces P deficiency. These data indicate that as N fertilization is increased greater amounts of phosphorus are required to produce a normal pattern of yields. Graphs D, E, and F of figure 1 show yield patterns from different rates of P fertilization plotted at each of the three N rates. In each case, each increment of P fertilizer accelerated the maturity of the crop as N fertilization increased.

Figure 2 shows the effect of different combinations of fertilizer on the grade of fruit produced. Without P fertilization there was a marked increase in the percentage of marketable fruit with the first increment of N fertilization. Where N was not used, there was some increase in the percentage of marketable fruit in response to the application of 25 pounds P_2O_5 per acre. However, when P was applied to plots receiving N, it had no effect on the grade of the fruit. Most of the culls were rejected because of poor netting (lack of corky net on the skin of the fruit), particularly from the plots without N. Lack of adequate leaf cover in the absence of N fertilization also allowed some sunburning of the fruit.

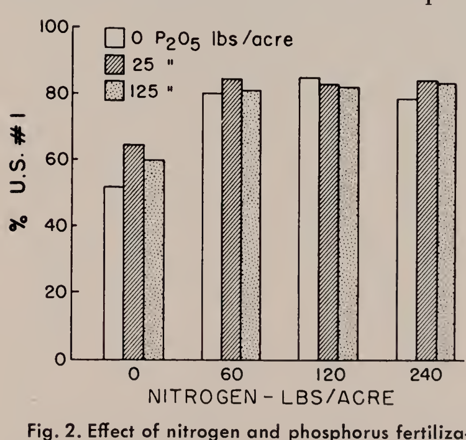


Fig. 2. Effect of nitrogen and phosphorus fertilization on per cent of total yield of cantaloupes meeting U.C. No. 1 grade (Davis, 1959). Bars represent different rates of P and pounds of P_2O_5 per acre.

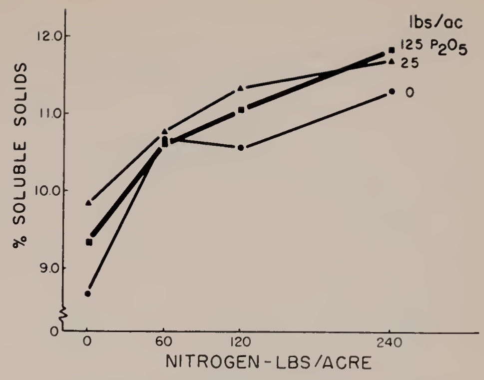


Fig. 3. Effect of nitrogen and phosphorus fertilization on per cent soluble solids of cantaloupes (Davis, 1959).

Figure 3 shows the effect of N and P on the soluble solids content of the fruit. It is obvious that application of nitrogenous fertilizers increased the soluble solids content, and that the first application of N increased soluble solids content more than did the following heavier applications. At the higher rates of N fertilization, P application tended to increase the soluble solids content of the fruit.

Figure 4 shows the effect of fertilizer treatment on fruit size. These data indicate that fruit size increased with N applications up to 120 pounds per acre, but increasing the rate of N per acre beyond this rate did not increase fruit size further. P applications tended to increase the numbers of fruit set but to reduce fruit size.

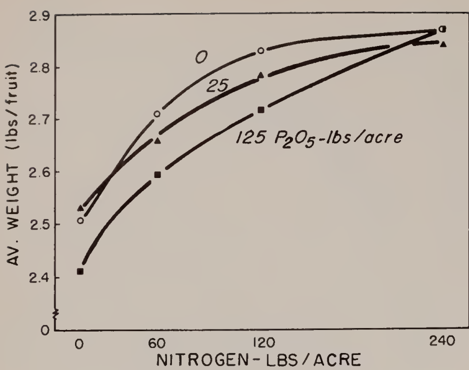


Fig. 4. Effect of nitrogen and phosphorus fertilization on fruit size, (Davis, 1959).

Tables 5 through 10 summarize the effect of different treatments on the nutrient analysis of plant leaf tissue. Due to the effect of fertilizer treatment on growth, different physiological ages existed between treatments, and thus the nutritional status of plants from different treatments may not be exactly comparable. In general, plots not receiving N grew very slowly and were quite chlorotic. Plots without P grew more slowly than plots fertilized with it. Plants fertilized with both nutrients grew normally and had approximately the same physiological age regardless of the rate of fertilizer applied.

Table 5 shows the nitrate-nitrogen content of cantaloupe leaves taken at the first sampling (six-leaf stage). Plants not receiving N were typically yellow, and tissue analysis confirmed the deficiency. Plants receiving various rates of N fertilizers were dark green and growing rapidly at time of sampling. There were no differences in the nitrate-nitrogen content of plants receiving the different rates of N fertilization. Phosphate fertilization significantly increased the nitrate-nitrogen content of the cantaloupe leaves at this sampling. This unusual effect was probably due to a condition similar to that reported by Lingle (1960), in which increased N absorption in response to P fertilization was found to be due to more rapid root growth in the seedling stages, allowing greater absorption of native soil N.

Table 6 shows the nitrate-nitrogen content of the leaves at initial fruit-set growth stage. The data are similar to those of table 5, but reflect the lower levels characteristic of more mature plants with developing fruit.

Tables 7 and 8 show the soluble P content of cantaloupe leaves at the two stages of sampling as influenced by fertilization. Application of 25 pounds

Table 5

EFFECT OF NITROGEN AND/OR PHOSPHORUS FERTILIZATION ON THE NITRATE-NITROGEN CONTENT OF CANTALOUPE LEAVES AT SIX-LEAF STAGE OF GROWTH, DRY-WEIGHT BASIS
(Davis, 1959)

Nitrogen	Pounds P_2O_5 per acre			
	0	25	125	Mean*
pounds per acre	**ppm**			
0	500	500	500	500a
60	4230	5187	5167	4861b
120	4567	5810	5423	5267b
240	3982	5357	5013	4784b
Mean	3320x	4213y	4026y	

* Means followed by a common letter are not significantly different (5% level).

Table 6

EFFECT OF NITROGEN AND/OR PHOSPHORUS FERTILIZATION ON THE NITRATE-NITROGEN CONTENT OF CANTALOUPE LEAVES AT INITIAL FRUIT SET, DRY-WEIGHT BASIS
(Davis, 1959)

Nitrogen	Pounds P_2O_5 per acre			
	0	25	125	Mean*
pounds per acre	**ppm**			
0	750	890	1120	920a
60	1120	1250	1200	1190b
120	1300	1380	1710	1463c
240	2740	3090	3260	3030d
Mean	1470x	1650y	1820z	

* Means followed by a common letter are not significantly different (5% level).

Table 7

EFFECT OF NITROGEN AND/OR PHOSPHORUS FERTILIZATION ON THE SOLUBLE PHOSPHORUS CONTENT OF CANTALOUPE LEAVES AT THE SIX-LEAF STAGE OF GROWTH, DRY-WEIGHT BASIS
(Davis, 1959)

Nitrogen	Pounds P_2O_5 per acre			
	0	25	125	Mean*
pounds per acre	**ppm**			
0	1507	2910	3793	2737a
60	1220	1847	3483	2183b
120	1227	1873	3177	2092b
240	1237	1813	2880	1977b
Mean	1298x	2111y	3330z	

* Means followed by a common letter are not significantly different (5% level).

Table 8

EFFECT OF NITROGEN AND/OR PHOSPHORUS FERTILIZATION ON THE SOLUBLE PHOSPHORUS CONTENT OF CANTALOUPE LEAVES AT INITIAL FRUIT SET, DRY-WEIGHT BASIS
(Davis, 1959)

Nitrogen	Pounds P_2O_5 per acre			
	0	25	125	Mean*
pounds per acre	**ppm**			
0	1913	1537	1753	1734a
60	1607	1717	2050	1791a
120	1437	1383	1943	1588a
240	1427	1397	1853	1599a
Mean	1596x	1508x	1900y	

* Means followed by a common letter are not significantly different (5% level).

Table 9

EFFECT OF NITROGEN AND/OR PHOSPHORUS FERTILIZATION ON THE TOTAL PHOSPHORUS CONTENT OF CANTALOUPE LEAVES AT THE SIX-LEAF STAGE OF GROWTH, DRY-WEIGHT BASIS (Davis, 1959)

Nitrogen	Pounds P_2O_5 per acre			
	0	25	125	Mean*
pounds per acre	per cent of dry weight			
0	0.353	0.539	0.653	0.515b
60	0.321	0.450	0.591	0.454a
120	0.327	0.452	0.616	0.465a
240	0.334	0.443	0.552	0.443a
Mean	0.334x	0.471y	0.603z	

* Means followed by a common letter are not significantly different (5% level).

of P_2O_5 per acre almost doubled the soluble P content of the leaves, and 125 pounds per acre almost tripled its concentration. Increased N fertilization tended to reduce the P concentration in the tissue on plots receiving the high rate of P fertilization.

Table 8 shows the soluble P content of the leaves at initial fruit set. In plots fertilized with P this content was considerably lower than it was at the earlier date of sampling; in plots not receiving P it was higher. This seeming conflict of results probably stems from two different situations. Plots that had received P fertilizers had begun to set fruit and the reserve P was being mobilized by the developing fruit. Plants not receiving P had not yet started to set fruit, and the leaf P content reflected the increased foraging capacity of a larger root system. At this stage of growth N fertilization had no effect upon the soluble P content of the tissue.

In relating tissue analysis to yield performance, one must note that the response of the high rate over the low rate of P fertilization was dependent to some extent on N fertilization. Therefore, the P content of plants receiving 25 pounds of P_2O_5 per acre was marginal. Plants sampled at thinning time and found to contain from 1800 to 2000 ppm soluble P would probably have benefited from P fertilization. At the later stage of growth (initial fruit set) the marginal or "critical" level had probably dropped to around 1500 ppm P.

There is much evidence in the literature that ammoniacal nitrogen enhances the absorption of P (Lorenz and Johnson, 1953; Grunes, 1959), although our data seem to conflict with this idea. However, if the effects of N fertilization on cantaloupe vine growth are considered, any effect of N on P uptake is probably obliterated by dilution due to stimulation of vine growth by N fertilization.

Tables 9 and 10 summarize the total P content of the leaves. (These data correlate closely with data in tables 7 and 8.) It was observed that the total P concentration in the tissue exhibited much less plot-to-plot variation than did soluble P content, so the total P content is probably a much more reliable index of the P status of the plant. However, the analysis of the plant tissue for total P is somewhat more complex to run, and therefore is much less adaptable to commercial laboratory determination. It appears that the critical level for total P in the leaf tissue is about 0.45 per cent total P at thinning time, and 0.40 per cent at the initial fruit-set stage.

Table 10

EFFECT OF NITROGEN AND/OR PHOSPHORUS FERTILIZATION ON TOTAL PHOSPHORUS CONTENT OF CANTALOUPE LEAVES TAKEN AT INITIAL FRUIT SET, DRY-WEIGHT BASIS
(Davis, 1959)

Nitrogen	Pounds P_2O_5 per acre			
	0	25	125	Mean*
pounds per acre	**per cent of dry weight**			
0	0.415	0.384	0.460	0.420ab
60	0.373	0.384	0.526	0.395a
120	0.405	0.355	0.463	0.408ab
240	0.438	0.408	0.458	0.435b
Mean	0.408x	0.384x	0.477y	

* Means followed by a common letter are not significantly different (5% level).

1960 Studies

These studies were made near Five Points, Fresno County, to determine if the general relationships found at Davis held true for the soils and climate of the west side of the San Joaquin Valley, where approximately half the melons produced in California are grown. A secondary purpose was to study the value of P placement. For most irrigated row crops the efficiency of band-placed P fertilizers has usually been greater than that of a broadcast application. However, most of these studies were conducted on cool-season vegetable crops in which root growth was limited by the cold soil. The commercially favored broadcast method of applying P—that is, broadcasting on the surface prior to forming the beds—was compared with band placement of P at planting time. The experiment was designed in such a way that any effect of N fertilization on P absorption and utilization would be detected.

Treatment included all possible combinations of 0, 60, 120, or 240 pounds of N per acre and two methods (band vs. broadcast) of P application at rates of 0, 25, or 125 pounds of P_2O_5 per acre. Broadcast P treatments were applied prior to forming the beds; band-placed P was applied at the time of seeding. Each treatment was replicated three times, each plot consisting of two rows 6 feet apart and 90 feet long. PMR 45 melons were seeded on March 15 and irrigated the next day. First emergence was on March 24, and perfect stands were achieved in all plots.

Cultural methods were those typical of commercial operations in that area. The plants were thinned on May 25 to single plants 15 inches apart in the row. The crop was irrigated at 4-week intervals until near harvest time, when irrigation frequency was increased to once every 2 weeks. The crop received a total of 30 acre-inches of water.

Recently matured leaf samples were collected from each plot on April 28, May 6 and 25, and June 14. These dates correspond to the four-, six-, and eight-leaf (first bloom) and initial fruit-set stages, respectively. This tissue was analyzed for nitrate-nitrogen and total and soluble P as outlined previously.

Harvest began on July 5 and continued through August 10, when yields of most of the plots had become too small to be commercially profitable. The fruits were graded according to USDA standards. Percentages of U.S. No. 1 ran somewhat lower than at Davis, but this probably

Table 11

EFFECT OF RATE OF NITROGEN AND PHOSPHORUS FERTILIZATION AND PHOSPHORUS PLACEMENT ON YIELD OF U. S. NO. 1 CANTALOUPES
(West Side Field Station, 1960)

Phosphorus		Pounds N per acre				
		0	60	120	240	Mean*
pounds P_2O_5 per acre	**placement**	**crates per acre**				
0	....	208.9	232.9	254.3	277.0	260.0a
25	Broadcast	.....	238.8	252.5	268.8	253.3a
125	Broadcast	.....	281.2	321.7	295.7	299.5b
25	Band	.....	272.6	320.7	305.0	299.4b
125	Band	.....	303.8	332.9	320.3	319.0c
Mean		208.9x	265.9y	296.4z	293.3z	

* Means followed by a common letter are not significantly different (5% level).

reflects differences in judgment of the grading crews. Fruit number as well as fruit weight was recorded. Sugar determinations were made three times during the season.

Results. Table 11 summarizes the effect of fertilizer treatment on the total yield of U.S. No. 1 cantaloupes. The data show that N alone increased yields slightly over 20 per cent, P at all rates of N application increased yields about 15 per cent, and the two nutrients used together increased yields over 34 per cent.

Figure 5 shows the effect of treatment on cumulative yields throughout the season. The effect of N on yields at different rates of P is reflected in the data in graphs A, B, and C of figure 5. Where zero or 25 pounds of P_2O_5 per acre was applied, yield differences due to higher N rates became apparent only after July 25 and continued to increase throughout the season. Significant yield responses were obtained up to 240 pounds of N per acre without P but, when P was applied, yields increased only to 120 pounds of N per acre.

Graphs D, E, and F of figure 5 show the effects of P application on the cumulative yield pattern at different rates of N. Graph D shows that using 240 pounds of N per acre produced no significant response in total yields to P applications. However, plots receiving 125 pounds of P_2O_5 were about 4 days earlier than those receiving 25 pounds, and 7 days

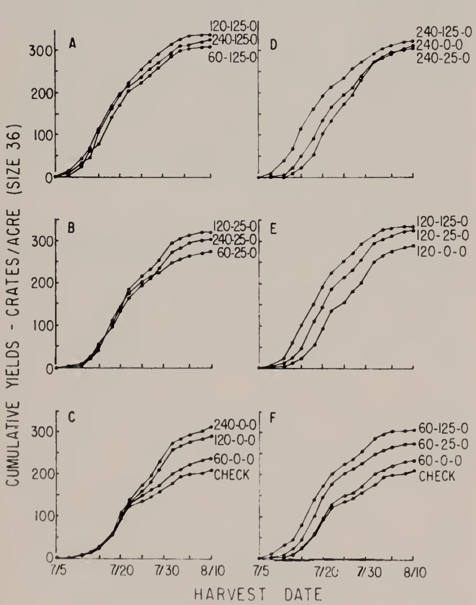


Fig. 5. Effect of different rates of nitrogen and phosphorus fertilizers on cumulative yields of cantaloupes (West Side Field Station, 1960). The numbers on each treatment refer to pounds per acre of N, P_2O_5, and K_2O, respectively.

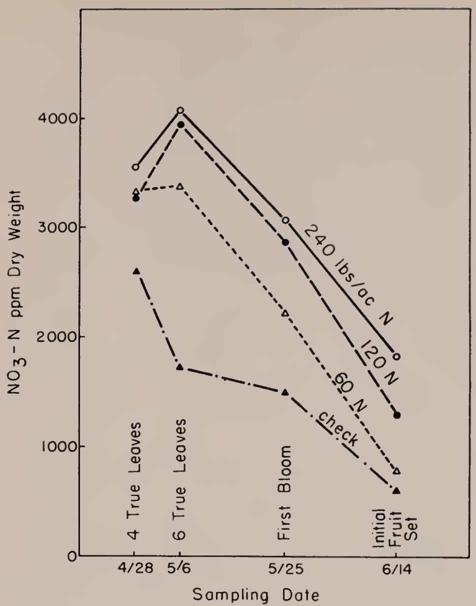


Fig. 6. Effect of nitrogen fertilization and date of sampling on the nitrate-nitrogen content of cantaloupe leaves (West Side Field Station, 1960).

earlier than those receiving no P. Where 120 pounds of N was applied there was a significant response in total yield to 25 pounds of P_2O_5 per acre. At this rate of N there was no significant response to 125 pounds over 25 pounds of P_2O_5 per acre, but plots receiving the high rate of P were 3 days earlier than those receiving the low rate. When only 60 pounds of N per acre was applied, there was a significant yield response in plots receiving 125 pounds over those receiving 25 pounds of P_2O_5 per acre.

Plant tissue samples were taken four times during the season—when the plants had four and six true leaves, when the first pistillate flowers appeared (thinning time), and when the "crown set" (first fruits set near center or "crown" of plant) was about the size of a baseball.

Figure 6 shows the effect of treatment and date of sampling on the nitrate-nitrogen content of cantaloupe leaves. On the first sampling date, little differences in N content were observed between plots receiving the various rates of N fertilization. On the second and third sampling dates plots receiving 120 or 240 pounds of N contained significantly higher nitrate-nitrogen concentrations than did those receiving the 60-pound application. On the last sampling date the N content of all treatments had dropped drastically; since this date coincided with the time of initial fruit set, the analysis reflects the effect seen in other crops—that is, the developing fruit provide a sink for reserve supplies of N in the plants. Plots receiving no N fertilization in the growing period were all significantly lower in nitrate-nitrogen than were fertilized plots. This was readily apparent in the appearance of the vines, which were light yellow and slow growing.

Relating tissue analysis to yield performance revealed that plants containing less than 3000 ppm nitrate-nitrogen at the four-to-six-true-leaf stage reflect insufficient N available for maximum yields. These plots would probably have benefited from an immediate application of N fertilizer. At first bloom, however, only those plants receiving the highest rate of N contained 3000 ppm; therefore, this tentative level could not be used as a satisfactory criterion for predicting fertilizer response at this stage of growth. As this crop matures in about 90 days, it is doubtful if application of nitrogenous fertilizers would be of economic value if delayed until after the plants are 6 weeks of age (six true leaves).

Figure 7 shows the soluble P content of the cantaloupe leaves at different sampling dates. During plant growth there was little difference between plots receiving no P and those receiving 25 or 125 pounds of P_2O_5 per acre broadcast. Plants receiving 25 pounds per acre as a band application contained significantly higher concentrations of soluble P on the first two sampling dates but not on the last two sampling dates. Plants receiving 125 pounds of band-applied P_2O_5 per acre contained high concentrations

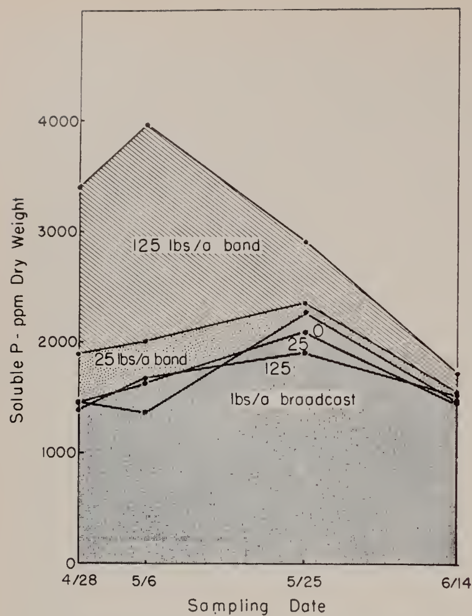


Fig. 7. Effect of phosphorus placement, rate of application, and date of sampling on the soluble phosphorus content of cantaloupe leaves (West Side Field Station, 1960).

(3500 to 4000 ppm) on the first three sampling dates, and only at the last sampling date (initial fruit set) did the P content fall to levels near those of plants receiving no P. As with nitrate-nitrogen, this indicates that the developing fruit provides a sink for reserve supplies of this vital element.

Since there was a slight increase in yield with 125 pounds of P_2O_5 over plots receiving 25 pounds of P_2O_5 per acre, it follows that the latter treatment was marginally supplied with P. Therefore, these plants contained a marginal or critical level (approximately 2000 ppm) of P in the tissue on both of the first two sampling dates. All plots contained nearly 2000 ppm on the third sampling date. As with most fruiting-type vegetable crops, in order for P to be effective it must be applied at or before the time of planting.

Figure 8 shows the total P content of the cantaloupe leaves at the different sampling dates. These data reflect a very close correlation with the soluble P content shown in figure 7, and they show that either soluble or total P concentrations can be used to assess the nutrient status of a crop. The data also provide a striking demonstration of the value of band versus broadcast applications of P. The yield data illustrate good response of cantaloupes to 25 pounds of P_2O_5 per acre in band applications and almost identical yield response to 125 pounds of P_2O_5 broadcast. This indicates that band placement was five times as effective as broadcast placement of P fertilizers.

Quality characteristics.

Grade, soluble solids, and size of cantaloupes from plots receiving the various treatments were determined during the harvest period. Table 12 shows that treatment had very little effect on the per cent of cantaloupes meeting U.S. No. 1 grade standards. This contrasts with data from the Davis experiments, which

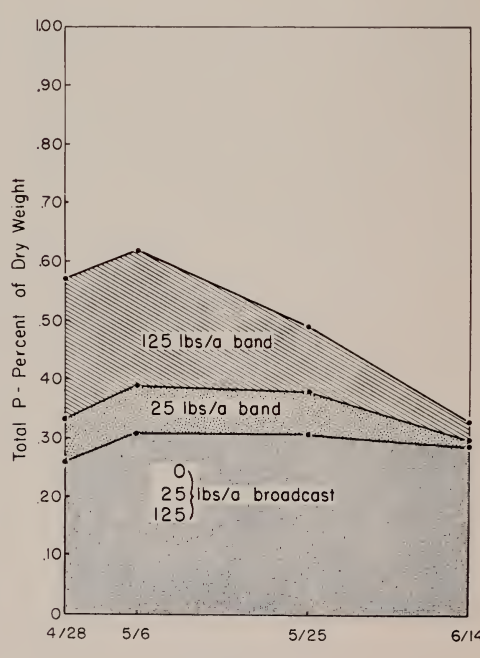


Fig. 8. Effect of phosphorus placement, rate of application, and date of sampling on total phosphorus content of cantaloupe leaves (West Side Field Station, 1960).

Table 12

EFFECT OF DIFFERENT RATES OF NITROGEN AND PHOSPHORUS FERTILIZATION AND PHOSPHORUS PLACEMENT ON PER CENT OF U. S. NO. 1 CANTALOUPES
(West Side Field Station, 1960)

Phosphorus		Pounds N per acre				
		0	60	120	240	Mean
pounds P_2O_5 per acre	**placement**	**per cent**				
0	....	61.4	55.8	59.2	60.8	59.3
25	Broadcast	....	56.8	56.4	56.7	56.6
125	Broadcast	....	58.9	60.2	55.5	58.2
25	Band	....	61.3	59.6	57.7	59.5
125	Band	....	62.8	60.3	60.6	61.2
Mean		61.4	59.1	59.1	58.3	

showed that the first increment of N (60 pounds per acre) significantly increased the percentage of U.S. No. 1 melons. The melons in this experiment were grown on land where cotton had been grown the previous year. The cotton had received a plentiful supply of N and a heavy cotton stubble was plowed down prior to planting the melons.

Table 13 shows that treatment had no effect on the size of melons produced. This also is in contrast with data from the 1959 plots at Davis, where significant increases in fruit size were observed up to 120 pounds of N per acre. Again, differences in the natural supply of N in the two soils probably accounted for this.

Table 14 shows the effect of N and P application and P placement on soluble solids content of the cantaloupes. Little difference due to treatment could be found. All melons averaged slightly over 10½ per cent soluble solids; this exceeds the sugar standards of the U.S. grade.

Table 13

EFFECT OF RATE OF NITROGEN AND PHOSPHORUS FERTILIZATION AND PHOSPHORUS PLACEMENT ON FRUIT SIZE OF CANTALOUPES
(West Side Field Station, 1960)

Phosphorus		Pounds N per acre				
		0	60	120	240	Mean
pounds P_2O_5 per acre	**placement**	**average fruit weight, pounds**				
0	....	2.87	2.86	2.98	2.98	2.94
25	Broadcast	....	2.93	2.85	2.89	2.89
125	Broadcast	....	2.92	2.90	2.91	2.91
25	Band	....	2.81	2.91	2.89	2.87
125	Band	....	2.94	2.89	2.90	2.91
Mean		2.87	2.89	2.91	2.91	

Table 14

EFFECT OF RATE OF NITROGEN AND PHOSPHORUS FERTILIZATION AND PHOSPHORUS PLACEMENT ON SOLUBLE SOLIDS CONTENT OF CANTALOUPES
(West Side Field Station, 1960)

Phosphorus		Pounds N per acre				
		0	60	120	240	Mean
pounds P_2O_5 per acre	**placement**	**per cent soluble solids**				
0	....	10.78	10.49	10.60	10.53	10.54
25	Broadcast	.....	10.61	10.53	10.65	10.60
125	Broadcast	.....	10.52	10.80	10.57	10.63
25	Band	.....	10.00	10.40	10.84	10.41
125	Band	.....	10.46	10.85	10.54	10.62
Mean		10.78	10.41	10.64	10.63	

Location of Phosphate Fertilizer Band

What is the best location for a fertilizer band? To find the answer, PMR 45 cantaloupes were seeded on plots at Davis (May, 1961) that had received the following treatments:

1. 50 pounds of P_2O_5 per acre placed 4 inches directly below the seed.
2. 50 pounds of P_2O_5 per acre placed 4 inches below and 4 inches to the side of the seed.
3. 50 pounds of P_2O_5 per acre placed 8 inches below and 8 inches to the side of the seed.
4. No P_2O_5.

All treatments were 120 pounds of N per acre—15 pounds at planting, and the remainder as ammonium sulphate at thinning time. The P and the initial application of N were from liquid 8-25-0. Each plot consisted of one row 80 inches wide and 50 feet long in a Latin Square design. Tissue samples were taken at the 4-true-leaf and full-bloom stage of growth.

Results. Figure 9 shows the effect of different locations of the phosphate band on the cumulative yields of U.S. No. 1 cantaloupes. No difference in yields was found as a result of different locations of the band, but significant yield responses were obtained from the use of P, as shown by comparison with the treatment containing no P. It was evident that melons lacking P were considerably delayed in reaching maturity.

Figure 10 shows the soluble P concentration of the leaves as influenced by different locations of the fertilizer band. Treatments receiving P 8 inches below and 8 inches to the side of the seed had not yet reached the fertilizer band at the time of initial sampling, whereas treatments receiving P in other locations contained almost twice as much P in the tissues. At the time of the second sampling some fruit had set, and the soluble P was undoubtedly being mobilized into these fruit. Consequently, the concentration in the leaves had fallen to the relatively low levels shown in the graph.

It appears that location of the band is not too important, but that it is possibly best in the area 4 to 6 inches below and 4 to 6 inches to the furrow side of the seed.

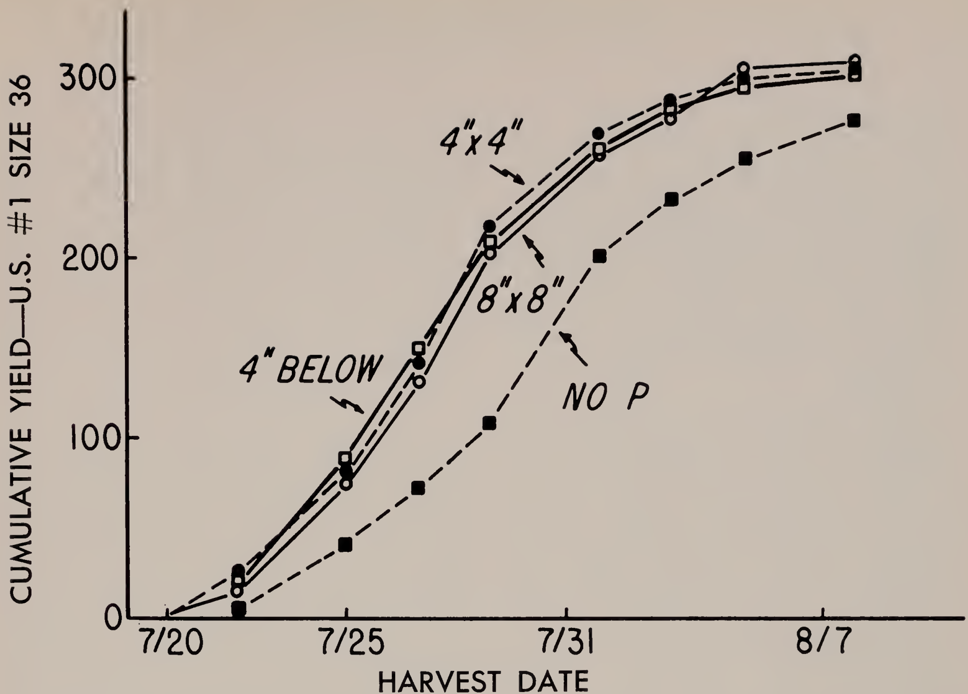


Fig. 9. Effect of location of the phosphorus fertilizer band in relation to the seed on cumulative yields of cantaloupes (Davis, 1961); 4″ × 4″ = 4″ below and 4″ to side of seed; 8″ × 8″ = 8″ below and 8″ to side of seed.

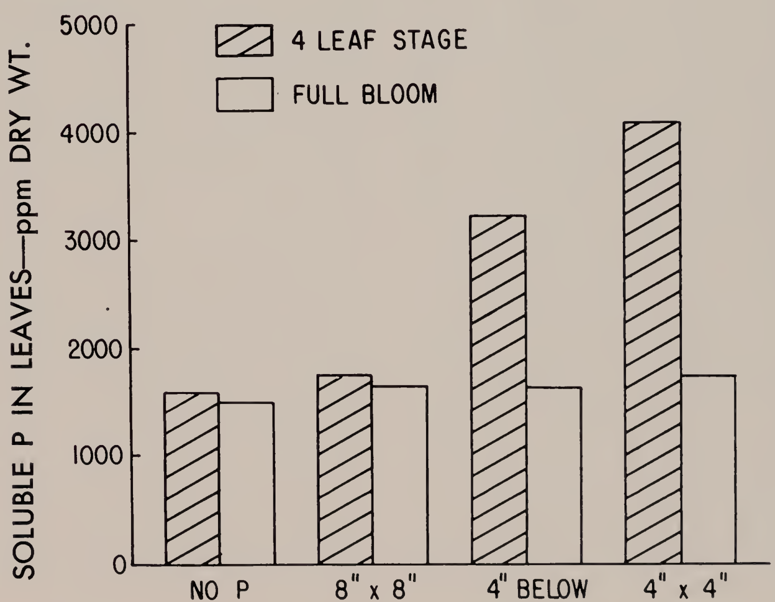


Fig. 10. Effect of location of the phosphorus fertilizer band in relation to the seed on the soluble phosphorus content of cantaloupe leaves (Davis, 1961); 4″ × 4″ = 4″ below and 4″ to side of seed; 8″ × 8″ = 8″ below and 8″ to side of seed.

SUMMARY

These experiments demonstrate that cantaloupes are responsive to good fertilizer management. Responses to N in applications up to 120 pounds per acre may be expected, and to even higher rates on the light soils low in organic matter. The fertilizer history of a given field may modify the N needs of a cantaloupe crop.

Yield responses to P are also large, especially in terms of earlier maturity of the crop. The quantities of P needed depend on the soil, the season, and the method of application. Cantaloupes seem to respond to P to a greater degree than other crops grown in rotation with them, such as cotton or tomatoes. Consequently, when cantaloupes are grown on soils where the latter crops respond to P, heavier applications of P are needed than where these rotational crops do not respond. If early maturity is important, proper P fertilization is essential. Crown-set fruit matured 7 days earlier in some experiments receiving P fertilization than in others receiving no P. The comparison of band versus broadcast application of P demonstrated that band application near the seed at or before planting is essential to be effective for this crop. Other experiments not reported here have shown that side-dressing P after emergence of the seedlings was of no value to the crop.

Possibilities of using leaf analysis as a guide to fertilization of this crop were explored. Either whole leaves or petioles may be used, but the different tissues have different critical levels. The most favorable time for tissue analysis was found to be at thinning, or when the plants have six to eight true leaves. If the NO_3-N level is less than 7500 ppm in the petioles or 5000 ppm in the whole leaves at thinning, the crop probably needs additional N for maximum yields. If analysis of leaves at thinning shows the soluble P level to be less than 2000 ppm in the petioles, or 2500 ppm in the whole leaves, the crop would likely have benefited from a higher rate or better placement of P fertilizer. A crop containing less than these concentrations will probably not respond to P fertilization, since the maximum benefit from P was observed before thinning.

All observations of several quality aspects in these experiments indicate that maximum quality of fruit will be associated with maximum yields. Heavy N applications did not reduce the appearance of quality of the fruit in terms of green sutures, netting, soft fruit, or sugar content. Some of these quality characteristics were lower on fruit harvested from plots obviously deficient in N. No quality defects were found to be associated with P deficiency. Application of K had no detectable effect on quality.

Decisions on fertilizer practices may depend on factors other than yield and quality response. The effect of such practices on maturity patterns has economic implications (Eidman *et al.*, 1963). Heavier P applications should be made in years when prices are high early in the season; when a relatively stable price structure is expected, heavy N applications should be favored.

Irrigation practice affects fertilization management. Response to heavy fertilization is dependent on adequate but not excessive irrigation. Fertilizer needs are higher on thickly planted crops. Since the cantaloupe is indeterminate (non-uniform maturity) in growth habit, the quantity of fertilizer needed (especially N) depends on the plant population. Thickly planted crops need more N than widely spaced crops. The interdependence of all these factors provides the basis for future research.

CONVERSION TABLE

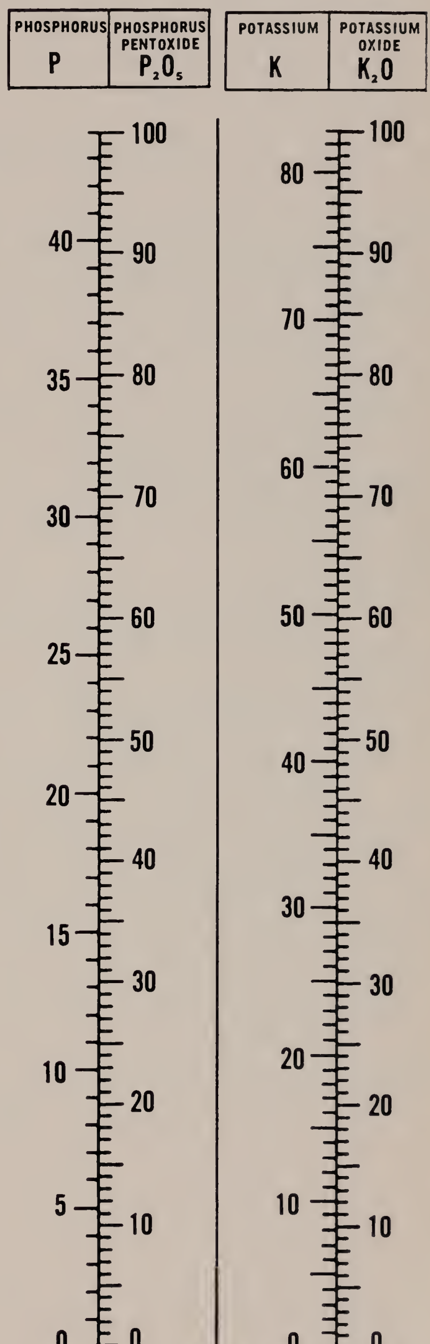
In the past, fertilizer terminology has been confusing, because the elemental terms have been used for nitrogen and the oxide terms for phosphorus and potassium. Nitrogen (N) and most other plant nutrients have customarily been described according to the actual amount of the element present. But phosphorus (P) is traditionally listed according to the amount of phosphorus pentoxide (P_2O_5), even though P_2O_5 contains only 44% phosphorus. Potassium (K) is commonly described in terms of potassium oxide (K_2O) which contains only 83% potassium.

To convert P_2O_5 and K_2O to actual amounts of P and K, use the conversion table.

FERTILIZER CONVERSION SCALES

Element to Oxide

(Pounds or Per Cent)



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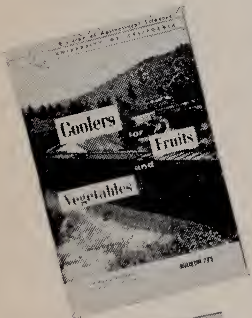

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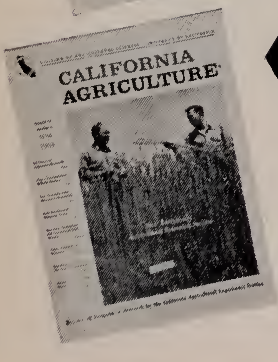

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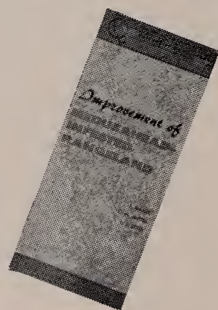

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