LEVELS OF NUTRITION IN RELATION TO GROWTH AND FRUITING OF THE CANTALOUPE, WITH REFERENCE TO NITROGEN, POTASSIUM, CALCIUM, MAGNESIUM AND BORON

By

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INTRODUCTION

The cantaloupe is an important truck crop in Maryland, being grown primarily on light sandy loams and loamy sands. In this region these soils are almost universally deficient in organic matter.

Commercial practice in the cantaloupe producing areas is to plant the seed in five- or six-foot rows with a seeder which places 700 to 1000 pounds of a 4-8-12 or 5-8-12 fertilizer in bands 2 1/2 inches to the side and 1 1/2 inches below the level of the seed. Two to three weeks after emergence the plants are thinned to a single plant 2 1/2 to 3 feet apart in the row.

Most growers spray or dust four to seven times during the season with a copper fungicide or with one of the newer organic fungicides, yet in most seasons defoliation is the major production problem. Fruits from defoliated plants are very poor in quality, and growers have been forced to take considerable loss in competing with the higher quality melons shipped to the East from the irrigated regions of the West.

In earlier years it was the usual procedure to make heavy, annual applications of manure. The manure was either broadcast or placed in the furrow. Since fewer difficulties were encountered when the use of manure was standard practice, and since adequate spraying or dusting has not given complete control of defoliation, it is conceivable that the present difficulties encountered in fruit production and quality might be materially alleviated with a better understanding of the nutritional requirements of this crop.

The present study is a part of a comprehensive program inaugurated in 1938 to determine the physiological aspects of the entire cantaloupe production problem. Work previously published has been concerned with the physiological effects of certain fungicides on growth and fruiting (34), and some of the symptoms resulting from deficient levels of mineral elements and their interactions (17, 35). The phase of the program reported herein is concerned with the effects of nutrient levels on the growth and fruiting of the cantaloupe, with especial reference to nitrogen, potassium, calcium, magnesium and boron, in sand culture. Future work will amplify these results under field conditions.

REVIEW OF LITERATURE

The literature concerning nutrition of plants has been partially reviewed by Hoagland (11, 12), and Nightingale (19). Since 1932, much of the literature pertaining to the broad field of plant nutrition has annually been reviewed by various leaders in the field, for inclusion in the Annual Review of Biochemistry (1). Shear, Crane and Myers (32) have recently discussed the concept of nutrient-element balance in plant nutrition.

Experimental work on the nutrition of the cantaloupe is limited. Wilkins (38), studying several species of cucurbits, found that cantaloupe plants accumulated large quantities of calcium, and that the fruits contained large amounts of potassium. Analyses at two dates of sampling showed that, on a percentage basis, the quantities of all the constituents studied except calcium and magnesium decreased considerably in the more mature plants. In comparison, the percentages of calcium and magnesium decreased only slightly. Wilkins also calculated the total amount of nutrients removed by a crop of cantaloupes, on an acre basis, when the fresh weight of the vines was 3,132 pounds and the fruits weighed 13,485 pounds. In pounds per acre, the nutrients removed were as follows: nitrogen, 50.2; phosphoric acid, 15.4; potassium oxide, 90.3; calcium oxide, 62.2; and magnesium oxide, 13.5. Jones and Rosa (15) examined the data of Wilkins, and postulated that

> "Since Ca increases in the vines toward maturity and is very low in the ripe fruit, it may be that, during ripening, there is a translocation of Ca from the fruit to the vines. This process may be connected with changes in the pectic compounds of the middle lamella of fruit cells and cause softening of the fruit and abscission of the fruit."

Hartwell and Damon (10) studied the value of lime applied to an acid soil as related to the growth of many species of plants, and classed the cantaloupe as a crop benefiting considerably from liming.

Eisenmenger and Kucinski (8) reported on the effect of the application of lime, magnesium, and lime plus magnesium on eleven species of plants. Their studies showed that the lime application hastened the maturity of cantaloupes and watermelons by nearly two weeks. Furthermore, the limed melons were considerably higher in sugar content.

Foliar symptoms of cantaloupes grown in sand culture with various mineral elements omitted from the different nutrient solutions, have been described by Stier (35). The symptoms described include those observed when nitrogen, phosphorus, potassium, calcium, magnesium, boron, manganese, sulfur and iron were lacking from individual solutions.

Also included was a discussion of the foliar effects of the Ca x N, Ca x Mg, and Ca x K interactions. Plants grown with a nutrient solution containing a high level of nitrogen and a low level of calcium showed a distinct marginal chlorosis of the leaves. As the level of nitrogen was lowered, the chlorotic condition disappeared and the leaves became a lighter green in color. A low level of calcium and a high level of magnesium resulted in the appearance of severe calcium deficiency symptoms. The symptoms disappeared when the concentration of magnesium was decreased. Likewise, a low level of magnesium in the presence of a high level of calcium resulted in the manifestations of magnesium deficiency which disappeared when the calcium level was lowered, but was accompanied by decreased growth. He also felt there was an indication of more pronounced symptoms of potassium deficiency when the calcium level was increased at a low level of potassium.

Mahoney (17) observed the foliar symptoms exhibited by cantaloupes growing under various levels of mineral nutrition and reported that when the crown set of fruit is about three-fourths mature, leaves on the plants which failed to receive an adequate supply of balanced nutrients begin to break down and show deficiency symptoms, or may show the interaction of symptoms. On the basis of these observations, it was concluded that at this stage of growth the plants need high levels of calcium and potassium with a medium level of magnesium. He concludes by suggesting that 5-8-12 fertilizer mixtures be made to include 300 pounds per ton of dolomitic limestone, to provide a greater amount of available exchangeable calcium and magnesium during the early seedling stage of growth.

Pierce and Stoddard (21) studied the occurrence of a physiological leaf spot of cantaloupes which they believed to be due to a lack of adequate aeration in the substrate. Two grades of sand were used, and the nutrient solution was applied by the slop and the constant drip methods, at rates of 500 and 1000 milliliters daily. The results of this study point to a greatly reduced amount of the physiological spotting when the plants were grown under the conditions which provided the best degree of aeration. The better conditions for growth were found when a course grade of predominantly 20 mesh sand was used, and when the solution was applied at the rate of 500 ml. daily by the slop method.

In studies on the relations of nitrogen, potassium and calcium to Fusarium wilt of cantaloupe, Stoddard (36, 37) reported that high levels of nitrogen resulted in a greater invasion of the plants by the Fusarium wilt organism. There was little evidence that the potassium concentration in the substrate was important in affecting susceptibility when nitrogen and potassium were balanced and in amounts sufficient for normal growth of the plant. In field plots, the addition of sufficient lime to the soil to provide a pH of 6.0, significantly reduced the amount of disease over plots with pH values of 4.8 and 4.1.

Pierce and Appleman (20) studied the cation-anion balance in twelve species of plants under controlled conditions, so that all plants received the same nutrient supply. Inorganic ions were found to be taken up in varying proportions according to inherent characteristics of the species. In all species there was a large excess of inorganic cations over inorganic anions, and with the exception of the cantaloupe, this excess was found to be highly correlated with total ether soluble organic acids. The cantaloupe contained the largest amounts of cations, but had the lowest organic acid content of any of the species tested. These workers also found the calcium content of the cantaloupe leaves quite high, and noted that approximately 85 percent of the calcium was insoluble. Since they found no oxalic acid in the plant, and a pH of 7.4 to 7.6 of the expressed sap, they postulate that part of the cations may be tied up as carbonate and bicarbonate.

Studying the effect of sodium chloride and sodium sulfate on sugar content in melons, Morozov (18) reported that the addition of 0.1 moles of these salts to soils in which watermelon "Melitopolsky 142" and muskmelon "Kassaba pyatnistaya" were growing, decreased the total sugar and monosaccharides of both species. The addition of 0.2 moles of sodium chloride to watermelons resulted in a greater decrease of total sugar and monosaccharides. The sucrose content of watermelons was correspondingly decreased on application of the salts, but in the muskmelons the sucrose content increased. Morozov concluded that the watermelon proved to be more resistant than the muskmelon to soil salinity. He also stated that both species agreed with chlorides better than with the sulfates, although the data on the carbohydrate fractions of the fruits do not corroborate this conclusion.

Jacob and White-Stevens (14) in presenting the results of their work on the relation of nutrition to flavor and sugar content of cantaloupes in field tests, showed that a high level of potash reduced the content of both hexose and sucrose in the fruit. And in all interactions involving potash, the negative effect occurred. Magnesium showed a consistent stimulating effect upon flavor, total dispersed solids and sugar concentration. Boron showed a general reducing effect, but increased sucrose at the expense of hexose. Boron also showed a distinct neutralizing effect upon the deleterious potash influence. When magnesium interacted with boron a negative effect was produced which indicated that each element inhibited the beneficial effects of the other.

A table developed by Purvis and Hanna (22, 23) from studies with twenty-three vegetable crops shows the maximum safe applications of borax per acre for each of these crop plants. Cantaloupes are classified as a boron-sensitive vegetable crop, and a maximum safe application of 20 pounds borax per acre is suggested. Eaton (7), on the other hand, found no toxicity of boron on muskmelons until a concentration of 5 ppm boron in the substrate was attained.

In field studies, Hollar and Haber (13) found that with cantaloupes grown on a Buckner coarse sand in the Muscatine Island district of Iowa, delaying the application of 250 pounds per acre of 4-8-8 or 10-6-4 fertilizer until seven weeks after planting produced greater yields than did the application of eight tons of manure. A winter cover crop of rye had been listed into the furrow in the spring, according to commercial practice. Conversely, Rahn and Phillips (24), working on a Sassafras loamy sand in Delaware concluded that in order to produce the highest yields, placement of manure in the furrow was necessary. When no manure is available, however, the application of 1100 pounds of 4-8-12, 5-10-10 or 5-10-15 fertilizer was suggested. It was recommended that two-thirds of the amount be applied in bands at seeding and one-third later when the vines start to spread. Results of experiments on a gravelly, sandy loam in New York, reported by Carolus and Lorenz (6), show the need for liberal applications of potash where the soil is low in this element. Application of 100 pounds per acre of potash was beneficial when manure was not used, although 200 pounds per acre reduced the early yield of melons. It was further reported that the application of manure favored early maturity and increased total yield, as did also the application of lime when the soil was acid.

In addition to the works reviewed pertaining to cantaloupes, two recent researches on nutrient-element balance with vegetable crops are of interest. Working with spinach, swiss chard, lettuce, tampala and tomato, Wittwer, et.al. (39) reported that a lack of balance between calcium, nitrogen and phosphorus was more detrimental to plant growth than a deficiency of all of the variable elements. Beckenbach (2) found certain of the interactions of nitrate, phosphate and boron to be significant on the growth of tomato plants.

GENERAL MATERIALS AND METHODS

Plot Technique and Statistical Treatment

A factorial experiment designed to include three levels of each of four elements requires 81 treatments to include all possible combinations. The design of a 3 x 3 x 3 x 3 factorial experiment may be arranged so that the 81 treatment combinations form a 9 x 9 quasi-Latin square, as described by Yates (40). This arrangement was used in both of the experiments reported in this study. This design confounds sixteen degrees of freedom from the second-order interactions with rows and columns, eight being confounded with rows and eight with columns. Yates explains that in experiments of this magnitude, replication is unnecessary inasmuch as "hidden" replication exists.

Plants are known to be susceptible to rather slight environmental differences, and in greenhouse experiments systematic rotation of pots is frequently employed to reduce positional effects. In the present study, the cantaloupe stems were trained on twine so that a shifting of the pots was not possible. The 9 x 9 quasi-Latin square designed by Yates then assumes a more significant role by making it possible to eliminate the variation due to rows and columns from the error variance.

Analysis of variance of the data was made according to the method outlined by Yates (40) with certain modifications suggested by Brandt (4) for ease of calculation.

Cultural Procedure

The experiments were conducted in the Department of Horticulture greenhouses at the University of Maryland. Two-gallon, glazed coffee urn liners were used as containers, and the drainage hole, which was 1-1/16 inches in diameter, was covered with glass wool. Washed, quartz sand was used as the growing media. The containers, glass wool and sand were steam sterilized for a minimum of three hours before the sand was placed in the pots. Sand was placed into the pots to 1 1/2 inches of the top and was then leached with 2 liters of distilled water.

In order to gain a possibly greater degree of uniformity, an inbred line of cantaloupe (Maryland #4008) was used in these experiments. This strain was developed from a selection of Honey Rock and was inbred for eight generations. In order to reduce any variability that might exist in age of plants resulting from differences in time of germination, the seeds were germinated on moist paper. Ten seeds with the radicles protruding 1/8 to 1/4 inches were placed in each container at a time when germination had predominantly reached this stage.

The ten seedlings were allowed to develop until the plants in some of the containers showed signs of crowding. The four plants which deviated the greatest from the mode for each container, as determined by visual inspection, were removed. Additional plants were removed at other times, until two plants, as uniform as possible, remained in each container. These two plants were allowed to develop to maturity.

Growth Measurements

Measures of linear growth were made by direct measurement of the two plants which developed to maturity, and the results were averaged. At the time of removing these two plants separation of the leaves (including petioles), stems and roots were made. All of the plants when removed from the containers were dried at 70 degrees C. with forced draft for 48 hours, for the dry weight determinations.

Percent soluble solids in the fruit was determined on the expressed juice of the flesh of each fruit. Sampling consisted of taking plugs with a cork borer at three positions in the equatorial plane of each fruit and squeezing out the juice. The first sample was always obtained from the top sector of the fruit and the other two were obtained at equal distances from the first so that the fruit was sampled in three equal sectors. The percent soluble solids was measured with a Zeiss hand refractometer.

Chemical Determinations

Leaf samples were dried as previously described, and ground in a Wiley mill to pass through a 20-mesh screen. All of the leaves from the two plants which developed to maturity in each treatment were ground in this manner, and the ground material was thoroughly mixed before aliquots were taken.

Total nitrogen was determined with the micro-Kjeldahl apparatus according to the method described by Ranker (25), modified by using 2% boric acid to catch the distillate as suggested by Gauch (9), with adaptations described by Scott (31).

Boron determinations were made according to the method of Berger and Truog (3) with modifications described by Scott (27).

Determinations of potassium, calcium, magnesium and phosphorus were made according to accepted analytical procedures currently in use in the laboratory of the Department of Horticulture. For these procedures the ground material was ashed in an electric muffle at 525 degrees C. Calcium was determined titrimetically as the oxalate (16), phosphorus as the molybdate (16), and magnesium was measured colorimetrically with Titan yellow (30). Potassium was determined as the cobaltinitrite (26, 28) for the studies in Experiment I, and by using a Perkin-Elmer flame photometer in Experiment II (29).

The results of the analyses are expressed as milligrams per gram of dry weight, with the exception of the boron determinations, which are expressed as parts per million.

PROCEDURES AND RESULTS

EXPERIMENT I. The Nitrogen, Potassium, Calcium and Magnesium Nutrition of the Cantaloupe. 1942 Studies.

Materials and Methods

The quartz sand used in this experiment was a fine grade of approximately 40 mesh.

The germinated seeds were placed in the containers on February 28, 1942, and were covered with about one-half inch of washed sand. The individual treatments were started by applying the feeding solution immediately. An application of 500 ml. of feeding solution was made daily.

Stock solutions were prepared with c.p. chemicals and distilled water. Chemicals used in making up the feeding solutions included calcium chloride, calcium nitrate, magnesium nitrate, magnesium sulfate, potassium chloride, potassium nitrate, potassium phosphate (primary), potassium sulfate, sodium phosphate (primary), ammonium nitrate, ferric citrate, boric acid, manganese chloride, zinc sulfate, molybdic acid and copper sulfate. The concentrations used at the different levels are given in Table 1.

The feeding solutions were prepared by adding known amounts of the stock solutions to distilled water. No attempt was made to hold the total concentration of the solutions constant. The pH of the solutions varied between 4.9 and 5.5 and no adjustment was made.

For convenience the concentrations used are designated as low (L), medium (M), and high (H). The low concentrations were planned as deficiency levels; the medium concentrations were planned to be in the vicinity of that amount believed necessary for satisfactory growth, and

TABLE 1. Concentrations of Ions in the Feeding Solutions, at the Three Levels of Nutrition, (Experiment I).

Nutrient Element	Level of Nutrition		
	Low	Medium	High
	m.e./L.	m.e./L	m.e./L.
Nitrogen as NO_3	2	10	50
Potassium	1	5	25
Calcium	2	10	50
Magnesium	1	5	25
Phosphorus as PO_4	6	6	6
	ppm.	ppm.	ppm.
Boron	0.5	0.5	0.5
Manganese	0.5	0.5	0.5
Zinc	0.05	0.05	0.05
Molybdenum	0.05	0.05	0.05
Copper	0.02	0.02	0.02
Iron	1.4	1.4	1.4

the high concentrations were selected with the possibility that they might prove to be in excess of the needs of the cantaloupe plant.

Each of the containers was leached with one liter of distilled water every 14 days to remove any accumulated salts. By March 25, certain of the nutrient combinations had proved so unfavorable for growth that a nutrient solution was uniformly provided to all of the combinations for a period of two weeks, after which the sand was leached for two days and the original treatments restored. The composition of the nutrient solution used during this two week period was as follows: nitrogen (as NO_3), 15 m.e./L., phosphorus (as PO_4), 3 m.e./L., potassium, 6 m.e./L., calcium, 10 m.e./L., magnesium, 4 m.e./L., sulfur (as SO_4), 4 m.e./L., and minor elements and iron in the same concentrations given in Table 1.

Effect of Nutrition on Growth of Tops

Plants were removed for dry weight determinations on April 1, April 10, and May 14. After May 14, two plants remained in each container which were allowed to mature, and the final samplings were made over a period of nine days starting on June 1, 1942.

Data showing the means for the main effects and the first-order interactions of the three levels of each element on the dry weight of the tops for each sampling date are shown in Tables 2 to 5. The analyses of variance are presented in the Appendix Tables 1 to 4.

Examination of the tabular data reveals that throughout the entire growth cycle of the cantaloupe plants nitrogen exerted a significant effect on the amount of growth produced. The response was greatest at the medium level of nitrogen, which is indicated by the high variance for the quadratic term N(b). Although at any sampling date the weight of dried tops produced at the low level of nitrogen slightly exceeded

TABLE 2. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Dry Weight, in Grams per Plant, of Cantaloupe Leaves and Stems. (April 1, 1942).

		Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H	K-L	K-M	K-H
		.189	.166	.192	.151	.227	.168	.148	.234	.165
N-L	.176	.198	.159	.171	.189	.226	.113	.130	.222	.176
N-M	.236	.224	.236	.248	.155	.364	.188	.205	.316	.186
N-H	.135	.145	.104	.156	.108	.093	.203	.108	.162	.134
K-L	.148	.144	.157	.141	.125	.222	.095			
K-M	.234	.258	.196	.246	.152	.286	.263			
K-H	.165	.164	.145	.187	.176	.174	.146			
Ca-L	.151	.136	.168	.149						
Ca-M	.227	.278	.169	.235						
Ca-H	.168	.153	.161	.191						

TABLE 3. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Dry Weight, in Grams per Plant, of Cantaloupe Leaves and Stems. (April 10, 1942).

		Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H	K-L	K-M	K-H
		1.39	1.34	1.63	1.22	1.57	1.58	1.51	1.64	1.22
N-L	1.40	1.47	1.47	1.27	1.47	1.70	1.04	1.18	1.66	1.37
N-M	1.82	1.57	1.66	2.25	1.41	2.18	1.88	2.17	1.94	1.37
N-H	1.14	1.13	.90	1.38	.77	.84	1.81	1.17	1.33	.91
K-L	1.51	1.58	1.61	1.34	1.57	1.72	1.24			
K-M	1.64	1.54	1.42	1.97	1.07	1.66	2.20			
K-H	1.22	1.05	1.01	1.59	1.02	1.34	1.29			
Ca-L	1.22	1.24	1.33	1.08						
Ca-M	1.57	1.61	1.60	1.52						
Ca-H	1.58	1.33	1.11	2.30						

TABLE 4. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Dry Weight, in Grams per Plant, of Cantaloupe Leaves and Stems (May 14, 1942).

		Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H	K-L	K-M	K-H
		8.36	7.96	7.57	6.03	9.38	8.91	8.28	8.15	7.88
N-L	7.52	8.60	7.48	6.46	5.85	9.24	7.44	7.69	7.43	7.44
N-M	9.89	9.51	10.39	9.78	7.89	10.98	10.81	9.63	10.65	9.40
N-H	6.87	6.98	5.96	7.66	4.36	7.92	8.32	7.45	6.36	6.79
K-L	8.28	7.59	9.25	8.11	6.56	9.80	7.56			
K-M	8.15	9.24	7.42	7.79	5.46	9.38	9.60			
K-H	7.88	8.26	7.36	8.00	6.09	8.96	8.58			
Ca-L	6.03	5.74	7.95	4.41						
Ca-M	9.38	10.75	7.51	9.89						
Ca-H	8.91	8.60	8.48	9.60						

TABLE 5. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Dry Weight, in Grams per Plant, of Cantaloupe Leaves and Stems. (June 1-9, 1942).

		Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H	K-L	K-M	K-H
		12.13	12.56	10.65	13.34	12.09	9.92	12.50	11.00	11.84
N-L	11.59	10.61	14.47	9.70	13.59	11.67	9.52	11.49	11.54	11.76
N-M	13.36	14.06	13.13	12.89	15.66	13.84	10.56	14.87	12.55	12.65
N-H	10.39	11.74	10.07	9.37	10.76	10.74	9.68	11.14	8.92	11.12
K-L	12.50	12.25	14.89	10.35	13.22	13.43	10.85			
K-M	11.00	12.59	10.63	9.78	11.42	11.53	10.06			
K-H	11.84	11.56	12.14	11.82	15.38	11.30	8.85			
Ca-L	13.34	12.09	16.58	11.34						
Ca-M	12.09	13.60	11.53	11.13						
Ca-H	9.92	10.71	9.56	9.49						

that produced at the high level, the "F" value for this linear term is not significant.

The level of potassium proved quite important in determing the amount of dry weight produced at the early stages of growth, as indicated by an "F" value of 5.62 for the April 1 sampling date. Separation of the 2 degrees of freedom for potassium into its components reveals that on the April 1 sampling date, significance for potassium was due entirely to the quadratic term, which by comparison with the means shows that a greater dry weight resulted at the medium level, while no significant difference occurred between the low and the high levels. On the April 14 sampling, the significant variance for potassium was again the result of the greater growth at the medium level. The "F" value decreased to 3.85 for the potassium effect at the time of the second sampling. At the May 14 sampling date this value had further decreased to 0.04, which indicates that no significance can be attributed to the differences due to the levels of potassium by this date. Moreover, there was no effect of potassium level on dry weight at the final sampling on June 1.

The effect of calcium on dry weight is particularly interesting. On the first sampling date there was no significant response to differences in the level of calcium. On April 10 the response was significant in favor of the high and medium levels of calcium. It will be noted that the significance on April 10 resulted from the difference between the response at the high and the low levels of calcium rather than from the deviation in response at the medium level of calcium. By May 14, the response to calcium was greatest at the medium level with 10.75 grams per plant, intermediate at the high level with 8.60 grams per plant, and the least response was at the low level with 6.03 grams per plant. The variance for each degree of freedom was significant on the May 14 sampling date. On the final sampling date, on June 1, however, significance is attributed only to the linear term, which indicates that the response to the medium level of calcium did not deviate significantly from the linearity between the low and the high levels. Furthermore, the greatest response was to the low level with a mean dry weight per plant of 13.34 grams, while the dry weight was 12.09 grams at the medium level, and 9.92 grams at the high level.

Magnesium, at the levels used in this experiment, did not exert any effect on the growth of the tops, as measured by dry weight, at any time during the life cycle of the plants.

Effect of Nutrition on Growth of Leaves, Stems and Roots.

In Tables 6, 7 and 8 are presented the mean values for dry weights of the leaves, stems and roots of the mature plants harvested during the final sampling period beginning on June 1. The analyses of variance given in Appendix Tables 5, 6 and 7 reveal that the nitrogen level exerted a significant influence on the growth of leaves, stems and roots. The weight of stems was greatest at the low level of nitrogen and least at the high level of nitrogen. At the medium level of nitrogen the mean weight of stems was between that of the low and high levels, but deviated significantly from linearity, as revealed by the significant variance for the quadratic term. The dry weight of both the leaves and the roots was greatest at the medium level of nitrogen and least at the low level. The dry weight of leaves and the roots was intermediate at the high nitrogen level, but was significantly greater than at the low level.

The top-root ratios given in Table 9 indicate that there was one-third as much root growth per unit of top growth at the low nitrogen level as there was at the medium and high levels of nitrogen, on a dry weight

TABLE 6. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Dry Weight, in Grams per Plant, of Cantaloupe Leaves. (June 1-9, 1942).

		Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H	K-L	K-M	K-H
		7.98	8.00	7.45	8.52	7.90	7.01	8.41	7.13	7.88
N-L	5.83	5.13	7.13	5.23	6.42	5.68	5.40	5.81	5.74	5.95
N-M	9.96	10.39	9.60	9.89	11.41	10.21	8.26	11.33	9.10	9.45
N-H	7.64	8.41	7.28	7.22	7.72	7.81	7.38	8.11	6.57	8.24
K-L	8.41	8.24	9.43	7.57	8.77	8.65	7.83			
K-M	7.13	8.00	6.75	6.65	6.81	7.66	6.93			
K-H	7.88	7.69	7.83	8.12	9.97	7.39	6.27			
Ca-L	8.52	7.58	10.36	7.61						
Ca-M	7.90	8.91	7.16	7.63						
Ca-H	7.01	7.44	6.49	7.10						

TABLE 7. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Dry Weight, in Grams per Plant, of Cantaloupe Stems. (June 1-9, 1942).

		Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H	K-L	K-M	K-H
		4.16	4.55	3.20	4.82	4.18	2.91	4.08	3.87	3.96
N-L	5.76	5.48	7.34	4.46	7.28	6.00	4.12	5.68	5.80	5.81
N-M	3.40	3.67	3.52	3.00	4.26	3.64	2.30	3.54	3.45	3.20
N-H	2.75	3.32	2.78	2.14	3.03	2.92	2.30	3.03	2.35	2.87
K-L	4.08	4.01	5.46	2.78	4.45	4.79	3.01			
K-M	3.87	4.59	3.88	3.13	4.60	3.87	3.13			
K-H	3.96	3.87	4.31	3.70	5.40	3.90	2.58			
Ca-L	4.82	4.51	6.22	3.73						
Ca-M	4.18	4.69	4.36	3.50						
Ca-H	2.91	3.27	3.06	2.38						

TABLE 8. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Dry Weight, in Grams per Plant, of Cantaloupe Roots. (June 1-9, 1942).

		Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H	K-L	K-M	K-H
		6.27	3.45	3.31	3.16	4.03	5.85	5.02	4.48	3.53
N-L	1.78	1.67	1.46	2.21	1.86	1.18	2.30	1.26	2.32	1.77
N-M	6.52	10.63	4.42	4.51	4.88	6.24	8.44	8.51	6.50	4.55
N-H	4.73	6.51	4.46	3.22	2.73	4.66	6.80	5.30	4.61	4.28
K-L	5.02	7.36	4.94	2.77	4.96	4.31	4.80			
K-M	4.48	6.25	3.10	4.08	1.95	3.65	7.83			
K-H	3.53	5.21	2.31	3.08	2.56	3.12	4.91			
Ca-L	3.16	4.66	3.41	1.39						
Ca-M	4.03	6.46	2.73	2.88						
Ca-H	5.85	7.68	4.20	5.66						

TABLE 9. Ratios of Leaves, Stems and Roots at Varying Levels of Nitrogen.

Nitrogen Level	Tops gms.	Roots gms.	Top:Root Ratio
Low	11.59	1.78	6.51:1
Medium	13.36	6.52	2.05:1
High	10.39	4.73	2.20:1
	Leaves gms.	**Roots** gms.	**Leaf:Root Ratio**
Low	5.83	1.78	3.28/1
Medium	9.96	6.52	1.53/1
High	7.64	4.73	1.62/1
	Leaves gms.	**Stems** gms.	**Leaf:Stem Ratio**
Low	5.83	5.76	1.01/1
Medium	9.96	3.40	2.93/1
High	7.64	2.75	2.78/1

basis. At the medium and high levels, the ratios are similar. When the dry weights of the roots are compared with the dry weights of the leaves alone, however, it is found that at the low nitrogen level there was one-half the amount of roots per unit of leaves as in the two higher levels. The ratio of leaves to stems is 1.01 at the low level of nitrogen and 2.93 and 2.78 respectively at the medium and high levels.

Nitrogen was the only nutrient in this experiment which exhibited a significant influence on the production of leaf tissue as measured by dry weight. In the calcium x magnesium interaction there was a significant difference in the effect of the high and the low levels of calcium on dry weight of leaves at the different magnesium levels. When the calcium level was low, leaf weight was greatest at the medium level of magnesium, whereas, leaf weight was least at the medium level of magnesium when the calcium level was high.

The level of potassium had no significant effect on the amount of leaves, stems or roots produced.

The calcium level produced a significant linear response upon the dry weights of the stems and the roots, and the deviation from linearity was slight. However, the trend in the linear response was quite different for the stems and for the roots. For the stems, the greatest dry weight was produced at the low level of calcium, and the dry weight decreased as the amount of calcium in the substrate increased. For the roots, on the other hand, the dry weight at the low level of calcium was 3.16 grams per plant, and increased to 4.03 grams per plant at the medium level, and to 5.85 grams per plant at the high level.

Varying the level of magnesium resulted in significant differences in the dry weights of the stems, as well as of the roots. For the dry weights of stems produced at the different levels of magnesium, significance is attributed to both the linear and the quadratic terms. In this case the dry weight at the low level is significantly greater than at the high level, and greatest at the medium level. For the roots, the dry weight was greatest at the low level of magnesium and least at the high level, while the medium level resulted in a dry weight intermediate to that of the low and the high levels.

Stem growth was also influenced by the N(a) x Ca(b) interaction and the N(a) x Mg(b) interaction. The first interaction mentioned may be interpreted as the difference between the effect of high nitrogen and low nitrogen on the linear response to calcium. The N(a) x Mg(b) interaction is interpreted as the different response to the three levels of magnesium at the high and low levels of nitrogen. Examination of Table 8 will show the actual means for these interactions.

When the interactions of the nutrient elements on root growth are considered it is found that the N(b) x Mg(a) interaction is important. Furthermore, it is found that when the four degrees of freedom for the N x Mg interaction are averaged, the "F" value is 3.09, which is significant at the 5% point. Examination of the means in Table 8 shows that there is a mutual effect of nitrogen on magnesium and of magnesium on nitrogen. The difference in the trend at the various levels is quite evident when the three levels of magnesium are compared at the low and high nitrogen levels. The K(b) x Ca(a) interaction is also significant and may be seen readily by comparing the means for the different levels of potassium as influenced by high and low calcium.

Effect of Nutrition on Main Stem Length, Lateral Length and Number of Laterals.

Length of the main stems produced under the various treatments in this experiment was influenced only by the levels of nitrogen and potassium in the substrate. The response to the nitrogen level was greater than the response to potassium, as will be seen from the "F" values in Appendix Table 8. Examination of the means in Table 10 reveals that length of the main stem was greatest at the medium level of nitrogen, intermediate at the low level of nitrogen and least at the high level of nitrogen. No significance is attributed to the difference between the response at the low and the high level. The response to potassium was greatest at the low level with a mean length of 51.7 inches per plant whereas the mean length at the high level of potassium was only 42.4 inches. Only the linear term for potassium is significant, and when the linear and quadratic terms are combined the "F" value for the effect of potassium is not significant.

The growth of laterals, or branches from the main stem of the cantaloupe plant, was different from that of the main stem. Significance in the length of lateral growth is found to be a response to nitrogen and calcium, whereas the differences which resulted from varying the concentration of potassium were relatively unimportant. It is seen from Table 11 and Appendix Table 9 that nitrogen was definitely limiting at the low level, and, since the variance for the linear term is significant, that growth was significantly greater at the high level of nitrogen. Furthermore, the greatest length of laterals resulted at the medium level.

Varying the level of calcium in the substrate resulted in decreasing length of the laterals as the concentration in the substrate was increased. Also, it is seen from the N(b) x Ca(a) interaction, that the response to the different levels of nitrogen varied at the low and at the high levels of calcium. At the low calcium level the length of the laterals was considerably greater at the medium level of nitrogen than

TABLE 10. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Length, in Inches per Plant, of the Main Stem of Cantaloupes. (June 1, 1942).

		Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H	K-L	K-M	K-H
		47.6	49.1	40.3	45.1	36.0	42.6	51.7	42.9	42.4
N-L	46.0	46.3	53.3	38.2	52.1	46.3	39.4	51.8	43.6	43.6
N-M	52.3	55.4	55.7	46.1	52.0	60.0	45.2	59.3	52.0	45.9
N-H	38.6	41.1	38.2	36.4	31.2	41.6	43.0	45.0	33.1	37.7
K-L	51.7	50.8	62.1	42.2	52.4	54.3	48.3			
K-M	42.9	46.8	42.4	39.4	39.1	49.2	40.3			
K-H	42.4	45.3	42.7	39.1	43.8	44.3	39.0			
Ca-L	45.1	43.1	53.7	38.6						
Ca-M	36.0	50.3	52.8	44.8						
Ca-H	42.6	49.4	40.7	37.4						

TABLE 11. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Length, in Inches per Plant, of the Lateral Stems of Cantaloupes. (June 1, 1942).

		Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H	K-L	K-M	K-H
		94.3	97.0	82.1	119.7	97.7	56.0	101.2	80.8	91.4
N-L	58.8	49.4	74.8	52.2	77.8	58.8	39.9	50.7	64.6	61.2
N-M	121.6	126.6	123.3	114.9	173.1	127.6	64.1	150.2	106.1	108.4
N-H	93.0	106.9	92.9	79.3	108.4	106.8	63.9	102.9	71.7	104.5
K-L	101.2	100.2	126.8	76.8	116.8	119.4	67.6			
K-M	80.8	98.3	71.4	72.6	106.7	86.6	49.1			
K-H	91.4	84.3	92.8	97.1	135.9	87.1	51.2			
Ca-L	119.6	102.6	147.0	109.8						
Ca-M	97.7	111.6	99.6	82.0						
Ca-H	56.0	68.8	44.4	54.7						

at either the low or high levels, while at the high level of calcium there was essentially no difference in the length of laterals at the medium and high levels but growth in length was least at the low level of nitrogen.

The number of laterals which developed per plant was a result of the same nutritional factors (Appendix Table 10) which were important in determining the length of the laterals. This would indicate that the total length of lateral stems per plant was a function of the number of laterals per plant. Furthermore, the response to the different levels of nitrogen and calcium was parallel. The results given in Table 12 show that at the medium level of nitrogen an average of 6.04 laterals was produced, while there were 4.96 laterals per plant at the high level and 3.33 at the low level. The response to calcium was greatest at the low level, and as the concentration of calcium increased the number of laterals per plant decreased. The response to the concentration of calcium is modified by the level of magnesium in the substrate, and is due entirely to the deviation which occurs at the medium level of magnesium as compared to the response to calcium at the low and high levels of magnesium. When the calcium level was low the number of laterals per plant was greatest at the medium level of magnesium.

Effect of Nutrition on Fruits.

From examination of Appendix Table 11 it will be seen that many nutritional factors had significant roles in determing the number of fruits which set. At the time of blossoming there were numerous bees in the greenhouse affecting pollination. Because of the number, it was deemed unnecessary to bring in additional bees. Failure of certain treatments to set fruit may be regarded therefore as the result of

TABLE 12. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Number of Lateral Stems per Cantaloupe Plant. (June 1, 1942).

		Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H	K-L	K-M	K-H
		5.11	4.74	4.54	5.78	5.28	3.33	5.04	4.48	4.87
N-L	3.38	3.11	3.67	3.39	4.39	3.33	2.44	3.17	3.33	3.66
N-M	6.04	6.56	5.67	5.89	7.72	6.72	3.67	7.11	5.50	5.50
N-H	4.96	5.67	4.89	4.33	5.22	5.78	3.89	4.83	4.61	5.44
K-L	5.04	4.89	6.17	4.06	5.78	5.78	3.56			
K-M	4.48	5.44	3.72	4.28	5.33	4.94	3.17			
K-H	4.87	5.00	4.33	5.28	6.22	5.11	3.28			
Ca-L	5.78	5.33	7.17	4.83						
Ca-M	5.28	5.83	4.61	4.39						
Ca-H	3.33	4.17	2.44	3.39						

unbalanced nutrition rather than to lack of pollination. The following effects on fruit set (Appendix Table 11) are seen to be significant: N, K, Ca, Mg, N x K, N x Ca, N x Mg, Ca x Mg, and N x K x Ca.

It will be seen in Table 13 that at the different levels of nitrogen, the number of fruits produced was highest at the low level, with 1.81 fruits on 2 plants. As the concentration of nitrogen in the substrate was increased the number of fruits set was decreased, 1.41 fruits developing at the medium level, and 1.04 fruits per two plants at the high level. The significance of nitrogen is due entirely to the linear term, with no deviation from linearity at the medium level.

The significance of potassium, however, is due entirely to the quadratic term, with no difference in response between the high and the low levels. The 1.70 fruits set at the medium level is significantly higher than the 1.3 fruits set per two plants at the high and low levels.

The response to large amounts of soluble calcium is shown by the marked increase in number of fruits produced at the medium and high level as contrasted with the number of fruits produced at the low level of calcium. Inasmuch as the variance for the Ca(a) degree of freedom is the largest for this set of data, it may be reasonably assumed that for the concentration of the elements used in this experiment, changes in the concentration of calcium resulted in the greatest response in number of fruits set. Significance in the Ca(b) variance is a result of the great difference between the number of fruits produced at the low and the medium levels of calcium and the somewhat smaller difference between the medium and high concentrations.

The response of the plant to magnesium level, as measured by the number of fruits produced, is somewhat unusual. There is no significant difference between the number of fruits produced at the low and high

TABLE 13. Mean Values for the Main Effects, First-Order Interactions, and the N x K x Ca Interaction, Giving the Effects of Nutrient Level on the Number of Fruits Set on Two Cantaloupe Plants (1942).

		Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H	K-L	K-M	K-H
		1.52	1.26	1.56	0.74	1.74	1.85	1.33	1.70	1.30
N-L	1.81	2.11	1.44	1.89	1.56	1.89	2.00	1.67	2.00	1.78
N-M	1.48	1.67	1.33	1.44	0.56	1.78	2.11	1.11	1.78	1.56
N-H	1.04	0.78	1.00	1.33	0.11	1.56	1.44	1.22	1.33	0.56
K-L	1.33	1.33	1.11	1.56	0.56	1.67	1.78			
K-M	1.70	1.89	1.56	1.67	1.11	1.89	2.11			
K-H	1.30	1.33	1.11	1.44	0.56	1.67	1.67			
Ca-L	0.74	1.11	0.44	0.67						
Ca-M	1.74	1.67	1.56	2.00						
Ca-H	1.85	1.78	1.78	2.00						

	Ca-L			Ca-M			Ca-H		
	K-L	K-M	K-H	K-L	K-M	K-H	K-L	K-M	K-H
N-L	1.33	2.00	1.33	1.66	2.00	2.00	2.00	2.00	2.00
N-M	.00	1.33	.33	1.67	1.67	2.00	1.67	2.33	2.33
N-H	.33	.00	.00	1.67	2.00	1.00	1.67	2.00	.67

levels of magnesium, although the response at the medium level is significantly lower than that at either the low or high levels.

Considering the effects of nitrogen and potassium, it would be expected that the best combination of these two elements would be low nitrogen and medium potassium. Examination of Table 13 reveals that this was the best combination, and that there were more fruits set when this combination of nutrients existed than when the main effects of low nitrogen or medium potassium were considered separately. At any level of potassium, the number of fruits set was greater at the low level of nitrogen than at the high nitrogen level. This response is reflected in the variance for the N x K interaction in Appendix Table 11.

Nitrogen and calcium, also, are seen to be closely interrelated. That is, the concentration of calcium in the substrate played an important part in determining the response to the different levels of nitrogen. In all cases in this interaction, the number of fruits set was least at the high concentration of nitrogen, and furthermore, the repressive effect of high nitrogen was greatest at the low concentration of calcium.

The significance attributed to the N x Mg interaction results from the difference in the response to the three levels of magnesium at the high and at the low concentrations of nitrogen. The greatest differences were in the number of fruits set at the low magnesium and high magnesium levels in response to the low concentration of nitrogen, as compared with the high concentration of nitrogen. At the high level of nitrogen, the number of fruits set increased with increasing concentration of magnesium, whereas, at the low level of nitrogen, the number of fruits set was greatest at the low magnesium level and least at the medium magnesium level.

In the Ca x Mg interaction, the significance of the variance is due to the different response to low and high magnesium at the different levels of calcium. At the low level of calcium, the greatest production of fruits per plant was at the low level of magnesium, whereas, at the medium and high levels of calcium, there was little difference between the responses to change in concentration of magnesium, although there were slightly more fruits produced at the high magnesium level.

In the N x K x Ca relationship, significance is attributed to the variance for the four degrees of freedom for this interaction. Confounding of four degrees of freedom for each second-order interaction with rows and columns makes it impossible to separate out the individual degrees of freedom, so that the individual term responsible for the significant variance may not be determined. However, from an examination of the means for this interaction as shown in Table 13, it will be seen that the level of calcium modified the response to the different levels of nitrogen and potassium. Low calcium had a definite repressive effect on the number of fruits produced at the high level of nitrogen in conjunction with the three levels of potassium. At the low level of calcium and the medium level of nitrogen the best degree of balance appeared at the medium level of potassium. Nitrogen at the low level appeared to overcome the repressive effect of the low calcium concentration. It will be seen that in this second order interaction potassium did not materially influence the response to the interacting levels of nitrogen and calcium.

Effect of Nutrition on the Mineral Composition of the Leaves.

All of the leaves from each treatment at the final sampling date on June 1-9, 1942, were dried and ground for chemical analysis.

A. Nitrogen Content. The nitrogen analyses of the leaves are given in Table 14 as the means for the main effects and first-order interactions. As would be expected, the most important factor affecting the nitrogen content of the leaves was the amount of nitrogen in the substrate. The analysis of variance in Appendix Table 12 shows that the high variance for the nitrogen effect was due entirely to the linear term with no deviation from linearity. Inasmuch as the linearity referred to actually conforms to the rule of logarithmic progression, it is observed that the amount of nitrogen found in the leaves was a logarithmic function of the amount of nitrogen in the substrate (Figure 1).

Furthermore, the amount of nitrogen found in the leaves was influenced by the concentrations of elements other than nitrogen in the substrate. The nitrogen content of the leaves was lower at the medium level of potassium than at the low or at the high levels of potassium. The difference between the low and the high levels of potassium is not significant, although the deviation at the medium level is quite important.

Increasing the concentration of calcium had a repressive action on the amount of nitrogen in the leaves. As the concentration of calcium increased from the low level to the medium level, the nitrogen content decreased markedly, as attested by the rather high variance in Appendix Table 12. Further reduction in nitrogen content between the medium calcium level and the high calcium level resulted.

The concentration of magnesium in the substrate also exhibited a marked effect on the nitrogen content. As the magnesium concentration was increased from the low level to the high level a proportionate logarithmic decrease in the nitrogen content was observed, from which the medium concentration of magnesium did not deviate.

TABLE 14. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Total Nitrogen Content, in Milligrams per Gram, of Cantaloupe Leaves Sampled June 1-9, 1942.

		Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H	K-L	K-M	K-H
		31.32	28.73	26.76	35.17	26.55	25.09	30.99	26.74	29.01
N-L	19.30	18.81	20.16	18.93	22.83	16.28	18.79	18.88	18.46	20.56
N-M	28.97	32.26	27.68	26.95	37.96	27.39	21.55	32.77	27.15	26.98
N-H	38.55	42.87	38.36	34.41	44.73	35.99	34.93	41.33	34.60	39.71
K-L	30.99	34.55	31.31	27.12	37.45	29.22	26.31			
K-M	26.74	28.57	25.94	25.70	31.54	25.22	23.45			
K-H	29.01	30.83	28.95	27.47	36.53	25.22	25.50			
Ca-L	35.17	35.65	34.27	35.59						
Ca-M	26.55	29.90	27.09	22.67						
Ca-H	25.09	28.40	24.85	22.03						

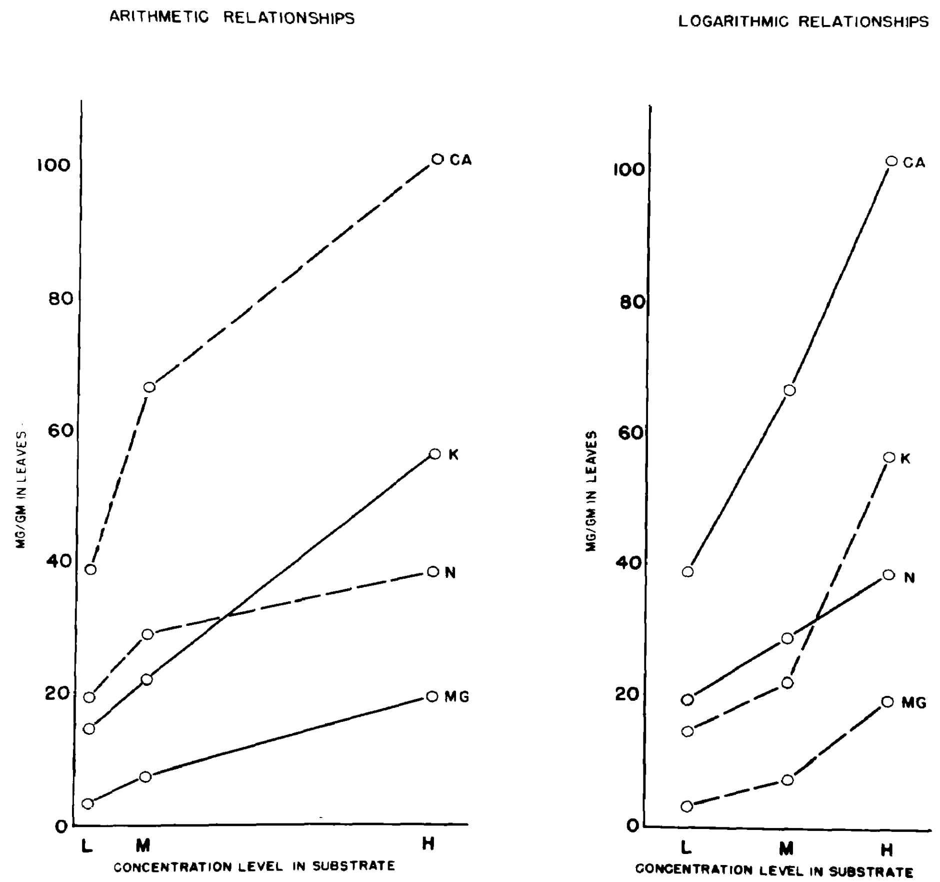

Figure 1. Nitrogen, Potassium, Calcium and Magnesium Contents of Cantaloupe Leaves as Functions of the Low, Medium and High Concentrations of These Individual Elements in the Substrate, (Experiment I).
Solid line indicates a fit with the relationship; broken line indicates lack of a fit with the relationship.

B. Potassium Content. The concentration of potassium in the substrate was the most important factor responsible for the potassium content in the leaves (Appendix Table 13). The mean values for the potassium content are given in Table 15. The content of potassium in the leaves is seen to be an arithmetic function of the potassium concentration in the substrate (Figure 1) which accounts for the relatively high variance for the quadratic term.

Response to nitrogen concentration was greatest at the medium level, there being little difference between the potassium content when the nitrogen concentration was at the low or high level.

Calcium concentration increasing in arithmetic proportions resulted in corresponding decreases in the potassium content of the leaves in logarithmic proportions. At the low level of calcium the potassium content was 42.66 mgs. per gram of dry weight, while at the medium level of calcium the potassium content was 31.34 mgs. per gram, and at the high level of calcium the potassium content was 19.25 mgs. per gram.

Increases in the magnesium concentration of the substrate resulted in decreasing values for the potassium content of the leaves. This decrease in the potassium content was rather consistent for the concentrations of magnesium used, and mathematically the trend fits a logarithmic progression.

C. Calcium Content. Examination of the analysis of variance in Appendix Table 14 will show that the nitrogen concentration in the substrate had no significant effect on the calcium content in the leaves. As would be expected, the variance is highest for the calcium effect. Separation of the calcium effect into its components reveals that the high variance for this effect is due almost entirely to the linear term,

TABLE 15. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Potassium Content, in Milligrams per Gram, of Cantaloupe Leaves Sampled June 1-9, 1942.

		Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H	K-L	K-M	K-H
		37.36	32.33	23.56	42.66	31.34	19.25	14.68	22.00	56.57
N-L	30.17	38.41	32.75	19.35	42.52	30.67	17.33	15.51	22.28	52.71
N-M	34.52	41.64	34.02	27.89	48.59	35.62	19.34	16.30	25.05	62.20
N-H	28.57	32.04	30.23	23.43	36.88	27.73	21.09	12.23	18.67	54.81
K-L	14.68	17.95	14.98	11.11	19.31	14.51	10.23			
K-M	22.00	26.30	24.71	14.99	31.46	21.56	12.98			
K-H	56.57	67.84	57.30	44.58	77.23	57.94	34.55			
Ca-L	42.66	47.46	47.88	32.64						
Ca-M	31.34	39.89	31.00	23.13						
Ca-H	19.25	24.73	18.12	14.91						

with no significance attributed to the quadratic term. This indicates, then, that the calcium content in the leaves performs as a direct logarithmic function of the calcium concentration in the substrate (Figure 1). The mean values are shown in Table 16.

At the low and the medium levels of potassium the calcium content of the leaves was significantly higher than at the high level of potassium. The calcium content of the leaves was greatest at the medium potassium level.

A significant difference exists in the calcium content of the leaves at the low level of magnesium and at the high level of magnesium, while no difference is apparent at the mdeium level in comparison with the low level of magnesium. Magnesium affected the calcium content less than did potassium, but the calcium content was somewhat higher at the low and medium level of magnesium than it was at the high level.

D. Magnesium Content. Examination of the mean values in Table 17 and the analysis of variance in Appendix Table 15 will show that the magnesium content of the leaves was influenced to the greatest extent by the magnesium concentration of the substrate. Furthermore, it is seen that as the magnesium concentration increased in the substrate, the magnesium content found in the leaves increased in arithmetic proportion (Figure 1).

The level of nitrogen in the substrate had no effect on magnesium content in the leaves. Potassium in the substrate, on the other hand, exhibited quite a profound repressive effect on magnesium content. At the low level of potassium the leaves contained 12.09 mgs. of magnesium per gram of dry weight. At the medium potassium level the magnesium content was 10.28 mgs. per gram, while at the high potassium level the

TABLE 16. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Calcium Content, in Milligrams per Gram, of Cantaloupe Leaves Sampled June 1-9, 1942.

		Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H	K-L	K-M	K-H
		72.2	72.5	64.4	38.8	66.5	101.5	74.8	79.5	55.6
N-L	72.3	77.4	71.9	67.6	46.2	67.7	103.0	83.2	73.4	60.3
N-M	65.6	70.7	69.2	56.7	36.5	60.8	99.4	69.9	74.3	52.5
N-H	71.5	68.4	76.8	69.5	32.4	71.1	102.2	71.4	93.9	54.1
K-L	74.8	75.5	80.3	68.7	43.6	72.3	108.5			
K-M	79.5	83.0	85.4	69.6	43.1	74.4	112.9			
K-H	55.6	58.1	53.3	55.5	30.7	52.9	83.2			
Ca-L	38.8	41.6	41.3	33.2						
Ca-M	66.5	71.5	68.2	60.0						
Ca-H	101.5	103.4	104.5	96.7						

TABLE 17. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Magnesium Content, in Milligrams per Gram, of Cantaloupe Leaves Sampled June 1-9, 1942.

		Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H	K-L	K-M	K-H
		3.21	7.41	19.43	12.45	11.48	6.12	12.09	10.28	7.68
N-L	9.49	4.11	6.75	17.63	13.23	9.95	5.30	11.27	10.54	6.67
N-M	9.78	2.41	8.44	18.47	12.11	11.91	5.31	13.20	8.29	7.83
N-H	10.79	3.11	7.05	22.19	12.02	12.58	7.76	11.81	12.02	8.53
K-L	12.09	3.77	9.72	22.80	16.19	14.79	6.31			
K-M	10.28	3.27	7.49	20.10	12.55	12.17	6.14			
K-H	7.68	2.60	5.03	15.41	8.62	8.49	5.92			
Ca-L	12.45	3.79	11.22	22.36						
Ca-M	11.48	3.57	8.12	22.75						
Ca-H	6.12	2.28	2.90	13.18						

magnesium content was 7.68 mgs. per gram.

The repressive effect of calcium in the substrate on the magnesium content was greatest at the high level of calcium. Examination of Figure 3 will show that as the calcium concentration increases arithmetically the magnesium content of the leaves decreases correspondingly.

The variance of a number of the interactions were statistically significant. In the N x K interaction, the most obvious differences were in the effect of the level of potassium on the magnesium content at the three levels of nitrogen. At the low level of potassium there was little difference in the magnesium content between the low and the high levels of nitrogen, while at the medium nitrogen level the magnesium content was much higher. At the medium level of potassium, on the other hand, the magnesium content was least at the medium level of nitrogen, intermediate at the low level of nitrogen, and greatest as the high level of nitrogen. At the high level of potassium the magnesium content was least at the low nitrogen level, and increased as the nitrogen level increased.

In the N x Mg interaction the significance was due largely to the N(a) x Mg(a) term. This will be seen from the means as the difference in magnesium content between the low and high levels of nitrogen at the low level of magnesium as compared with the high level of magnesium.

The high variance for the K(a) x Ca(a) term was mainly responsible for the significance found for the K x Ca interaction. When both calcium and potassium were low in the substrate the magnesium content was quite high, whereas when the calcium was low and the potassium was low in the substrate, the magnesium content was quite low. On the other hand, when the calcium level in the substrate was high there was little difference in the magnesium content in the leaves between the high and the low concentrations of potassium.

A similar relationship existed in the K x Mg interaction except that the response to the low and the high level of potassium was slight at the low level of magnesium in the substrate, whereas at the high level of magnesium the magnesium content of the leaves was greatest at the low level of potassium, and least at the high level of potassium.

The magnesium content of the leaves as a response to the level of magnesium in the substrate is seen to have been modified in rather extreme proportions by the content of calcium in substrate. This is reflected in the variance for the Ca x Mg interaction in Appendix Table 15. In the mean values in Table 18, this relationship is most apparent from the relatively small differences in magnesium content at the low level of magnesium and the three levels of calcium as compared to the relatively great differences resulting from the level of calcium at the high magnesium concentration.

E. Phosphorus Content. As was indicated in Table 1, the phosphorus content in the substrate was held constant in all of the nutrient solutions at 6 m.e. per liter. The analysis of variance given in Appendix Table 16 indicates that the phosphorus content of the leaves was influenced significantly by the levels of nitrogen and potassium, and the N x K interaction.

The means for the phosphorus values are shown in Table 18. In the nitrogen series, the phosphorus content was highest at the low level of nitrogen and was considerably less at the medium level. Very little difference was observed between the medium and the high levels of nitrogen in the substrate.

For the three levels of potassium, the phosphorus content was

TABLE 18. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Phosphorus Content, in Milligrams per Gram, of Cantaloupe Leaves Sampled June 1-9, 1942.

		Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H	K-L	K-M	K-H
		11.24	10.72	10.12	11.08	10.36	10.65	14.44	10.38	7.37
N-L	13.17	14.26	13.56	11.68	13.52	12.95	13.03	18.37	12.98	8.15
N-M	9.36	10.40	9.23	8.46	10.01	8.67	9.41	12.79	9.63	5.67
N-H	9.56	9.07	9.39	10.23	9.72	9.45	9.51	12.17	8.23	8.28
K-L	14.44	16.16	14.65	12.52	14.29	14.53	14.50			
K-M	10.28	10.54	10.16	10.14	11.20	10.15	9.49			
K-H	7.37	7.03	7.36	7.71	7.76	6.38	7.96			
Ca-L	11.08	10.83	11.22	11.21						
Ca-M	10.36	10.81	9.88	10.38						
Ca-H	10.65	12.09	11.08	8.78						

14.44 mgs. per gram at the low potassium concentration. As the concentration of potassium in the substrate was increased the phosphorus content of the leaves decreased, so that at the medium level of potassium the phosphorus content was 10.28 mgs. per gram, and at the high level of potassium the phosphorus content was 7.37 mgs. per gram.

The significance attributed to the N x K interaction was due primarily to the N(a) x K(a) term. The significance for this term is a reflection of the difference in response to the low and high levels of nitrogen at the low level of potassium as compared to the high level of potassium. At the low concentration of potassium in the substrate the phosphorus content of the leaves was higher when the nitrogen concentration was low than when the nitrogen level was high. On the other hand, when the potassium level was high, there was essentially no difference in response to the low and to the high levels of nitrogen.

<u>F. Boron Content.</u> The boron supplied in the substrate was constant for all treatments at the 0.5 ppm. concentration, but it was found from the boron determinations that the boron content in the leaves was influenced significantly by the levels of nitrogen and potassium in the substrate. The analysis of variance is shown in Appendix Table 17, and the mean values for the boron determinations are presented in Table 19.

In the nitrogen series, the boron content in the leaves was highest at the low concentration of nitrogen. As the concentration of nitrogen increased logarithmically in the substrate, the content of boron in the leaves decreased correspondingly.

In the potassium series, the boron content was highest at the medium concentration of potassium, and was considerably higher at this concentration than at the low or high concentration. Only a slight difference

TABLE 19. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Boron Content, in Parts per Million, of Cantaloupe Leaves Sampled June 1-9, 1942.

		Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H	K-L	K-M	K-H
		209	217	194	211	226	183	183	241	195
N-L	266	292	285	222	305	304	191	272	293	235
N-M	203	202	199	208	218	205	185	164	257	187
N-H	150	133	167	151	108	168	174	113	174	164
K-L	183	203	196	150	189	208	152			
K-M	241	236	248	240	265	247	212			
K-H	195	188	207	191	177	222	187			
Ca-L	211	230	210	191						
Ca-M	226	235	237	205						
Ca-H	183	162	204	185						

resulted in the boron content of the leaves when the potassium level was low or high.

EXPERIMENT II. The Potassium, Calcium, Magnesium and Boron Nutrition of the Cantaloupe. 1947 Studies.

Materials and Methods.

The quartz sand used in this experiment was a fairly course grade of approximately 18 mesh.

The germinated seeds were placed in the containers on May 1, 1947, and were covered with about one-half inch of washed sand. Tap water was supplied daily until the plants emerged on May 6, at which time the individual treatments were started. An application of 500 ml. of feeding solution was made daily.

Stock solutions were prepared with reagent chemicals and distilled water. Chemicals used in making up the feeding solutions included potassium nitrate, potassium phosphate (primary), potassium phosphate (secondary), calcium chloride, calcium nitrate, magnesium chloride, magnesium nitrate, magnesium sulfate, sodium sulfate, sodium chloride, sodium nitrate, sodium phosphate (primary), boric acid, ferric citrate, manganese chloride, zinc sulfate, molybdic acid and copper sulfate. The concentrations used at the different levels of nutrition are given in Table 20.

The feeding solutions were prepared by adding known amounts of the stock solutions to distilled water. In an attempt to control the total concentration of salts at 26 m.e./L., it was necessary to allow the concentration of one cation to vary throughout the experiment. Sodium was the variable cation. The pH of the solutions varied between 5.4 and 5.9,

TABLE 20. Concentrations of Ions in the Feeding Solutions at the Three Levels of Nutrition. (Experiment II).

Nutrient Element	Level of Nutrition: Low	Medium	High
	m.e./L.	m.e./L.	m.e./L.
Potassium	.25	1.25	4.00
Calcium	1.00	5.00	15.00
Magnesium	.20	1.00	3.00
Nitrogen as NO_3	10.00	10.00	10.00
Phosphorus as PO_4	6.00	6.00	6.00
Sulfur as SO_4	4.00	4.00	4.00
Chlorine	6.00	6.00	6.00
	p.p.m.	p.p.m.	p.p.m.
Boron	0.108	0.540	1.620
Manganese	0.5	0.5	0.5
Zinc	0.05	0.05	0.05
Molybdenum	0.05	0.05	0.05
Copper	0.02	0.02	0.02
Iron	1.0	1.0	1.0

and no adjustment was made.

The concentrations are in this experiment again designated as low (L), medium (M), and high (H). The low concentrations were planned to be definitely deficient levels, approximating the amounts of the elements found in the soil solution under unfertilized field conditions; the medium concentrations were five times that at the low level; and the high concentrations were fifteen times that at the low level. From the results of Experiment I it was expected that the growth and fruiting would be greatest at the high levels of potassium, calcium and magnesium. The high concentration of boron was planned to be in excess of the needs of the cantaloupe plant.

No distilled water was available between June 7 and June 23, and it became necessary to use tap water in the preparation of the feeding solutions. Daily water analyses made by the Washington Suburban Sanitary Commission were examined, and it was found that the tap water used for this sixteen day period contained the following, in ppm.: silicon, 0.0; calcium, 46.0; magnesium, 3.8; sulfate, 46.7; iron, trace; manganese, 0.0; ammonia, 0.0; and chloride, 11.0.

Each of the containers was leached at approximately monthly intervals to remove any accumulated salts. Leaching was effected by the application of one gallon of tap water, followed thirty minutes later with one liter of distilled water. After the distilled water had drained the feeding solutions were again supplied.

The data from this experiment were analysed statistically, using the same procedure used in Experiment I. However, inasmuch as the medium concentrations in Experiment II are not equidistant from the low and the high concentrations on a geometric scale, only the total variance for each effect is shown in the statistical analyses presented in the appendix tables.

Effect of Nutrition on Growth as Measured by Dry Weight.

Plants were removed for dry weight determinations on June 7 and June 30, after which there remained two plants in each container which were allowed to develop to maturity. The final sampling was begun on September 1 and continued through September 10.

Data showing the means for the main effects and the first-order interactions of the three levels of each element on the dry weight of the plants at the June 7 sampling date are shown in Table 21, and the analysis of variance is presented in Appendix Table 18. Examination of these data reveal that in these young plants, the amount of growth as measured by dry weight was influenced significantly by the concentration of potassium, calcium and magnesium in the substrate.

The response to the concentration of potassium was greatest at the high level, and as the concentration of potassium was decreased in the substrate the amount of growth was decreased. A parallel situation existed in the responses to calcium and magnesium. The amount of dry weight was greatest with each of these elements when the concentration was at a high level. No significant difference is observed between the responses to different levels of boron.

In addition to these main effects, the variances for the K x Ca and the K x Mg interactions are significant. Reference to Table 21 reveals that the dry weight produced was greatest for the potassium and calcium combination when both of these nutrient elements were at the high level of concentration. The response to the varying levels of calcium at the medium level of potassium is seen to differ from the response to the same concentrations of calcium at the low or high

TABLE 21. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Dry Weight, in Grams per Plant, of Cantaloupe Leaves and Stems. (June 7, 1947).

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		.243	.264	.241	.186	.257	.305	.147	.270	.331
K-L	.121	.120	.131	.113	.082	.108	.173	.062	.147	.154
K-M	.255	.273	.288	.205	.140	.262	.364	.176	.332	.259
K-H	.372	.336	.375	.405	.337	.401	.377	.204	.332	.579
Ca-L	.147	.142	.161	.139	.103	.173	.166			
Ca-M	.270	.251	.309	.250	.181	.287	.343			
Ca-H	.331	.336	.323	.333	.275	.311	.406			
Mg-L	.186	.179	.186	.194						
Mg-M	.257	.224	.272	.275						
Mg-H	.305	.326	.336	.252						

potassium levels. At the medium potassium level the response was actually greatest at the medium level of calcium, whereas at the low and medium levels of potassium the response is greatest at the high levels of calcium.

The response to magnesium in the main effects was greatest at the high level of concentration of that nutrient element, and in the K x Mg interaction this relationship remained true except when the level of potassium was high. At the high level of potassium the response to magnesium level was greatest at the medium concentration.

The plants sampled for dry weight determinations on June 30 and September 1-10, were separated into the leaves and stems, and the weights were recorded separately for these tissues. The data showing the means for the dry weight of the leaves at these two sampling dates are shown in Tables 22 and 23. The analyses of variance are presented in Appendix Tables 19 and 20. Examination of these tabular data reveal that on the June 30 sampling the response in dry weight of leaves was still influenced considerably by the level of potassium, calcium and magnesium, whereas at the final sampling date on September 1-10, the dry weight of the leaves was influenced significantly only by the concentration of calcium.

At the June 30 sampling, the response in dry weight was greatest at the high level of potassium, the high level of calcium and the high level of magnesium. There was no significant difference between the response to the medium and to the high concentration of potassium or calcium, although at the low concentration of these elements the response was significantly less.

The significance of the variance due to the Ca x Mg interaction may be explained on the basis of the difference in response to the varying

TABLE 22. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Dry Weight, in Grams per Plant, of Cantaloupe Leaves. (June 30, 1947).

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		1.75	2.03	2.10	1.04	2.12	2.72	1.14	2.31	2.43
K-L	1.07	1.05	1.08	1.09	0.49	1.03	1.70	0.39	1.40	1.43
K-M	2.26	2.14	2.31	2.34	1.10	2.64	3.05	1.46	2.67	2.67
K-H	2.55	2.07	2.71	2.86	1.54	2.69	3.40	1.58	2.86	3.20
Ca-L	1.14	0.95	1.25	1.22	0.78	1.29	1.35			
Ca-M	2.31	2.02	2.38	2.52	1.22	2.32	3.39			
Ca-H	2.43	2.28	2.46	2.56	1.13	2.76	3.41			
Mg-L	1.04	1.04	1.08	1.02						
Mg-M	2.12	1.91	2.17	2.29						
Mg-H	2.72	2.30	2.86	2.99						

TABLE 23. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Dry Weight, in Grams per Plant, of Cantaloupe Leaves. (September 1-10, 1947).

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		15.09	14.19	15.40	14.27	13.35	17.06	9.89	16.23	18.56
K-L	14.09	11.82	15.40	15.04	13.05	13.44	15.77	6.18	14.12	21.96
K-M	15.49	17.71	14.06	14.69	16.75	12.29	17.42	12.45	18.90	15.11
K-H	15.10	15.74	13.11	16.46	13.00	14.31	17.99	11.05	15.66	18.59
Ca-L	9.89	8.85	8.87	11.96	9.90	8.40	11.38			
Ca-M	16.23	18.56	14.21	15.91	17.10	14.02	17.56			
Ca-H	18.56	17.86	19.49	18.32	15.80	17.62	22.25			
Mg-L	14.27	13.28	13.46	16.07						
Mg-M	13.35	13.55	12.07	14.41						
Mg-H	17.06	18.44	17.04	15.71						

levels of calcium at the low concentration of magnesium as compared to the medium and high concentrations of magnesium. At the low concentration of magnesium there was little difference in the response to the three levels of calcium, whereas at the medium and high concentrations of magnesium there was a great difference in the response between the low and medium levels of calcium, and the response at the medium and high concentrations of calcium was similar.

At the final sampling on September 1-10 only the calcium level influenced the dry weight of leaves. From Table 23 it will be seen that the greatest difference in response was between the low and the medium levels of concentration, the greater dry weight being found at the medium level. The greatest dry weight was produced at the high level of calcium, although the dry weight produced at this concentration was not significantly greater than at the medium level.

The significant variance for the K x Ca interaction indicates that the level of potassium materially changes the normal response to the different levels of calcium. Reference to Table 23 will show that at the low and the high levels of potassium the response to calcium is in the same direction as for the main calcium effect. At the medium level of potassium, however, the dry weight was greatest at the medium level of calcium, intermediate at the high level of calcium and least at the low level of calcium.

The response in stem growth, as measured by dry weight, closely parallels that of the dry weight of leaves, except that at the June 30 sampling date the concentration of boron in the substrate influenced the stem growth. The mean values for the dry weight of stems at the June 30 sampling are shown in Table 24, and the analysis of variance is presented in Appendix Table 21. It will be observed that in the potassium series

TABLE 24. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Dry Weight, in Grams per Plant, of Cantaloupe Stems. (June 30, 1947).

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		1.023	1.247	1.253	.555	1.379	1.586	.655	1.478	1.388
K-L	.444	.440	.458	.436	.200	.424	.709	.142	.654	.537
K-M	1.356	1.266	1.450	1.352	.584	1.701	1.782	.840	1.700	1.528
K-H	1.720	1.357	1.833	1.971	.881	2.012	2.268	.982	2.080	2.099
Ca-L	.655	.544	.766	.654	.449	.858	.658			
Ca-M	1.478	1.250	1.597	1.588	.666	1.627	2.142			
Ca-H	1.388	1.268	1.379	1.517	.551	1.653	1.959			
Mg-L	.555	.553	.596	.517						
Mg-M	1.379	1.118	1.462	1.558						
Mg-H	1.586	1.391	1.683	1.684						

the greatest dry weight was produced at the high level of potassium, and as the potassium level was decreased the dry weight decreased. In the calcium and boron series there was no significant difference between the response at the medium and the high levels of concentration although the response at the low level was significantly less. In the magnesium series the response was similar to that of the potassium series. The dry weight was greatest at the high level of magnesium concentration, intermediate at the medium level, and least at the low level.

From Appendix Table 21 it is seen that the K x Mg and the Ca x Mg interactions are significant, or in other words, the level of potassium alters the response to the different levels of magnesium and the level of calcium alters the response to the different levels of magnesium. In the K x Mg interaction, the dry weight at the high level of magnesium increased as the concentration of potassium increased, whereas at the low and medium levels of magnesium there was a significant difference between the dry weight at the low and the medium levels of potassium but there was no difference in the dry weight at the medium and the high levels of potassium. Considering the Ca x Mg interaction, the response was greatest when the calcium was medium and the magnesium was high, although this response was not significantly higher than the response at the high calcium and the high magnesium levels. Only at the medium level of calcium was there a difference between the response at the medium and high levels of magnesium.

At the September 1-10 sampling, calcium was the only element to which the dry weight of stems displayed a significant response (Appendix Table 22). From the mean values in Table 25 it will be seen that there was no significant difference in the response to the high and to the medium levels of calcium, although both concentrations resulted in a

TABLE 25. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Dry Weight, in Grams per Plant, of Cantaloupe Stems. (September 1-10, 1947).

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		10.02	9.13	10.51	10.61	8.85	10.20	7.72	11.11	10.82
K-L	9.08	7.42	10.26	9.54	9.18	9.03	9.01	4.39	9.64	13.20
K-M	9.92	11.29	8.64	9.83	12.44	7.71	9.60	9.58	12.04	8.14
K-H	10.66	11.35	8.49	12.15	10.19	9.82	11.97	9.19	11.66	11.13
Ca-L	7.72	7.25	6.57	9.34	8.49	7.15	7.52			
Ca-M	11.11	12.13	9.76	11.45	12.88	9.21	11.25			
Ca-H	10.82	10.69	11.06	10.73	10.45	10.20	11.83			
Mg-L	10.61	9.03	8.93	12.10						
Mg-M	8.85	9.96	8.00	9.44						
Mg-H	10.20	12.83	9.63	9.05						

significantly greater response than at the low level of calcium concentration.

The dry weight of the roots, sampled on September 1-10, was influenced by the level of concentration of potassium, calcium, and magnesium, which is indicated by the variance shown in Appendix Table 23. The mean values for the dry weights of the roots are given in Table 26. Examination of these data reveals that the greatest dry weight of roots resulted when the concentration of potassium was at the high level, although the response at the medium level was not significantly less, while the dry weight at the low level of potassium was the least in the potassium series. In both the calcium and the magnesium series the dry weight was greatest at the high level of concentration and decreased as the concentration decreased.

The high variance for the K x Ca interaction is reflected in the mean values. At the low level of calcium the dry weight of roots at the low level of potassium was less than at the medium or high levels, whereas at the high level of calcium the dry weight at the high level of potassium was less than at the low or medium levels.

Examination of the mean values for the K x B interaction reveals that at the low boron concentration the response to potassium was greater at the medium and high levels than at the low level. At the medium and high boron levels, however, the difference in response to potassium was minimized so that there was no significant difference in the response to the three levels of potassium. Furthermore, at the low level of potassium the response was significantly less at the low level of boron than at the medium or high levels of boron. Whereas at the high level of potassium the response to the low level of boron was significantly greater than to the medium or high levels of boron.

TABLE 26. Mean Values for the Main Effects, First-Order Interactions, and the K x Mg x B Interaction, Giving the Effects of Nutrient Level on the Dry Weight, in Grams per Plant, of Cantaloupe Roots. (September 1-10, 1947).

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		2.63	2.13	2.42	1.52	2.54	3.13	1.59	2.55	3.04
K-L	1.78	1.25	2.09	2.00	1.20	1.50	2.64	.54	1.55	3.26
K-M	2.66	3.30	2.07	2.60	2.02	2.96	3.00	2.24	2.54	3.20
K-H	2.74	3.34	2.23	2.67	1.33	3.16	3.74	2.01	3.57	2.66
Ca-L	1.59	1.73	1.35	1.69	1.28	1.78	1.73			
Ca-M	2.55	2.72	2.12	2.82	1.76	2.41	3.48			
Ca-H	3.04	3.44	2.92	2.76	1.51	3.43	4.18			
Mg-L	1.52	.95	1.48	2.12						
Mg-M	2.54	3.23	2.41	1.97						
Mg-H	3.13	3.71	2.49	3.18						

	B-L			B-M			B-H		
	Mg-L	Mg-M	Mg-H	Mg-L	Mg-M	Mg-H	Mg-L	Mg-M	Mg-H
K-L	.47	.91	2.37	1.63	2.38	2.28	1.50	1.21	3.28
K-M	1.25	4.88	3.79	1.07	2.36	2.79	3.74	1.64	2.42
K-H	1.12	3.92	4.99	1.75	2.51	2.42	1.12	3.06	3.83

The interaction of calcium on magnesium may be seen by examination of the means in Table 26. When calcium was at the low level of concentration there was no difference in the response to the magnesium level, and likewise, when the magnesium was at the low level of concentration there was no difference in the response to the calcium level. When calcium was at the medium or high concentrations the dry weight of the roots increased with increasing concentrations of magnesium. And when magnesium was at the medium or high concentrations the dry weight of the roots increased with increasing concentrations of calcium.

In the Mg x B interaction it is observed that when the magnesium level was low the dry weight of roots increased with increasing levels of boron. When the magnesium level was medium the dry weight of roots decreased with increasing levels of boron. And when the magnesium level was high the response to the low level of boron was significantly higher than the response to the medium level of boron only. At the low or medium levels of boron the response was greater at the medium and high levels of magnesium than at the low level of magnesium. At the high level of boron the response was greater at the high level of magnesium than at the low or medium levels of magnesium.

In the mean values for the dry weight of roots for the K x Mg x B interaction it is seen that the concentration of magnesium altered the response to the concentration of K x B, and that the concentrations of potassium altered the response to the concentrations of Mg x B. When potassium and boron were low the dry weight was greater at the high level of magnesium than at the low or medium level of magnesium. When potassium was low and boron was high the response was greatest at the high level of magnesium. When potassium was medium and boron was high the response was greatest at the low level of magnesium. And when both potassium and boron were high the response was greatest at the medium or high levels of magnesium. When magnesium was low and boron was low or medium there was little response to changes in potassium level, but when magnesium was low and boron was high the dry weight of roots was significantly greater at the medium level of potassium than at the low or high level of potassium.

Effect of Nutrition on Main Stem Length, Lateral Stem Length and Number of Laterals.

Mean values for the main effects and the first-order interactions on length of the main stem are given in Table 27. The analysis of variance is given in Appendix Table 24. The analysis of variance yields the information that a significant response to concentration resulted only from variations in the level of magnesium. Reflection of the high variance for magnesium is seen in the mean values. At the low concentration of magnesium the main stems averaged 351 cm. in length, while at the medium concentration of magnesium the main stems averaged 275 cm., and at the high level of magnesium the averaged length was 283 cm. Two interactions, the K x Ca and the K x Mg interactions, are seen to be significant. Inasmuch as there was no significance in either of the potassium or the calcium main effects no statements in regard to the interaction are justified. In the K x Mg interaction the level of potassium materially altered the response to magnesium. At the low level of potassium there was no significant difference between the response to the three magnesium levels, while at the medium and high levels of potassium the main stem was longer at the low concentration of magnesium than at the medium or high concentration of magnesium.

TABLE 27. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Length, in Centimeters per Plant, of the Main Stem of Cantaloupes. (September 1, 1947).

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		293	291	326	351	275	283	292	308	310
K-L	317	271	327	353	323	333	295	244	338	368
K-M	310	344	289	297	402	234	295	350	300	281
K-H	283	264	256	328	329	259	260	281	286	281
Ca-L	292	278	273	324	312	282	281			
Ca-M	308	302	289	334	359	300	266			
Ca-H	310	299	312	320	383	244	303			
Mg-L	351	321	315	419						
Mg-M	275	252	286	288						
Mg-H	283	306	272	271						

The length of the lateral stems was influenced only by the concentration levels of potassium and of calcium (Appendix Table 25). In the potassium series the length of the lateral stems was greatest at the high level, and as the potassium concentration was decreased the length of the laterals decreased, although there was no significant difference between the response to the medium and to the high concentration (Table 28). In the calcium series the response was greater at the medium level than at the low level of concentration. There was no significant difference between the response to the low level and to the high level.

The number of laterals was influenced by the same main effects which influenced the length of the laterals (Appendix Table 26), and the response to concentration level was similar (Table 29). In the potassium series the number of laterals was greater at the medium and high levels than at the low level. Again there was no difference in response to the low and medium levels of calcium, but the number of laterals was significantly greater at the medium calcium level. A significant variance for the K x Ca interaction is reflected in the means as the effect of potassium level on the response of the calcium concentration. At the high and medium levels of calcium the number of laterals is significantly greater than at the low levels of calcium when the potassium was at the low level of concentration. At the medium level of potassium concentration the number of laterals was significantly greater at the low and the medium levels of calcium than at the high level of calcium. Whereas, at the high potassium level there was no difference in response to the three levels of calcium.

TABLE 28. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Length, in Centimeters per Plant, of the Lateral Stems of Cantaloupes. (September 1, 1947).

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		744	672	785	785	657	758	617	859	726
K-L	514	469	578	494	505	483	554	263	598	681
K-M	779	797	703	837	983	623	732	697	1024	616
K-H	908	966	736	1023	868	866	990	890	953	881
Ca-L	617	579	514	757	670	508	671			
Ca-M	859	892	814	870	931	762	882			
Ca-H	726	761	689	727	754	701	722			
Mg-L	785	650	786	920						
Mg-M	657	718	559	695						
Mg-H	758	863	672	740						

TABLE 29. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Number of Lateral Stems per Cantaloupe Plant. (September 1, 1947).

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		8.28	8.00	7.06	7.44	7.89	8.00	7.11	8.67	7.56
K-L	4.69	4.50	5.39	4.17	4.94	5.44	3.67	3.00	5.28	5.78
K-M	8.79	9.33	8.89	8.17	8.94	8.33	9.11	9.11	10.28	7.00
K-H	9.85	11.00	9.72	8.83	8.44	9.89	11.22	9.22	10.44	9.89
Ca-L	7.11	6.78	7.56	7.00	7.11	7.33	6.89			
Ca-M	8.67	9.94	8.22	7.83	8.22	8.61	9.17			
Ca-H	7.56	8.11	8.22	6.33	8.11	8.22	6.33			
Mg-L	7.44	7.33	8.39	6.61						
Mg-M	7.89	8.61	7.39	7.67						
Mg-H	8.00	8.89	8.22	6.89						

Effect of Nutrition on the Number, Weight and Percent Soluble Solids of Fruits.

The mean number of fruits on the two plants which developed to maturity are shown in Table 30. The analysis of variance is given in Appendix Table 27. Examination of the variance table reveals that the number of fruits was significantly influenced by the levels of potassium, calcium and magnesium. The exceptionally high variance for the potassium effect would indicate that one of the levels was definitely limiting. Referring to the mean values it will be seen that at the low level the number of fruits set was very small. At the medium and the high levels of potassium there was a significantly greater set of fruits than at the low level.

In the calcium series the greatest number of fruits set was at the high level of concentration. The response at the high level was not significantly greater than at the medium level, but the response to both the medium and the high level of calcium was significantly greater than at the low level. The difference between the response to the low level and to the high level was not so great in the calcium series as in the potassium series, and this is reflected in the relatively smaller variance.

In the magnesium series the response was again greater at the medium and high levels of concentration than at the low level, and no difference in response resulted between the medium and the high levels.

The significant variance attributed to the K x Mg interaction is the result of the failure of any appreciable number of fruit to set and develop at either the low potassium or the low magnesium level, so that there was no difference in the response to magnesium at the low concentration of potassium. Also, at the low level of magnesium there was no

TABLE 30. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Number of Fruits Set on Two Cantaloupe Plants. (1947).

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		.89	.93	.89	.30	1.22	1.19	.70	.96	1.04
K-L	.04	.11	.00	.00	.11	.00	.00	.00	.00	.11
K-M	1.26	1.00	1.33	1.44	.11	1.78	1.89	1.00	1.44	1.33
K-H	1.41	1.56	1.44	1.22	.67	1.89	1.67	1.11	1.44	1.67
Ca-L	.70	.56	.89	.67	.22	1.00	.89			
Ca-M	.96	1.00	.78	1.11	.22	1.33	1.33			
Ca-H	1.04	1.11	1.11	.89	.44	1.33	1.33			
Mg-L	.30	.44	.33	.11						
Mg-M	1.22	1.11	1.11	1.44						
Mg-H	1.19	1.11	1.33	1.11						

difference in response to the low and the medium concentration of potassium, although the number of fruits set at the high potassium level (with low magnesium) was somewhat greater.

Because many of the treatments failed to set any fruit it was not possible to analyze the data for weight of fruit and for the percent soluble solids, statistically. However, the mean values are presented.

The mean values for the weight of fruit, in grams per fruit are given in Table 31. In general, it appears that the same conditions which were conducive to increasing the number of fruits set contributed also to increasing the weight of the fruit. In the potassium, calcium and magnesium series the weight of fruits was least at the low levels of concentration. There was little difference in the weight of the fruits in these series between the medium and the high levels of concentration. In the boron series there was little difference in the response to the low and to the high levels, but the weight of fruits at the medium level of boron was somewhat less.

In Table 32 are presented the mean values for the percentage of soluble solids in the fruits which developed to maturity. The single fruit which developed in all of the low potassium treatments rotted before maturity, so that it was not possible to obtain a reading of the soluble solids for that treatment level. There was little difference in the mean percent soluble solids between the medium level and the high level of potassium concentration. In the calcium series the soluble solids was least at the low concentration, intermediate at the high concentration, and greatest at the medium concentration. A very low mean resulted at the low level of magnesium as compared to the readings on the fruits from the medium and the high levels. The level of boron exerted some influence on quality, and the mean soluble solids at the

TABLE 31. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on Weight, in Grams, per Fruit. (1947).

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		233	188	241	152	230	238	172	253	228
K-L	67	67	0	0	67	0	0	0	0	67
K-M	228	285	185	231	71	247	229	155	305	224
K-H	220	222	191	252	185	215	249	188	214	252
Ca-L	172	184	155	183	105	180	190			
Ca-M	253	273	202	272	264	268	234			
Ca-H	228	230	209	247	109	234	282			
Mg-L	152	110	98	428						
Mg-M	230	384	184	218						
Mg-H	238	260	221	232						

TABLE 32. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Percent Soluble Solids in Cantaloupe Fruits. (1947).

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		6.5	6.7	7.4	4.2	7.2	7.3	6.2	7.5	6.7
K-L	x	x	x	x	x	x	x	x	x	x
K-M	7.0	7.0	6.9	7.1	x	6.8	7.2	5.8	7.1	7.9
K-H	6.8	6.3	6.5	7.8	4.2	7.5	7.6	6.6	7.8	5.8
Ca-L	6.2	6.0	5.7	7.2	3.3*	6.6	6.5			
Ca-M	7.5	6.9	7.6	8.0	6.6	7.4	7.9			
Ca-H	6.7	6.6	6.7	6.9	2.3	7.4	7.5			
Mg-L	4.2	3.0	2.7*	9.3*						
Mg-M	7.2	7.5	6.7	7.4						
Mg-H	7.3	7.5	7.4	7.1						

*Represents readings on only one fruit.

high level of boron was 7.4%, while the mean reading at the medium level was 6.7%, and at the low level of boron the mean reading was 6.5%. Furthermore, it is interesting to observe that when the calcium level was low the difference in response to level of boron was quite marked in favor of the high boron concentration.

Effect of Nutrition on the Mineral Composition of the Leaves.

As in Experiment I, all of the leaves from each of the two plants which developed to maturity in Experiment II were dried at 70 degrees C. and ground for the chemical analyses.

A. Potassium Content. The mean values for the potassium content as expressed in mgs. per gram of dry weight are presented in Table 33. The analysis of variance is given in Appendix Table 28. The variances for potassium, calcium and magnesium were significant. The potassium content of the leaves was least at the low level of potassium in the substrate, intermediate at the medium level and greatest at the high level. The increase in potassium content of the leaves is seen to be a function of the arithmetic increase of potassium in the substrate (Figure 2).

In the calcium series, the potassium content was greater at the low calcium level than at the medium calcium level. Little difference resulted by increasing the calcium concentration to the high level. A similar relationship is observed in the magnesium series. Little difference resulted between the medium and the high levels of magnesium concentration, but the potassium content of the leaves was significantly greater at the low magnesium level.

The response to calcium concentration was altered by the level of potassium in the substrate. The potassium content of the leaves was

TABLE 33. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Potassium Content, in Milligrams per Gram, of Cantaloupe Leaves Sampled September 1-10, 1947.

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		17.10	16.99	16.62	25.54	13.33	11.84	20.83	15.20	15.69
K-L	6.76	7.29	7.16	5.84	9.08	6.40	4.81	7.51	6.30	6.48
K-M	13.90	14.69	13.90	13.11	23.64	8.91	9.14	13.51	13.00	15.19
K-H	30.05	29.33	29.92	30.90	43.91	24.69	21.56	38.47	26.30	25.39
Ca-L	19.83	20.39	20.19	18.91	29.32	15.30	14.87			
Ca-M	15.20	15.30	15.63	14.67	23.68	11.98	9.94			
Ca-H	15.69	15.62	15.16	16.28	23.63	12.72	10.70			
Mg-L	25.54	26.78	25.80	24.06						
Mg-M	13.33	12.79	13.84	13.37						
Mg-H	11.84	11.74	11.33	12.43						

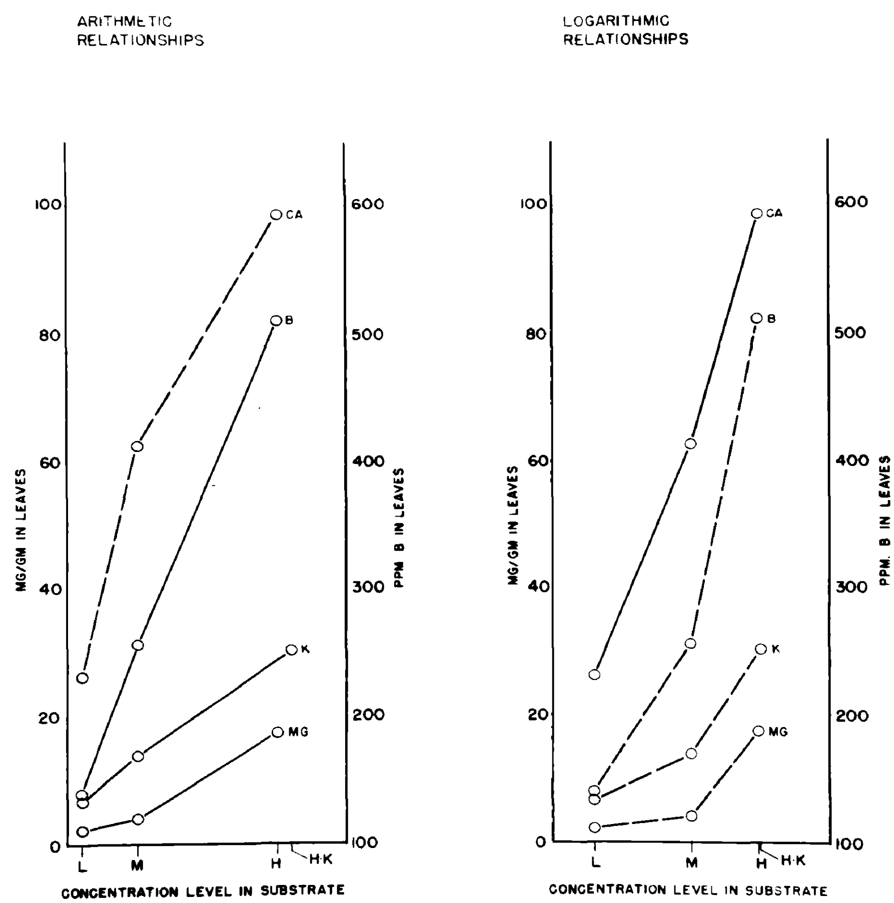

Figure 2. Potassium, Calcium, Magnesium and Boron Contents of Cantaloupe Leaves as Functions of the Low, Medium and High Concentrations of These Individual Elements in the Substrate, (Experiment II).

Solid line indicates a fit with the relationship; broken line indicates lack of a fit with the relationship.

unchanged by the calcium concentration in the substrate when the potassium concentration was at the low or the medium level. When the potassium level was high, however, the potassium content was greater at the low calcium level than at the medium or the high calcium level.

The response to magnesium concentration was also altered by the level of potassium in the substrate. At the low level of potassium in the substrate, the quantitative difference in potassium content of the leaves between the three levels of magnesium was slight, but at the medium and the high levels of potassium the potassium content was greater at the low magnesium concentration than at the medium or the high magnesium concentrations.

B. Calcium Content. As would be expected, the greatest difference in the calcium content of the leaves resulted from the different levels of calcium in the substrate. The high variance for the calcium effect as shown in Appendix Table 29 is reflected in the mean values in Table 34, where it will be seen that the calcium content of the leaves increased as a function of the logarithmic increase in concentration of calcium in the substrate. This is presented graphically in Figure 2.

Differences in the calcium content of the leaves resulted from variations in the potassium and the magnesium concentrations in the substrate. In the potassium series there was only a slight difference between the response at the medium and the high concentrations but the calcium content was significantly less at the low level of potassium. In the magnesium series, there was only a slight difference in the response to the low and the medium concentrations but the calcium content at the high level of magnesium was significantly less.

In the K x Ca interaction there was little difference in the calcium

TABLE 34. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Calcium Content, in Milligrams per Gram, of Cantaloupe Leaves Sampled September 1-10, 1947.

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		62.0	63.4	61.5	67.4	62.6	56.9	26.1	62.5	98.3
K-L	57.4	56.2	61.6	54.5	64.7	56.7	50.9	28.9	57.7	85.6
K-M	65.9	66.3	64.4	67.1	72.4	64.9	60.5	26.8	67.8	103.2
K-H	63.5	63.4	64.3	62.9	65.0	66.4	59.3	22.7	61.8	106.1
Ca-L	26.1	25.3	26.1	26.9	35.1	23.8	19.4			
Ca-M	62.5	62.6	62.9	61.9	71.5	62.5	53.3			
Ca-H	98.3	98.0	101.3	95.6	95.4	101.5	98.0			
Mg-L	67.4	66.5	69.3	66.3						
Mg-M	62.6	61.9	64.2	61.8						
Mg-H	56.9	57.5	56.8	56.4						

content at any of the potassium levels when the calcium level was low, but at the high calcium levels the response to potassium level was similar in proportion to that for the main potassium effect.

In the Ca x Mg interaction there was little response to magnesium concentration when the calcium concentration was high, but when the calcium concentration was low or medium the calcium content responded to the magnesium level in proportions similar to that for the magnesium main effect.

C. Magnesium Content. The magnesium content of the leaves was influenced by the quantities of potassium, calcium and magnesium in the substrate. Reference to the analysis of variance in Appendix Table 30 shows the "F" value for the magnesium effect to be 287.52. Examination of the mean values in Table 35 reveals that the magnesium content of the leaves from the plants grown at the low level of magnesium was 2.19 mgs. per gram, at the medium level was 4.09 mgs. per gram, and at the high level was 17.43 mgs. per gram.

In the potassium series the magnesium content was greater at the low and the high levels of potassium than at the medium level of potassium. No significance can be attributed to the difference between the response at the low level and the response at the high level.

In the calcium series there was no significant difference in the magnesium content of the leaves between the plants grown at the low and at the medium levels of calcium concentration. The response to the low and medium levels of calcium was greater than the response to the high level of calcium.

The variance for two of the interactions was significant. In the K x Ca interaction, it will be seen from the means that at the low level

TABLE 35. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Magnesium Content, in Milligrams per Gram, of Cantaloupe Leaves Sampled September 1-10, 1947.

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		7.35	7.86	8.50	2.19	4.09	17.43	9.27	8.32	6.13
K-L	8.81	7.88	8.36	10.20	4.13	5.12	7.18	12.42	7.54	6.47
K-M	6.59	6.56	6.23	6.97	.94	2.94	15.87	6.49	7.07	6.19
K-H	8.31	7.61	9.00	8.33	1.50	4.19	19.26	8.89	10.33	5.72
Ca-L	9.27	8.29	8.77	10.74	3.21	4.77	19.82			
Ca-M	8.32	7.94	8.37	8.64	1.63	4.14	19.18			
Ca-H	6.13	5.81	6.46	6.11	1.73	3.34	13.30			
Mg-L	2.19	1.36	1.57	3.66						
Mg-M	4.09	3.73	4.01	4.51						
Mg-H	17.43	16.96	18.01	17.33						

of calcium the response to potassium was greatest at the low level, intermediate at the high level and least at the medium level. At the medium level of calcium the response was greater to the high level of potassium than at the low or medium level. And at the high level of calcium there was little difference in the response to any of the three levels of potassium.

In the Ca x Mg interaction there was little difference in the magnesium content of the leaves between the three levels of calcium when the magnesium concentration was at the low or the medium levels. At the high level of magnesium, the magnesium content was greater at the low and medium levels of calcium than at the high calcium level.

D. Boron Content. Examination of the mean values for the boron content of the leaves in Table 36, and of the analysis of variance in Appendix Table 31, reveals that the boron content was influenced by the concentrations of boron, potassium and calcium in the substrate. In the boron series the boron content was 140 ppm. at the low boron level, 256 ppm. at the medium boron level, and 510 ppm. at the high boron level. This indicates that the boron content of the leaf tissue is a function of the arithmetic increase of boron in the substrate (Figure 2).

In the potassium series the boron content was greater at the low and the high potassium levels than at the medium potassium level. In the calcium series the boron content was greatest at the medium level of calcium, intermediate at the high level of calcium, and least at the low level of calcium.

In the K x B interaction the level of boron influenced the response to the level of potassium. At the low and medium levels of boron the boron content was greatest at the low level of potassium, but at the high

TABLE 36. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Boron Content, in Parts per Million, of Cantaloupe Leaves Sampled September 1-10, 1947.

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		140	256	510	283	307	318	276	326	306
K-L	306	176	277	466	311	294	314	295	341	284
K-M	272	117	224	476	239	281	297	248	285	284
K-H	328	128	268	589	299	344	342	285	351	350
Ca-L	276	142	240	446	245	282	300			
Ca-M	326	150	288	539	324	324	329			
Ca-H	306	129	241	547	280	313	324			
Mg-L	283	165	269	415						
Mg-M	307	126	258	536						
Mg-H	318	131	242	581						

level of boron the boron content was greatest at the high level of potassium.

The boron level also influenced the response to the level of calcium, which is reflected in the significant variance for the Ca x B interaction. When boron was at the medium level, the boron content was greatest at the medium level of calcium. When the boron level was high the boron content was greatest when the calcium level was medium or high. And when the boron content was low there was no appreciable difference in the boron content at the three levels of calcium.

Although the primary magnesium effect did not exercise any control over the boron content, nor did the magnesium level influence the boron content of the leaves at the low or the medium levels of boron, the boron content was greater at the medium and high levels of magnesium when the boron level was high. This is reflected in the significant variance for the Mg x B interaction.

E. Nitrogen Content. In the potassium series the nitrogen content of the leaves was greater at the low potassium level than at the medium or the high potassium levels. The mean values shown in Table 37 are reflected in the high variance for the potassium effect shown in Appendix Table 32.

In the calcium series, there was no difference in response to the low and medium levels of calcium, but the response to these levels was significantly greater than the response to the high level of calcium.

In response to the magnesium level, the nitrogen content was greatest at the low level, and the nitrogen content decreased as the concentration of magnesium was increased.

F. Phosphorus Content. Reference to the analysis of variance in Appendix Table 33 shows that the phosphorus content of the leaves varied

TABLE 37. Mean Values for the Main Effects and First-Order Interactions, Giving the Effects of Nutrient Level on the Total Nitrogen Content, in Milligrams per Gram, of Cantaloupe Leaves Sampled September 1-10, 1947.

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		34.0	33.3	34.4	36.6	33.4	31.7	35.0	34.9	31.8
K-L	37.1	36.6	36.4	38.1	36.2	38.4	36.6	38.1	40.3	32.8
K-M	32.6	33.9	31.7	32.2	37.9	30.4	29.5	33.9	33.0	30.9
K-H	32.0	31.5	31.7	33.0	35.7	31.3	29.1	33.0	31.4	31.8
Ca-L	35.0	34.3	34.2	36.5	35.4	35.2	34.4			
Ca-M	34.9	34.8	33.9	36.0	38.4	34.7	31.5			
Ca-H	31.8	32.9	31.8	30.8	36.0	30.3	29.3			
Mg-L	36.6	36.6	35.8	37.4						
Mg-M	33.4	33.2	33.8	33.2						
Mg-H	31.7	32.1	30.3	32.6						

significantly as the levels of potassium, calcium and magnesium in the substrate were varied. Examination of the mean values presented in Table 38 show that the phosphorus content was greatest in the potassium series when the potassium concentration was at the low level, and that as the potassium concentration increased the phosphorus content of the leaves decreased.

The phosphorus content was greatest at the high calcium level in the calcium series and decreased as the calcium level decreased. In the magnesium series the phosphorus content was greater at the low level of magnesium than at the medium and high levels of magnesium, and there was little difference in the phosphorus content at the medium and high levels.

TABLE 38. Mean Values for the Main Effects, First-Order Interactions, and the K x Ca x Mg Interaction, Giving the Effects of Nutrient Level on the Phosphorus Content, in Milligrams per Gram, of Cantaloupe Leaves Sampled September 1-10, 1947.

		B-L	B-M	B-H	Mg-L	Mg-M	Mg-H	Ca-L	Ca-M	Ca-H
		18.7	19.5	19.3	22.2	17.3	18.1	17.9	19.2	20.4
K-L	23.3	22.6	23.3	24.1	22.6	25.7	21.7	23.0	23.1	23.9
K-M	19.0	18.0	20.4	18.6	22.6	14.8	19.6	15.5	17.0	24.5
K-H	15.2	15.6	14.8	15.1	21.3	11.3	12.9	15.3	17.4	12.8
Ca-L	17.9	17.0	19.1	17.6	17.5	18.1	18.1			
Ca-M	19.2	18.6	20.0	19.0	23.8	16.3	17.6			
Ca-H	20.4	20.6	19.4	21.2	25.4	17.3	18.5			
Mg-L	22.2	21.8	23.4	21.4						
Mg-M	17.3	16.1	17.7	18.0						
Mg-H	18.1	18.3	17.4	18.5						

	Ca-L			Ca-M			Ca-H		
	Mg-L	Mg-M	Mg-H	Mg-L	Mg-M	Mg-H	Mg-L	Mg-M	Mg-H
K-L	15.4	30.2	23.4	29.9	24.0	15.6	22.6	22.8	26.3
K-M	18.9	11.2	16.3	19.6	11.3	20.2	29.4	21.8	22.2
K-H	18.1	13.0	14.8	21.5	13.7	17.0	24.3	7.2	6.9

DISCUSSION

The data pertaining to the growth and fruiting of cantaloupe plants grown in the sand culture nutrition experiments contribute new information regarding the requirements of this crop for certain of the mineral elements.

The low amount of growth as measured by dry weight when the nitrogen (as nitrate) concentration was high (50.0 m.e./L.) indicates that such a concentration was considerably in excess of that necessary for best growth. At all of the sampling periods in Experiment I the dry weight of the leaves and stems was consistently the greatest at the nitrogen concentration of 10.0 m.e./L. The dry weight of the roots was likewise greater at the 10.0 m.e./L. concentration. When the ratio of leaves to roots at the medium concentration is compared with the same ratio at the low concentration (2.0 m.e./L) it is seen that the poor growth at the low concentration throughout the entire growth of the plants was associated with a restricted root system. The ratio of leaves to roots at the high level of nitrogen was similar to that found at the medium level.

The number of fruit set was greatest when nitrogen was at the low level of concentration (2.0 m.e./L.). No estimate of the value of nitrogen concentration on the quality of the fruit was obtained, so that it is not possible to predict the effect of nitrogen on quality. The possibility is seen that under field conditions, nitrogen should be applied to cantaloupes in fairly heavy amounts early in the growth cycle, and should be applied in a form which will be diminished by the time blossoming starts. Should subsequent studies reveal that such practice would provide insufficient nitrogen for optimum development of quality, additional nitrogen could be supplied after the original fruit setting cycle.

The results from two experiments indicate that a potassium concentration of 4.0 to 5.0 m.e./L. in the substrate was optimum among those levels under consideration. In the early stages of development the growth of leaf tissue as measured by dry weight was greatest at these concentrations of potassium in the substrate. As the plants became older the response to differences in potassium concentration became less pronounced, and at about the time the fruits were setting on plants supplied with 4.0-5.0 m.e./L., there was little difference in the dry weight of the leaves and stems at the different levels of potassium. It was found in Experiment II, that plants supplied with 0.25 m.e./L. of potassium failed to produce flowers. Actually the flowers abscised when approximately one mm. in diameter. Plants supplied with 1.25 m.e./L. and 4.0 m.e./L. produced flowers and set fruits readily, and since the number of fruits set at the high level exceeded the number set at the medium level it is possible that an increase in the set of fruits might have been obtained at still higher concentrations of potassium. In the first experiment, the greatest set was at the 5.0 m.e./L. concentration, and it is reasonable that the concentration of potassium required for the greatest set of fruit would be in the vicinity of 4.0 to 5.0 m.e./L.

The interesting possibility is seen that the cantaloupe plant must make a certain amount of leaf growth before flowers will be formed, and that the amount of growth made is controlled by the existing level of potassium in the substrate. Furthermore, there appears to be a definite requirement for a certain amount of potassium per unit weight of leaf tissue before flowering will occur. While it was not possible to make chemical determinations at various stages of growth it was found that the leaves, at the final sampling date, contained 6.76 mg/gm K when supplied 0.25 m.e./L., 13.90 mg/gm K when supplied 1.25 m.e./L., and 30.05 mg/gm K when supplied 4.0 m.e./L. It would therefore appear that the cantaloupe plant requires a potassium content of something greater than 6.76 mg/gm K before flower bud development will result.

In both experiments, the plant response at all stages of development was greatest when the concentration of calcium in the substrate was 10.0 or 15.0 m.e./L. The work of Wilkins (38) has shown that the cantaloupe plant contains a high content of calcium, and the results reported herein show that a relatively great supply is essential for optimal growth. In the first experiment, the dry weight of leaves and stems was greatest at a calcium concentration of 10.0 m.e./L., with the exception of the final sampling period, when the dry weight was greatest at the low concentration (2.0 m.e./L.) of calcium. It is possible that since the set of fruits was heavier at the medium level (10.0 m.e./L.) of calcium than at the low level, the fruits may have diminished the amount of calcium and other metabolites available for vegetative growth at the medium concentration, whereas at the low concentration there were fewer fruits and consequently more calcium may have been available to the vegetative portions. In the second experiment this response did not occur, however. Growth in dry weight and the number of fruit set, was greatest when the calcium concentration was 15.0 m.e./L. Furthermore, the dry weight at the final sampling remained the greatest at this concentration. No explanation of the difference in response in the two experiments is apparent from examination of the data, although differences in aeration associated with size of sand particles may have been a contributing factor.

Root growth apparently increases as the supply of calcium increases. In both experiments the dry weight of roots was greatest at the highest concentrations used. The dry weight of roots which resulted from a concentration of 10.0 m.e./L. calcium in Experiment I, may be considered satisfactory, however, for plant development.

The number of fruits set, likewise, increased with higher concentrations of calcium. In the first experiment, there was little difference in the number set at 10.0 m.e./L. calcium and at 50.0 m.e./L. calcium. In the second experiment there was again little difference in the number of fruit set at the 5.0 and the 15.0 m.e./L. concentrations, although the percent soluble solids was greatest at the 5.0 m.e./L. level. It is possible, on the basis of these experiments, that the concentration of calcium most desirable for fruit set would be in the range of 5.0 to 15.0 m.e./L. Additional work would be required to establish a more limited range. Should the set of fruit not be materially influenced by the calcium concentration within the range of 5.0 to 15.0 m.e./L., it is readily seen that fairly heavy applications of lime to the soil would be justified as a source of calcium, over and above its use as a soil amendment.

The response to magnesium concentration in these two experiments was variable. In Experiment I there was no difference in dry weight of leaves or tops at concentrations of 1.0, 5.0 and 25.0 m.e./L. magnesium. Believing that these concentrations might be too high, the levels used in Experiment II were reduced to 0.2, 1.0 and 3.0 m.e./L. magnesium. In this later experiment, the dry weight of the tops was greatest at the 3.0 m.e./L. concentration for the first two sampling periods. At the final sampling, however, there was no difference in the dry weights resulting from the three magnesium levels. In the latter experiment, the dry weight of roots was likewise greatest at the high level of magnesium. The concentration of 0.2 m.e./L. was definitely deficient for growth, and for fruit set and quality. The number of fruit set and the percent soluble solids was not significantly different at the concentrations of 1.0 and 3.0 m.e./L. It would appear likely, therefore, that under field conditions an annual application of magnesium should be made to insure that the amount of available magnesium in the soil was throughout the season above the deficiency level. Provided the supply of magnesium in the soil is not depleted too rapidly, resulting in deficiency conditions, an early application made at a fairly heavy rate should provide ample magnesium in the soil for fruit production and quality later in the season.

Under the conditions of this experiment, at least, the concentration of boron had little effect on growth or on the number of fruit set, revealing the possibility that the tolerance for this element may have been overemphasized (22, 23). It was observed that the percent soluble solids was highest when the boron level was at the 1.62 ppm. concentration. Since increasing the boron concentration increased the percent soluble solids, it is possible that the application of boron as a spray shortly after the first fruits are set would increase the quality of the melons produced on the lighter Maryland soils.

The results presented demonstrate that it is easily possible to introduce an unbalanced condition in the substrate so that the resultant growth by the plant will be decreased. No consistency was observed in the effects of most of the various interactions on growth and fruiting of the cantaloupe plant. Two of the interactions, however, are of interest; namely, the K x Ca and the Ca x Mg effects.

In a study with peach trees the importance of the K x Ca effects has previously been pointed out by Brown (5), who observed that the effects of increasing calcium from 100 to 1000 ppm. when potassium was low (8 ppm.), resulted in increased growth, whereas, increasing calcium when potassium was high (800 ppm.) resulted in decreased growth. The relationships found with cantaloupe in the present study offer a different aspect in that when the potassium concentration was 1.0 m.e./L. and calcium was increased from 2.0 to 50.0 m.e./L., growth was greatest at the intermediate level of calcium (10.0 m.e./L.), and the number of fruit set was greatest at the two higher concentrations of calcium. On the other hand, when the potassium concentration was 25.0 m.e./L. and the calcium was increased from 2.0 to 50.0 m.e./L. the resultant growth increased between the low and medium levels while the plants were young, but in the later stages of development the growth decreased with increasing calcium, and a greater fruit set was observed at the higher calcium levels. When the concentrations of the two nutrients were decreased and greater control of the variables was secured, as was done in the second experiment, the effect of the interaction is observed to be a reflection of poor growth and poor fruit set at the deficiency levels. When both elements were at the low level of concentration (K, 0.25; Ca, 1.0 m.e./L.), the growth and fruit set were very low, and as either element was increased the growth and number of fruit set increased, and the greatest response was obtained when both elements were at the high concentration (K, 4.0; Ca, 15.0 m.e./L.). The most substantial increase in growth and number of fruit set resulted, however, from increasing the concentration of potassium.

The Ca x Mg interaction is likewise of interest. Stier (35) reported that severe calcium deficiency symptoms appeared on the leaves when calcium was low and magnesium was high, and that severe magnesium deficiency symptoms appeared when magnesium was low and calcium high. In the first experiment described herein, similar relationships were exhibited on the growth of the tops. When the calcium concentration was 2.0 m.e./L. and the magnesium concentration was increased from 1.0 to 25.0 m.e./L. a decreased growth resulted. Likewise, with 1.0 m.e./L. magnesium a decreased growth resulted with an increase in the calcium concentration from 2.0 to 50.0 m.e./L. This response is a reflection of the excessive supply of either element at the high concentration, resulting in a very low degree of balance. Observation of the low calcium-high magnesium relationship would not be expected under field conditions, and observation of the high calcium-low magnesium relationship would be expected only under abnormal circumstances. The results from the second experiment, when the high levels were not greatly excessive, did not exhibit the same response. At a concentration of 0.20 m.e./L. magnesium, the growth in the later stages of development was less at a concentration of 15.0 m.e./L. calcium than at 5.0 m.e./L. calcium; however, it is observed that the number of fruit set was slightly higher at the higher calcium level.

The results observed in these experiments indicated that there is little association between the number of fruit set and the number of laterals or the length of laterals. It has long been the opinion of growers that to get maximum yields it is desirable to have several long laterals on the cantaloupe plants. It is observed from this work that the same factors which contribute to making for a greater number of laterals and for a greater length per plant are not always the same factors which contribute to greater fruit set. Most cantaloupe varieties are andromonoecious, and ordinarily, there will be few, if any, hermaphroditic flowers developed along the main stem. It is then seen that without the development of the lateral stems no hermaphroditic flowers would develop, and consequently few fruits could be set. The contributing effect of an increasing length or number of laterals appears to be in the increased dry weight of leaves. It has previously been seen that an increasing dry weight of leaves in the young plants is associated with the number of fruits set. There is also an indication that the percent soluble solids of the fruit is dependent upon the total leaf growth as measured by dry weight.

The question of the association of potassium content of the leaves with percent soluble solids in the fruit has been previously brought out by Stark and Cox (33). The previous work indicated that there was a significant inverse correlation between the potassium content of the leaves of mature plants and the percent soluble solids. Wilkins (38) has indicated that the potassium content of the fruit was relatively high. In the present study, chemical analyses of the fruit were not made, but there is a strong indication that the potassium may be translocated to the fruit along with the carbohydrates. Thus, the potassium content of the leaves was normally low when the percent soluble solids was high for any given main effect except potassium. The coefficient of correlation which shows the degree of association between the potassium content and the percent soluble solids, for all of the treatments on which soluble solids determinations were made in the second experiment, is -0.3609. No determination of soluble solids was made at the low level of potassium (0.25 m.e./L.), but when correlation coefficients are determined separately for each of the medium potassium (1.25 m.e./L.) and the high potassium (4.0 m.e./L.) levels, a differential degree of association is observed. For the medium potassium treatments, the coefficient of correlation between potassium content of the leaves and percent soluble solids is -0.1234, whereas for the high potassium treatments the coefficient of correlation is -0.5307. The coefficients for all treatments and for the high potassium treatments are significant at the 5% level. With the supply of potassium in the substrate influencing the degree of association between the potassium content of the leaves and the percent soluble solids in the fruits, it would appear that when potassium is not in optimum supply for vegetative growth, other factors influence the translocation of the potassium and the carbohydrates to the fruit.

It was observed, in the two experiments described, that the mineral composition per unit of leaf weight was in a mathematical proportion to the composition of the minerals supplied in the substrate. The nitrogen content of the leaves increased in proportion to the logarithmic increase of nitrogen in the substrate. The calcium content of the leaves was likewise a function of the logarithm of the concentration in the substrate. On the other hand, the potassium, magnesium and boron content in the leaves was in direct arithmetic proportion to the concentration of these elements in the substrate. The arithmetic proportion of the boron content of the leaves to the boron concentration in the substrate has previously been observed by Eaton (7). In the knowledge of the writer, no published information is available concerning the mathematical association between the content in the leaves and the concentration in the substrate of mineral elements other than boron.

The concept is generally held that the results of sand culture nutrient experiments may not be applied directly to the field. The information obtained from the experiments described herein, is, however, of considerable value in determining the direction of future field work with this crop. Any *a priori* statements regarding definitive results expected in field experimentation would be hazardous. However, it may be safe to generalize to the extent that these results would indicate that the nutrient element supply in the soil available to the plant should be relatively high, particularly in the early stages of growth. The supply of available nitrogen and magnesium may possibly be allowed to decrease as the plants become older, providing the supply does not diminish to a deficiency level. To insure a good yield and a high soluble solids content, it is indicated that the supply of potassium and calcium must remain high throughout the period of growth. Little response in growth to boron level was observed, but in order that the percent of soluble solids may be enhanced it is indicated that a delayed application of boracic materials might prove profitable in practice.

SUMMARY AND CONCLUSIONS

Investigations were undertaken to determine the effect of nutritional level and balance on the growth and fruiting of cantaloupes. Two factorial experiments were conducted in sand culture, using three levels each of four nutrient elements. The nutrient elements studied in the two experiments included nitrogen, potassium, calcium, magnesium and boron. An inbred strain of cantaloupe was used to reduce possible variability, and the seed were germinated on paper before being placed in the sand.

Under the conditions of these experiments, the following conclusions may be made:

1. The best growth and fruiting of cantaloupes occurred when the concentration of nitrogen in the substrate was 10 m.e./L.

2. Early growth was the greatest when the concentration of potassium was in the range of 4.0 to 5.0 m.e./L. The growth at later stages of development failed to show significance between different potassium levels. Flower production was inhibited when the concentration was as low as 0.25 m.e./L. potassium. Fruit set and percent soluble solids was greatest when the potassium level was 4.0 and 5.0 m.e./L.

3. The cantaloupe plant contains a high content of calcium, and the best growth of tops and set of fruit was obtained at concentrations of 10.0 and 15.0 m.e./L. calcium in the substrate. Root development increased with increasing calcium level up to the 50.0 m.e./L. concentration.

4. A concentration of 0.2 m.e./L. magnesium was definitely deficient for growth and for fruit set and percent soluble solids. The optimum concentration of magnesium for early growth appeared to be in the vicinity of 3.0 m.e./L. Growth during the later stages of development, and fruit

set and quality was not dependent on magnesium level as long as the concentration was 1.0 m.e./L. or greater. Deficiency conditions were encountered, resulting in poor fruit set and quality, below the 1.0 m.e./L. concentration.

5. The effect of boron concentration was primarily on the percent soluble solids. The highest soluble solids was obtained at the high boron concentration (1.62 ppm.). Variations in concentration between 0.108 and 1.620 ppm. had no effect on growth or fruit set.

6. The effects of the interactions of the nutrient elements on growth and fruiting were overshadowed by the main effects, particularly when the single nutrient elements were not in a concentration in excess of that needed. It was found that it is possible to develop an unbalanced condition rather easily by too high a concentration of either potassium, calcium or magnesium.

7. The effects of the K x Ca and the Ca x Mg interactions are discussed. When either potassium or calcium was in the deficiency range, the amount of growth increased as the concentration of the other element was increased. When potassium was in excess the growth was increased as the calcium concentration was increased up to 10 m.e./L., and decreased at stronger concentrations of calcium. In regard to the Ca x Mg interaction, an excessive supply of either calcium or magnesium when the other element was not excessive resulted in a very low degree of balance.

8. There was little association in these experiments between the number of fruit set and the number or length of laterals. Since the hermaphroditic flowers are borne primarily on the lateral stems, the occurrence of laterals is important to fruit set. However, laterals were produced in varying numbers and lengths at all of the nutrient levels. The contributing effect of an increased number or length of laterals is

in the increased dry weight of leaves, which is associated with the number of fruits set.

9. The potassium content of the leaves was found to be inversely correlated with the percent soluble solids of the fruits, when the potassium level in the substrate was in ample supply.

10. The mineral composition of the leaves, per unit of weight, in the case of nitrogen and calcium, increased in proportion to the geometric increase of nitrogen and calcium in the substrate. The potassium, magnesium and boron content of the leaves increased in direct arithmetic proportion to the concentration of these elements in the substrate.

11. Certain aspects of the possible applications to commercial practice are discussed.

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APPENDIX

APPENDIX TABLE 1. Analysis of Variance on Dry Weights of Cantaloupe Leaves and Stems Sampled April 1, 1942, (Experiment I).

Source	D/F	Variance	F	D/F	Variance	F
N(a)	1	.0228	1.70	2	.0694	5.18*
N(b)	1	.1159	8.65**			
K(a)	1	.0436	3.25	2	.0753	5.62**
K(b)	1	.1069	7.98**			
Ca(a)	1	.0049	.31	2	.0436	3.25
Ca(b)	1	.0830	6.19*			
Mg(a)	1	.0001	.01	2	.0053	.40
Mg(b)	1	.0104	.78			
N(a) x K(a)	1	.0009	.07	4	.0075	.56
N(a) x K(b)	1	.0023	.17			
N(b) x K(a)	1	.0096	.72			
N(b) x K(b)	1	.0172	1.28			
N(a) x Ca(a)	1	.0659	4.92*	4	.0660	4.93**
N(a) x Ca(b)	1	.0569	4.25*			
N(b) x Ca(a)	1	.0016	.12			
N(b) x Ca(b)	1	.1396	10.42**			
N(a) x Mg(a)	1	.0032	.24	4	.0031	.23
N(a) x Mg(b)	1	.0013	.10			
N(b) x Mg(a)	1	.0029	.22			
N(b) x Mg(b)	1	.0052	.39			
K(a) x Ca(a)	1	.0001	.01	4	.0226	1.69
K(a) x Ca(b)	1	.0293	2.19			
K(b) x Ca(a)	1	.0604	4.15*			
K(b) x Ca(b)	1	.0009	.07			
K(a) x Mg(a)	1	.0014	.10	4	.0046	.34
K(a) x Mg(b)	1	.0062	.46			
K(b) x Mg(a)	1	.0015	.11			
K(b) x Mg(b)	1	.0094	.70			
Ca(a) x Mg(a)	1	.0014	.10	4	.0138	1.03
Ca(a) x Mg(b)	1	.0040	.29			
Ca(b) x Mg(a)	1	.0138	1.03			
Ca(b) x Mg(b)	1	.0361	2.69			
Rows	8	.0053	.40			
Columns	8	.0233	1.74			
Error	32	.0134		32	.0134	

APPENDIX TABLE 2. Analysis of Variance on Dry Weights of Cantaloupe Leaves and Stems Sampled April 10, 1942, (Experiment I).

Source	D/F	Variance	F	D/F	Variance	F
N(a)	1	.965	3.00	2	3.249	9.79**
N(b)	1	5.533	16.67**			
K(a)	1	1.147	3.45	2	1.277	3.85*
K(b)	1	1.406	4.23*			
Ca(a)	1	1.742	5.25*	2	1.156	3.48*
Ca(b)	1	.569	1.71			
Mg(a)	1	.797	2.40	2	.652	1.97
Mg(b)	1	.507	1.53			
N(a) x K(a)	1	.458	1.38	4	.519	1.56
N(a) x K(b)	1	.029	.09			
N(b) x K(a)	1	1.508	4.54*			
N(b) x K(b)	1	.081	.24			
N(a) x Ca(a)	1	4.921	14.82**	4	2.144	6.46**
N(a) x Ca(b)	1	2.433	7.33*			
N(b) x Ca(a)	1	.086	.26			
N(b) x Ca(b)	1	1.134	3.42			
N(a) x Mg(a)	1	.433	1.30	4	.599	1.80
N(a) x Mg(b)	1	.618	1.86			
N(b) x Mg(a)	1	1.283	3.86			
N(b) x Mg(b)	1	.062	.19			
K(a) x Ca(a)	1	.810	2.44	4	1.264	3.81*
K(a) x Ca(b)	1	.047	.14			
K(b) x Ca(a)	1	3.998	12.04**			
K(b) x Ca(b)	1	.203	.61			
K(a) x Mg(a)	1	1.357	4.09	4	.626	1.89
K(a) x Mg(b)	1	.643	1.94			
K(b) x Mg(a)	1	.248	.75			
K(b) x Mg(b)	1	.258	.78			
Ca(a) x Mg(a)	1	2.828	8.52**	4	1.557	4.69**
Ca(a) x Mg(b)	1	2.291	6.90*			
Ca(b) x Mg(a)	1	.748	2.25			
Ca(b) x Mg(b)	1	.362	1.59			
Rows	8	.281	.85			
Columns	8	1.008	3.04*			
Error	32	.332		32	.332	

APPENDIX TABLE 3. Analysis of Variance on Dry Weights of Cantaloupe Leaves and Stems Sampled May 14, 1942, (Experiment I).

Source	D/F	Variance	F	D/F	Variance	F
N(a)	1	1.867	.14	2	73.695	5.66**
N(b)	1	145.522	11.17**			
K(a)	1	.127	.01	2	.513	.04
K(b)	1	.898	.07			
Ca(a)	1	87.554	6.72*	2	82.507	6.33**
Ca(b)	1	77.460	5.94*			
Mg(a)	1	2.140	.16	2	3.305	.25
Mg(b)	1	4.470	.34			
N(a) x K(a)	1	3.661	.28	4	3.664	.28
N(a) x K(b)	1	3.364	.26			
N(b) x K(a)	1	.121	.01			
N(b) x K(b)	1	7.508	.58			
N(a) x Ca(a)	1	23.056	1.77	4	7.969	.61
N(a) x Ca(b)	1	6.111	.47			
N(b) x Ca(a)	1	.946	.07			
N(b) x Ca(b)	1	1.764	.14			
N(a) x Mg(a)	1	17.921	1.38	4	8.876	.68
N(a) x Mg(b)	1	.678	.05			
N(b) x Mg(a)	1	2.993	.23			
N(b) x Mg(b)	1	13.913	1.07			
K(a) x Ca(a)	1	5.048	.39	4	6.083	.47
K(a) x Ca(b)	1	1.846	.14			
K(b) x Ca(a)	1	17.328	1.33			
K(b) x Ca(b)	1	.109	.01			
K(a) x Mg(a)	1	1.346	.10	4	4.009	.31
K(a) x Mg(b)	1	3.952	.30			
K(b) x Mg(a)	1	7.500	.58			
K(b) x Mg(b)	1	3.240	.25			
Ca(a) x Mg(a)	1	12.145	.93	4	30.222	2.32
Ca(a) x Mg(b)	1	59.274	4.55*			
Ca(b) x Mg(a)	1	1.468	.11			
Ca(b) x Mg(b)	1	48.002	3.68			
Rows	8	21.280	1.63			
Columns	8	11.531	.88			
Error	32	13.030		32	13.030	

APPENDIX TABLE 4. Analysis of Variance on Dry Weights of Cantaloupe Leaves and Stems Sampled June 1-9, 1942, (Experiment I).

Source	D/F	Variance	F	D/F	Variance	F
N(a)	1	19.4880	1.06	2	60.0594	3.47*
N(b)	1	100.6308	5.49*			
K(a)	1	5.8082	.34	2	15.1892	.88
K(b)	1	24.5701	1.42			
Ca(a)	1	157.7988	9.11*	2	80.7992	4.67*
Ca(b)	1	3.7996	.22			
Mg(a)	1	29.7186	1.72	2	27.0394	1.56
Mg(b)	1	24.3602	1.41			
N(a) x K(a)	1	.1835	.01	4	7.5682	.44
N(a) x K(b)	1	13.5610	.78			
N(b) x K(a)	1	16.5127	.95			
N(b) x K(b)	1	.0156	—			
N(a) x Ca(a)	1	20.1451	1.16	4	10.1143	.58
N(a) x Ca(b)	1	.5016	.03			
N(b) x Ca(a)	1	19.1437	1.11			
N(b) x Ca(b)	1	.6669	.04			
N(a) x Mg(a)	1	4.7961	.28	4	25.0720	1.45
N(a) x Mg(b)	1	68.9600	3.98			
N(b) x Mg(a)	1	.6690	.04			
N(b) x Mg(b)	1	25.8629	1.49			
K(a) x Ca(a)	1	38.8129	2.24	4	20.7767	1.20
K(a) x Ca(b)	1	14.7113	.85			
K(b) x Ca(a)	1	28.5825	1.65			
K(b) x Ca(b)	1	1.0000	.06			
K(a) x Mg(a)	1	10.5084	.61	4	19.6067	1.13
K(a) x Mg(b)	1	29.5683	1.71			
K(b) x Mg(a)	1	11.9135	.69			
K(b) x Mg(b)	1	26.4367	1.53			
Ca(a) x Mg(a)	1	.4853	.03	4	32.6906	1.89
Ca(a) x Mg(b)	1	87.6961	5.06*			
Ca(b) x Mg(a)	1	6.5811	.38			
Ca(b) x Mg(b)	1	36.0000	2.08			
Rows	8	14.9384	.86			
Columns	8	31.7125	1.83			
Error	32	17.3144		32	17.3144	

APPENDIX TABLE 5. Analysis of Variance on Dry Weights of Cantaloupe Leaves Sampled June 1-9, 1942, (Experiment I).

Source	D/F	Variance	F	D/F	Variance	F
N(a)	1	37.184	4.23*	2	112.090	12.74**
N(b)	1	186.996	21.26**			
K(a)	1	3.877	.44	2	11.163	1.27
K(b)	1	18.449	2.10			
Ca(a)	1	30.600	3.48	2	15.465	1.76
Ca(b)	1	.330	.04			
Mg(a)	1	3.766	.43	2	2.654	.30
Mg(b)	1	1.541	.18			
N(a) x K(a)	1	.000	——	4	4.876	.55
N(a) x K(b)	1	6.512	.74			
N(b) x K(a)	1	12.295	1.40			
N(b) x K(b)	1	.696	.08			
N(a) x Ca(a)	1	1.024	.12	4	5.125	.58
N(a) x Ca(b)	1	.735	.08			
N(b) x Ca(a)	1	18.229	2.07			
N(b) x Ca(b)	1	.514	.06			
N(a) x Mg(a)	1	3.777	.43	4	7.745	.88
N(a) x Mg(b)	1	21.032	2.39			
N(b) x Mg(a)	1	.000	——			
N(b) x Mg(b)	1	6.173	.70			
K(a) x Ca(a)	1	17.195	1.95	4	10.556	1.20
K(a) x Ca(b)	1	3.485	.40			
K(b) x Ca(a)	1	17.666	2.01			
K(b) x Ca(b)	1	3.877	.44			
K(a) x Mg(a)	1	2.745	.31	4	5.415	.62
K(a) x Mg(b)	1	7.723	.88			
K(b) x Mg(a)	1	4.498	.51			
K(b) x Mg(b)	1	6.697	.76			
Ca(a) x Mg(a)	1	.290	.03	4	14.881	1.69
Ca(a) x Mg(b)	1	37.630	4.28*			
Ca(b) x Mg(a)	1	3.827	.44			
Ca(b) x Mg(b)	1	17.776	2.02			
Rows	8	6.608	.75			
Columns	8	14.659	1.67			
Error	32	8.796		32		

APPENDIX TABLE 6. Analysis of Variance on Dry Weights of Cantaloupe Stems Sampled June 1-9, 1942, (Experiment I).

Source	D/F	Variance	F	D/F	Variance	F
N(a)	1	122.432	44.22**	2	67.858	24.51**
N(b)	1	13.284	4.80*			
K(a)	1	.202	.07	2	.317	.11
K(b)	1	.431	.16			
Ca(a)	1	49.421	17.85**	2	25.643	9.26**
Ca(b)	1	1.865	.67			
Mg(a)	1	12.327	4.45*	2	12.953	4.68*
Mg(b)	1	13.578	4.90*			
N(a) x K(a)	1	.189	.07	4	.515	.19
N(a) x K(b)	1	1.265	.46			
N(b) x K(a)	1	.108	.04			
N(b) x K(b)	1	.499	.18			
N(a) x Ca(a)	1	12.099	4.37*	4	3.037	1.10
N(a) x Ca(b)	1	.026	.01			
N(b) x Ca(a)	1	.011	.004			
N(b) x Ca(b)	1	.011	.004			
N(a) x Mg(a)	1	.061	.02	4	5.213	1.88
N(a) x Mg(b)	1	16.070	5.80*			
N(b) x Mg(a)	1	.563	.20			
N(b) x Mg(b)	1	4.157	1.50			
K(a) x Ca(a)	1	4.340	1.57	4	2.624	.95
K(a) x Ca(b)	1	3.922	1.42			
K(b) x Ca(a)	1	1.307	.47			
K(b) x Ca(b)	1	.926	.33			
K(a) x Mg(a)	1	2.512	.91	4	4.475	1.62
K(a) x Mg(b)	1	7.130	2.57			
K(b) x Mg(a)	1	1.771	.64			
K(b) x Mg(b)	1	6.488	2.34			
Ca(a) x Mg(a)	1	.025	.01	4	3.515	1.27
Ca(a) x Mg(b)	1	10.435	3.77			
Ca(b) x Mg(a)	1	.371	.13			
Ca(b) x Mg(b)	1	3.230	1.17			
Rows	8	3.001	1.08			
Columns	8	4.504	1.63			
Error	32	2.769		32	2.769	

APPENDIX TABLE 7. Analysis of Variance on Dry Weights of Cantaloupe Roots Sampled June 1-9, 1942, (Experiment I).

Source	D/F	Variance	F	D/F	Variance	F
N(a)	1	117.218	11.16**	2	154.562	14.71**
N(b)	1	191.906	18.27**			
K(a)	1	30.001	2.86	2	15.037	1.43
K(b)	1	.072	.01			
Ca(a)	1	97.714	9.30**	2	50.905	4.85*
Ca(b)	1	4.096	.39			
Mg(a)	1	118.222	11.25**	2	75.388	7.17**
Mg(b)	1	32.554	3.10			
N(a) x K(a)	1	5.344	.51	4	12.456	1.20
N(a) x K(b)	1	2.950	.28			
N(b) x K(a)	1	41.082	3.91			
N(b) x K(b)	1	.450	.04			
N(a) x Ca(a)	1	29.666	2.82	4	9.178	.87
N(a) x Ca(b)	1	1.920	.18			
N(b) x Ca(a)	1	5.105	.49			
N(b) x Ca(b)	1	.023	.002			
N(a) x Mg(a)	1	33.216	3.16	4	32.492	3.09*
N(a) x Mg(b)	1	.016	.002			
N(b) x Mg(a)	1	67.624	6.44*			
N(b) x Mg(b)	1	29.112	2.77			
K(a) x Ca(a)	1	14.188	1.35	4	25.586	2.44
K(a) x Ca(b)	1	3.343	.32			
K(b) x Ca(a)	1	68.960	6.56*			
K(b) x Ca(b)	1	15.855	1.51			
K(a) x Mg(a)	1	13.616	1.30	4	7.829	.75
K(a) x Mg(b)	1	8.727	.83			
K(b) x Mg(a)	1	4.240	.40			
K(b) x Mg(b)	1	4.733	.45			
Ca(a) x Mg(a)	1	3.484	.33	4	8.451	.80
Ca(a) x Mg(b)	1	24.463	2.33			
Ca(b) x Mg(a)	1	2.620	.25			
Ca(b) x Mg(b)	1	3.236	.31			
Rows	8	17.726	1.69			
Columns	8	24.345	2.32*			
Error	32	10.506		32	10.506	

APPENDIX TABLE 8. Analysis of Variance on Length of Main Stems of Cantaloupe Plants, June 1, 1942, (Experiment I).

Source	D/F	Variance	F	D/F	Variance	F
N(a)	1	733.35	2.98	2	1290.16	5.24*
N(b)	1	1846.97	7.50**			
K(a)	1	1176.00	4.78*	2	742.87	3.02
K(b)	1	309.73	1.26			
Ca(a)	1	88.17	.36	2	312.68	1.27
Ca(b)	1	537.19	2.18			
Mg(a)	1	733.35	2.98	2	603.50	2.45
Mg(b)	1	473.64	1.92			
N(a) x K(a)	1	.03	———	4	72.62	.29
N(a) x K(b)	1	63.79	.26			
N(b) x K(a)	1	114.08	.46			
N(b) x K(b)	1	112.60	.46			
N(a) x Ca(a)	1	134.44	.55	4	126.97	.52
N(a) x Ca(b)	1	45.37	.18			
N(b) x Ca(a)	1	12.03	.05			
N(b) x Ca(b)	1	316.05	1.28			
N(a) x Mg(a)	1	26.69	.11	4	114.42	.46
N(a) x Mg(b)	1	404.45	1.64			
N(b) x Mg(a)	1	26.01	.11			
N(b) x Mg(b)	1	.52	———			
K(a) x Ca(a)	1	.00	———	4	39.83	.16
K(a) x Ca(b)	1	3.00	.01			
K(b) x Ca(a)	1	9.63	.04			
K(b) x Ca(b)	1	146.68	.56			
K(a) x Mg(a)	1	12.25	.05	4	251.18	1.02
K(a) x Mg(b)	1	690.08	2.80			
K(b) x Mg(a)	1	.01	———			
K(b) x Mg(b)	1	302.37	1.23			
Ca(a) x Mg(a)	1	124.69	.51	4	216.94	.88
Ca(a) x Mg(b)	1	720.75	2.93			
Ca(b) x Mg(a)	1	22.23	.09			
Ca(b) x Mg(b)	1	.07	———			
Rows	8	167.76	.68			
Columns	8	90.18	.37			
Error	32	246.20		32	246.20	

APPENDIX TABLE 9. Analysis of Variance on Length of Lateral Stems of Cantaloupe Plants, June 1, 1942, (Experiment I).

Source	D/F	Variance	F	D/F	Variance	F
N(a)	1	12573.6	4.38*	2	25055.8	8.73**
N(b)	1	37538.0	13.08**			
K(a)	1	1310.3	.46	2	2833.0	.99
K(b)	1	4355.6	1.52			
Ca(a)	1	54976.5	19.16**	2	28358.5	9.89**
Ca(b)	1	1740.5	.61			
Mg(a)	1	1992.3	.69	2	1689.6	.59
Mg(b)	1	1386.9	.48			
N(a) x K(a)	1	177.8	.06	4	3137.0	1.09
N(a) x K(b)	1	4961.3	1.73			
N(b) x K(a)	1	6880.0	2.40			
N(b) x K(b)	1	529.0	.18			
N(a) x Ca(a)	1	100.0	.03	4	3792.5	1.32
N(a) x Ca(b)	1	1281.3	.45			
N(b) x Ca(a)	1	13781.5	4.80*			
N(b) x Ca(b)	1	7.1	——			
N(a) x Mg(a)	1	2070.3	.72	4	1041.5	.36
N(a) x Mg(b)	1	1753.1	.61			
N(b) x Mg(a)	1	1.6	——			
N(b) x Mg(b)	1	342.3	.12			
K(a) x Ca(a)	1	2826.7	.99	4	1628.7	.57
K(a) x Ca(b)	1	3411.6	1.19			
K(b) x Ca(a)	1	264.5	.09			
K(b) x Ca(b)	1	12.3	——			
K(a) x Mg(a)	1	2952.1	1.03	4	3202.9	1.12
K(a) x Mg(b)	1	3936.1	1.37			
K(b) x Mg(a)	1	1253.9	.44			
K(b) x Mg(b)	1	4669.4	1.63			
Ca(a) x Mg(a)	1	1024.0	.36	4	3382.0	1.18
Ca(a) x Mg(b)	1	10130.7	3.53			
Ca(b) x Mg(a)	1	2045.4	.71			
Ca(b) x Mg(b)	1	324.0	.11			
Rows	8	910.7	.32			
Columns	8	1818.8	.63			
Error	32	2868.8		32	2868.8	

APPENDIX TABLE 10. Analysis of Variance on Number of Lateral Stems of Cantaloupe Plants, June 1, 1942, (Experiment I).

Source	D/F	Variance	F	D/F	Variance	F
N(a)	1	33.449	8.40*	2	54.410	13.67**
N(b)	1	75.371	18.93**			
K(a)	1	.375	.09	2	2.195	.55
K(b)	1	4.014	1.01			
Ca(a)	1	80.667	20.26**	2	45.028	11.31**
Ca(b)	1	9.389	2.36			
Mg(a)	1	4.449	1.12	2	2.287	.57
Mg(b)	1	.125	.03			
N(a) x K(a)	1	.028	.01	4	3.926	.99
N(a) x K(b)	1	.593	.15			
N(b) x K(a)	1	14.083	3.54			
N(b) x K(b)	1	1.000	.25			
N(a) x Ca(a)	1	.840	.21	4	6.079	1.53
N(a) x Ca(b)	1	5.113	1.28			
N(b) x Ca(a)	1	17.521	4.40			
N(b) x Ca(b)	1	.840	.21			
N(a) x Mg(a)	1	5.840	1.47	4	2.185	.55
N(a) x Mg(b)	1	.836	.21			
N(b) x Mg(a)	1	.058	.01			
N(b) x Mg(b)	1	2.007	.50			
K(a) x Ca(a)	1	1.174	.29	4	.863	.29
K(a) x Ca(b)	1	1.688	.42			
K(b) x Ca(a)	1	.521	.13			
K(b) x Ca(b)	1	.069	.02			
K(a) x Mg(a)	1	2.778	.70	4	9.463	2.38
K(a) x Mg(b)	1	18.750	4.71*			
K(b) x Mg(a)	1	6.295	1.58			
K(b) x Mg(b)	1	10.028	2.52			
Ca(a) x Mg(a)	1	17.361	4.36	4	15.014	3.77*
Ca(a) x Mg(b)	1	35.021	8.80**			
Ca(b) x Mg(a)	1	.113	.03			
Ca(b) x Mg(b)	1	7.563	1.90			
N x K x Ca	4	13.480	3.39*	4	13.480	3.39*
N x K x Mg	4	4.960	1.25	4	4.960	1.25
N x Ca x Mg	4	4.320	1.09	4	4.320	1.09
K x Ca x Mg	4	8.633	2.17	4	8.633	2.17
Rows	8	1.694	.43			
Columns	8	5.548	1.39			
Error	16	3.981		16	3.981	

APPENDIX TABLE 11. Analysis of Variance on Number of Fruits Set on Cantaloupe Plants, (Experiment I).

Source	D/F	Variance	F	D/F	Variance	F
N(a)	1	8.170	62.37**	2	4.113	31.40**
N(b)	1	.056	.43			
K(a)	1	.019	.15	2	1.371	10.47**
K(b)	1	2.722	20.78**			
Ca(a)	1	16.667	127.23**	2	10.112	77.19**
Ca(b)	1	3.556	27.15**			
Mg(a)	1	.019	.15	2	.704	5.37*
Mg(b)	1	1.389	10.60**			
N(a) x K(a)	1	1.361	10.39**	4	.759	5.79**
N(a) x K(b)	1	.083	.63			
N(b) x K(a)	1	1.565	11.95**			
N(b) x K(b)	1	.028	.21			
N(a) x Ca(a)	1	1.778	13.57**	4	1.111	8.48**
N(a) x Ca(b)	1	1.333	10.18**			
N(b) x Ca(a)	1	1.333	10.18**			
N(b) x Ca(b)	1	.000	——			
N(a) x Mg(a)	1	1.361	10.39**	4	.648	4.95*
N(a) x Mg(b)	1	.750	5.73*			
N(b) x Mg(a)	1	.454	3.47			
N(b) x Mg(b)	1	.028	.21			
K(a) x Ca(a)	1	.028	.21	4	.093	.71
K(a) x Ca(b)	1	.009	.07			
K(b) x Ca(a)	1	.083	.63			
K(b) x Ca(b)	1	.250	1.91			
K(a) x Mg(a)	1	.028	.28	4	.129	.99
K(a) x Mg(b)	1	.009	.07			
K(b) x Mg(a)	1	.454	3.47			
K(b) x Mg(b)	1	.028	.28			
Ca(a) x Mg(a)	1	1.000	7.63*	4	.481	3.67*
Ca(a) x Mg(b)	1	.333	2.54			
Ca(b) x Mg(a)	1	.593	4.53*			
Ca(b) x Mg(b)	1	.000	——			
N x K x Ca	4	.592	4.52*	4	.592	4.52*
N x K x Mg	4	.076	.58	4	.076	.58
N x Ca x Mg	4	.370	2.82	4	.370	2.82
K x Ca x Mg	4	.344	2.63	4	.344	2.63
Rows	8	.528	4.03**			
Columns	8	.333	2.54			
Error	16	.131		16	.131	

APPENDIX TABLE 12. Analysis of Variance on Nitrogen Content of the Leaves of Cantaloupe Plants Sampled June 1-9, 1942, (Experiment I).

Source	D/F	Variance	F	D/F	Variance	F
N(a)	1	5000.09	374.14**	2	2500.06	186.57**
N(b)	1	.03	——			
K(a)	1	48.05	3.59	2	122.85	9.17**
K(b)	1	197.65	14.75**			
Ca(a)	1	1372.29	102.41**	2	801.42	59.81**
Ca(b)	1	230.55	17.21**			
Mg(a)	1	98.50	7.35*	2	62.91	4.69*
Mg(b)	1	27.32	2.04			
N(a) x K(a)	1	24.40	1.82	4	48.54	3.62*
N(a) x K(b)	1	64.99	4.85*			
N(b) x K(a)	1	101.69	7.59*			
N(b) x K(b)	1	3.06	.23			
N(a) x Ca(a)	1	74.45	5.56*	4	89.65	6.69**
N(a) x Ca(b)	1	1.42	.11			
N(b) x Ca(a)	1	269.52	20.11**			
N(b) x Ca(b)	1	13.19	.98			
N(a) x Mg(a)	1	165.72	12.37**	4	50.04	3.73*
N(a) x Mg(b)	1	7.41	.55			
N(b) x Mg(a)	1	3.52	.26			
N(b) x Mg(b)	1	23.49	1.75			
K(a) x Ca(a)	1	.03	——	4	17.93	1.34
K(a) x Ca(b)	1	29.59	2.21			
K(b) x Ca(a)	1	26.91	2.01			
K(b) x Ca(b)	1	15.17	1.13			
K(a) x Mg(a)	1	37.17	2.77	4	16.21	1.21
K(a) x Mg(b)	1	1.37	.10			
K(b) x Mg(a)	1	19.22	1.43			
K(b) x Mg(b)	1	7.09	.53			
Ca(a) x Mg(a)	1	89.46	6.68*	4	37.93	2.83*
Ca(a) x Mg(b)	1	2.93	.22			
Ca(b) x Mg(a)	1	48.33	3.61			
Ca(b) x Mg(b)	1	11.01	.82			
Rows	8	16.50	1.23			
Columns	8	18.40	1.37			
Error	29	13.40		29	13.40	

APPENDIX TABLE 13. Analysis of Variance on Potassium Content of the Leaves of Cantaloupe Plants Sampled June 1-9, 1942, (Experiment I).

Source	D/F	Variance	F	D/F	Variance	F
N(a)	1	34.74	.67	2	255.89	4.94*
N(b)	1	477.03	9.22**			
K(a)	1	23693.61	457.85**	2	13518.21	261.22**
K(b)	1	3342.80	64.60**			
Ca(a)	1	7399.08	142.98**	2	3700.86	71.51**
Ca(b)	1	2.63	.05			
Mg(a)	1	2572.60	49.71**	2	1317.84	25.47**
Mg(b)	1	63.07	1.22			
N(a) x K(a)	1	65.10	1.26	4	50.98	.99
N(a) x K(b)	1	27.37	.53			
N(b) x K(a)	1	108.46	2.10			
N(b) x K(b)	1	2.97	.06			
N(a) x Ca(a)	1	198.48	3.84	4	113.75	2.20
N(a) x Ca(b)	1	11.93	.23			
N(b) x Ca(a)	1	230.13	4.45*			
N(b) x Ca(b)	1	14.46	.09			
N(a) x Mg(a)	1	245.29	4.74*	4	78.13	1.51
N(a) x Mg(b)	1	5.64	.11			
N(b) x Mg(a)	1	.03	——			
N(b) x Mg(b)	1	61.58	1.19			
K(a) x Ca(a)	1	2538.98	49.06**	4	682.18	13.18**
K(a) x Ca(b)	1	16.00	.31			
K(b) x Ca(a)	1	164.06	3.17			
K(b) x Ca(b)	1	9.68	.19			
K(a) x Mg(a)	1	606.31	11.72**	4	173.23	3.35*
K(a) x Mg(b)	1	1.23	.02			
K(b) x Mg(a)	1	41.89	.81			
K(b) x Mg(b)	1	43.49	.84			
Ca(a) x Mg(a)	1	56.08	1.08	4	109.76	2.12
Ca(a) x Mg(b)	1	272.75	5.27*			
Ca(b) x Mg(a)	1	59.19	1.14			
Ca(b) x Mg(b)	1	51.04	.99			
Rows	8	36.03	.70			
Columns	8	17.88	.35			
Error	30	51.75		30	51.75	

APPENDIX TABLE 14. Analysis of Variance on Calcium Content of the Leaves of Cantaloupe Plants Sampled June 1-9, 1942, (Experiment I).

Source	D/F	Variance	F	D/F	Variance	F
N(a)	1	505.1	4.07	2	374.8	3.02
N(b)	1	244.5	1.97			
K(a)	1	4979.9	40.10**	2	3119.4	25.12**
K(b)	1	1258.8	10.14**			
Ca(a)	1	58063.9	467.50**	2	29075.7	234.10**
Ca(b)	1	87.4	.70			
Mg(a)	1	1384.0	11.14**	2	758.0	6.10**
Mg(b)	1	132.0	1.06			
N(a) x K(a)	1	67.0	.54	4	130.0	1.05
N(a) x K(b)	1	224.9	1.81			
N(b) x K(a)	1	21.6	.17			
N(b) x K(b)	1	206.6	1.66			
N(a) x Ca(a)	1	908.4	7.31*	4	238.9	1.92
N(a) x Ca(b)	1	1.0	.01			
N(b) x Ca(a)	1	46.3	.37			
N(b) x Ca(b)	1	.1	—			
N(a) x Mg(a)	1	22.3	.18	4	58.3	.47
N(a) x Mg(b)	1	41.4	.33			
N(b) x Mg(a)	1	98.9	.80			
N(b) x Mg(b)	1	70.6	.57			
K(a) x Ca(a)	1	344.0	2.77	4	432.4	3.48*
K(a) x Ca(b)	1	.3	—			
K(b) x Ca(a)	1	1280.9	10.31**			
K(b) x Ca(b)	1	104.2	.84			
K(a) x Mg(a)	1	40.4	.33	4	317.3	2.55
K(a) x Mg(b)	1	409.4	3.30			
K(b) x Mg(a)	1	813.3	6.55*			
K(b) x Mg(b)	1	6.0	.05			
Ca(a) x Mg(a)	1	64.8	.52	4	27.5	.22
Ca(a) x Mg(b)	1	32.2	.26			
Ca(b) x Mg(a)	1	12.6	.10			
Ca(b) x Mg(b)	1	.5	—			
Rows	8	142.6	1.15			
Columns	8	56.7	.46			
Error	32	124.2		30	124.2	

APPENDIX TABLE 15. Analysis of Variance on Magnesium Content of the Leaves of Cantaloupe Plants Sampled June 1-9, 1942, (Experiment I).

Source	D/F	Variance	F	D/F	Variance	F
N(a)	1	22.57	4.71*	2	12.49	2.61
N(b)	1	2.41	.50			
K(a)	1	263.57	55.03**	2	133.21	27.81**
K(b)	1	2.84	.59			
Ca(a)	1	541.12	112.97**	2	313.87	65.53**
Ca(b)	1	86.62	18.08**			
Mg(a)	1	3551.86	741.52**	2	1913.38	399.45**
Mg(b)	1	274.90	57.39**			
N(a) x K(a)	1	3.98	.83	4	18.06	3.77*
N(a) x K(b)	1	.23	.05			
N(b) x K(a)	1	6.14	1.28			
N(b) x K(b)	1	61.88	12.92**			
N(a) x Ca(a)	1	30.18	6.30*	4	13.25	2.77
N(a) x Ca(b)	1	12.15	2.54			
N(b) x Ca(a)	1	1.48	.31			
N(b) x Ca(b)	1	9.17	1.91			
N(a) x Mg(a)	1	69.61	14.53**	4	27.26	5.69**
N(a) x Mg(b)	1	6.55	1.37			
N(b) x Mg(a)	1	.17	.04			
N(b) x Mg(b)	1	32.71	6.83*			
K(a) x Ca(a)	1	116.24	24.27**	4	31.29	6.53**
K(a) x Ca(b)	1	5.26	1.10			
K(b) x Ca(a)	1	.04	.01			
K(b) x Ca(b)	1	3.61	.75			
K(a) x Mg(a)	1	87.05	18.17**	4	22.70	4.74*
K(a) x Mg(b)	1	.52	.11			
K(b) x Mg(a)	1	2.49	.52			
K(b) x Mg(b)	1	.73	.15			
Ca(a) x Mg(a)	1	132.33	27.63**	4	57.37	11.98**
Ca(a) x Mg(b)	1	26.46	5.52*			
Ca(b) x Mg(a)	1	59.17	12.35**			
Ca(b) x Mg(b)	1	11.52	2.41			
N x K x Ca	4	11.44	2.39	4	11.44	2.39
N x K x Mg	4	5.29	1.10	4	5.29	1.10
N x Ca x Mg	4	10.14	2.12	4	10.14	2.12
K x Ca x Mg	4	8.53	1.78	4	8.53	1.78
Rows	8	1.03	.22			
Columns	8	5.55	1.16			
Error	14	4.79		14	4.79	

APPENDIX TABLE 16. Analysis of Variance on Phosphorus Content of the Leaves of Cantaloupe Plants Sampled June 1-9, 1942, (Experiment I).

Source	D/F	Variance	F	D/F	Variance	F
N(a)	1	175.50	32.87**	2	123.72	23.17**
N(b)	1	71.93	13.47**			
K(a)	1	676.28	126.64**	2	341.66	63.98**
K(b)	1	7.04	1.32			
Ca(a)	1	2.54	.48	2	3.63	.68
Ca(b)	1	4.72	.88			
Mg(a)	1	16.92	3.17	2	8.48	1.59
Mg(b)	1	.03	.01			
N(a) x K(a)	1	90.03	16.86**	4	27.11	5.08**
N(a) x K(b)	1	8.93	1.67			
N(b) x K(a)	1	.01	——			
N(b) x K(b)	1	9.47	1.77			
N(a) x Ca(a)	1	.18	.03	4	.75	.14
N(a) x Ca(b)	1	.07	.01			
N(b) x Ca(a)	1	.20	.04			
N(b) x Ca(b)	1	2.54	.48			
N(a) x Mg(a)	1	31.44	5.89*	4	9.67	1.81
N(a) x Mg(b)	1	2.20	.41			
N(b) x Mg(a)	1	4.51	.84			
N(b) x Mg(b)	1	.55	.10			
K(a) x Ca(a)	1	.01	——	4	4.94	.93
K(a) x Ca(b)	1	7.79	1.46			
K(b) x Ca(a)	1	11.08	2.07			
K(b) x Ca(b)	1	.90	.17			
K(a) x Mg(a)	1	42.03	7.87*	4	11.59	2.17
K(a) x Mg(b)	1	.31	.06			
K(b) x Mg(a)	1	3.57	.67			
K(b) x Mg(b)	1	.45	.08			
Ca(a) x Mg(a)	1	30.45	5.70*	4	9.37	1.75
Ca(a) x Mg(b)	1	.61	.11			
Ca(b) x Mg(a)	1	3.18	.60			
Ca(b) x Mg(b)	1	3.23	.60			
N x K x Ca	4	5.84	1.09	4	5.84	1.09
N x K x Mg	4	6.08	1.14	4	6.08	1.14
N x Ca x Mg	4	5.67	1.06	4	5.67	1.06
K x Ca x Mg	4	11.29	2.11	4	11.29	2.11
Rows	8	8.86	1.66			
Columns	8	4.69	.88			
Error	14	5.34		14	5.34	

APPENDIX TABLE 17. Analysis of Variance on Boron Content of the Leaves of Cantaloupe Plants Sampled June 1-9, 1942, (Experiment I).

Source	D/F	Variance	F	D/F	Variance	F
N(a)	1	182353	26.49**	2	91436	13.28**
N(b)	1	519	.08			
K(a)	1	2078	.30	2	25393	3.69*
K(b)	1	48707	7.08*			
Ca(a)	1	9923	1.44	2	12339	1.79
Ca(b)	1	14754	2.14			
Mg(a)	1	3204	.47	2	3801	.55
Mg(b)	1	4397	.64			
N(a) x K(a)	1	17248	2.51	4	6428	.93
N(a) x K(b)	1	40	.01			
N(b) x K(a)	1	757	.11			
N(b) x K(b)	1	7666	1.11			
N(a) x Ca(a)	1	729	.11	4	2241	.33
N(a) x Ca(b)	1	2523	.37			
N(b) x Ca(a)	1	2	—			
N(b) x Ca(b)	1	5709	.83			
N(a) x Mg(a)	1	17030	2.47	4	6214	.90
N(a) x Mg(b)	1	37	.01			
N(b) x Mg(a)	1	3558	.52			
N(b) x Mg(b)	1	4232	.61			
K(a) x Ca(a)	1	5017	.73	4	4364	.63
K(a) x Ca(b)	1	28	—			
K(b) x Ca(a)	1	4602	.67			
K(b) x Ca(b)	1	3810	.55			
K(a) x Mg(a)	1	7168	1.04	4	2495	.36
K(a) x Mg(b)	1	29	—			
K(b) x Mg(a)	1	2484	.36			
K(b) x Mg(b)	1	297	.04			
Ca(a) x Mg(a)	1	8618	1.25	4	3238	.47
Ca(a) x Mg(b)	1	2852	.41			
Ca(b) x Mg(a)	1	1459	.21			
Ca(b) x Mg(b)	1	24	—			
Rows	8	4120	.60			
Columns	8	4081	.59			
Error	29	6884		29	6884	

APPENDIX TABLE 18. Analysis of Variance on Dry Weights of Cantaloupe Leaves and Stems Sampled June 7, 1947, (Experiment II).

Source	D/F	Sum Squares	Variance	F
Potassium	2	.85174	.42587	73.17**
Calcium	2	.47032	.23516	40.41**
Magnesium	2	.19165	.09583	16.47**
Boron	2	.00927	.00464	.80
K x Ca	4	.33966	.08492	14.59**
K x Mg	4	.09264	.02314	3.98**
K x B	4	.04835	.01209	2.08
Ca x Mg	4	.03879	.00970	1.67
Ca x B	4	.01468	.00367	.63
Mg x B	4	.04450	.01113	1.91
Rows	8	.10943	.01368	2.35*
Columns	8	.09841	.01230	2.11
Error	32	.18632	.00582	
Total	80	2.4958		

APPENDIX TABLE 19. Analysis of Variance on Dry Weights of Cantaloupe Leaves Sampled June 30, 1947, (Experiment II).

Source	D/F	Sum Squares	Variance	F
Potassium	2	32.962	16.481	57.83**
Calcium	2	27.429	13.715	48.12**
Magnesium	2	38.820	19.410	68.11**
Boron	2	1.828	.914	3.21
K x Ca	4	.942	.236	.83
K x Mg	4	2.710	.678	2.38
K x B	4	1.590	.397	1.39
Ca x Mg	4	8.934	2.234	7.84**
Ca x B	4	.200	.050	.18
Mg x B	4	1.218	.304	1.07
Rows	8	3.493	.437	1.53
Columns	8	4.698	.537	2.06
Error	32	9.120	.285	
Total	80	133.944		

APPENDIX TABLE 20. Analysis of Variance on Dry Weights of Cantaloupe Leaves Sampled September 1-10, 1947, (Experiment II).

Source	D/F	Sum Squares	Variance	F
Potassium	2	28.23	14.12	.41
Calcium	2	1085.22	542.61	15.88**
Magnesium	2	202.21	101.11	2.96
Boron	2	21.22	10.61	.31
K x Ca	4	484.69	121.17	3.55*
K x Mg	4	97.37	24.34	.71
K x B	4	173.56	43.39	1.27
Ca x Mg	4	103.82	25.96	.76
Ca x B	4	135.78	33.95	.99
Mg x B	4	81.56	20.39	.60
Rows	8	290.47	36.31	1.06
Columns	8	476.41	59.55	1.74
Error	32	1093.04	34.16	
Total	80	4273.58		

APPENDIX TABLE 21. Analysis of Variance on Dry Weights of Cantaloupe Stems Sampled June 30, 1947, (Experiment II).

Source	D/F	Sum Squares	Variance	F
Potassium	2	23.325	11.663	82.72**
Calcium	2	11.010	5.505	39.04**
Magnesium	2	16.066	8.033	56.97**
Boron	2	.947	.474	3.36*
K x Ca	4	1.370	.343	2.43
K x Mg	4	2.972	.743	5.27**
K x B	4	1.080	.270	1.91
Ca x Mg	4	4.667	1.167	8.28**
Ca x B	4	.257	.064	.45
Mg x B	4	.560	.140	.99
Rows	8	1.113	.139	.99
Columns	8	1.855	.232	1.65
Error	32	4.499	.141	
Total	80	69.721		

APPENDIX TABLE 22. Analysis of Variance on Dry Weights of Cantaloupe Stems Sampled September 1-10, 1947, (Experiment II).

Source	D/F	Sum Squares	Variance	F
Potassium	2	33.95	16.98	.61
Calcium	2	191.24	95.62	3.41*
Magnesium	2	44.19	22.10	.79
Boron	2	26.28	13.14	.47
K x Ca	4	262.82	65.71	2.34
K x Mg	4	80.84	20.21	.72
K x B	4	111.06	27.77	.99
Ca x Mg	4	38.03	9.51	.34
Ca x B	4	38.61	9.65	.34
Mg x B	4	106.14	26.54	.95
Rows	8	190.66	23.83	.85
Columns	8	311.34	38.92	1.39
Error	32	897.24	28.04	
Total	80	2332.40		

APPENDIX TABLE 23. Analysis of Variance on Dry Weights of Cantaloupe Roots Sampled September 1-10, 1947, (Experiment II).

Source	D/F	Sum Squares	Variance	F
Potassium	2	15.53	7.77	8.35**
Calcium	2	29.20	14.60	15.70**
Magnesium	2	35.92	17.96	19.31**
Boron	2	3.42	1.71	1.84
K x Ca	4	20.28	5.07	5.45**
K x Mg	4	8.63	2.16	2.32
K x B	4	12.99	3.25	3.49*
Ca x Mg	4	13.07	3.27	3.52*
Ca x B	4	2.25	.56	.60
Mg x B	4	16.96	4.24	4.56**
K x Mg x B	4	17.75	4.44	4.77**
Rows	8	4.50	.56	.60
Columns	8	10.11	1.26	1.35
Error	28	26.08	.93	
Total	80	216.69		

APPENDIX TABLE 24. Analysis of Variance on Length of Main Stem of Cantaloupe Plants, September 1-10, 1947, (Experiment II).

Source	D/F	Sum Squares	Variance	F
Potassium	2	17829	8915	1.36
Calcium	2	5592	2796	.43
Magnesium	2	94442	47221	7.22**
Boron	2	20825	10413	1.59
K x Ca	4	92658	23165	3.54*
K x Mg	4	72383	18096	2.77*
K x B	4	54615	13654	2.09
Ca x Mg	4	38949	9737	1.49
Ca x B	4	5140	1285	.20
Mg x B	4	55791	13948	2.13
Rows	8	42362	5295	.81
Columns	8	49077	6135	.94
Error	32	209141	6536	
Total	80	758804		

APPENDIX TABLE 25. Analysis of Variance on Length of Lateral Stems of Cantaloupe Plants, September 1-10, 1947, (Experiment II).

Source	D/F	Sum Squares	Variance	F
Potassium	2	2183663	1091832	10.22**
Calcium	2	792096	396048	3.71*
Magnesium	2	246231	123116	1.15
Boron	2	174759	87380	.82
K x Ca	4	957255	239314	2.24
K x Mg	4	483159	120790	1.13
K x B	4	386816	96704	.91
Ca x Mg	4	61390	15348	.14
Ca x B	4	163090	40773	.38
Mg x B	4	455409	113852	1.07
Rows	8	1319567	164946	1.54
Columns	8	915044	114381	1.07
Error	32	3417741	106804	
Total	80	11556220		

APPENDIX TABLE 26. Analysis of Variance on Number of Lateral Stems of Cantaloupe Plants, September 1-10, 1947, (Experiment II).

Source	D/F	Sum Squares	Variance	F
Potassium	2	402.389	201.195	41.39**
Calcium	2	34.667	17.334	3.57*
Magnesium	2	4.667	2.334	.48
Boron	2	22.167	11.084	2.28
K x Ca	4	61.222	15.306	3.15*
K x Mg	4	48.222	12.056	2.48
K x B	4	12.611	3.153	.65
Ca x Mg	4	4.667	1.167	.24
Ca x B	4	23.012	5.753	1.18
Mg x B	4	18.278	4.569	.94
Rows	8	44.500	5.563	1.14
Columns	8	70.556	8.819	1.81
Error	32	155.546	4.861	
Total	80	902.500		

APPENDIX TABLE 27. Analysis of Variance on Number of Fruits Set on Cantaloupe Plants, (Experiment II).

Source	D/F	Sum Squares	Variance	F
Potassium	2	30.543	15.272	93.69**
Calcium	2	1.654	.827	5.07*
Magnesium	2	14.840	7.420	45.52**
Boron	2	.025	.013	.08
K x Ca	4	.790	.198	1.21
K x Mg	4	10.716	2.679	16.44**
K x B	4	1.531	.383	2.35
Ca x Mg	4	.494	.124	.76
Ca x B	4	1.309	.327	2.01
Mg x B	4	1.457	.364	2.23
Rows	8	2.099	.262	1.61
Columns	8	2.543	.318	1.95
Error	32	5.210	.163	
Total	80	73.210		

APPENDIX TABLE 28. Analysis of Variance on the Potassium Content of the Leaves of Cantaloupe Plants Sampled September 1-10, 1947, (Experiment II).

Source	D/F	Sum Squares	Variance	F
Potassium	2	7687.73	3843.87	120.16**
Calcium	2	349.61	174.81	5.46**
Magnesium	2	3053.19	1526.60	47.72**
Boron	2	3.49	1.75	.05
K x Ca	4	641.34	160.34	5.01**
K x Mg	4	950.13	237.53	7.43**
K x B	4	30.46	7.62	.23
Ca x Mg	4	24.30	6.08	.19
Ca x B	4	18.14	4.54	.14
Mg x B	4	41.33	10.33	.32
Rows	8	205.04	25.63	.80
Columns	8	278.12	34.77	1.09
Error	31	991.64	31.99	
Total	79	14274.92		

APPENDIX TABLE 29. Analysis of Variance on the Calcium Content of the Leaves of Cantaloupe Plants Sampled September 1-10, 1947, (Experiment II).

Source	D/F	Sum Squares	Variance	F
Potassium	2	1045.0	522.5	15.06**
Calcium	2	70352.9	35176.5	1013.73**
Magnesium	2	1487.7	743.9	21.44**
Boron	2	56.1	28.1	.81
K x Ca	4	1801.1	450.3	12.98**
K x Mg	4	287.3	71.8	2.07
K x B	4	235.0	58.8	1.69
Ca x Mg	4	1366.0	341.5	9.84**
Ca x B	4	106.7	26.7	.77
Mg x B	4	32.6	8.2	.24
Rows	8	400.2	50.0	1.44
Columns	8	372.7	46.6	1.34
Error	31	1075.6	34.7	
Total	79	78618.9		

APPENDIX TABLE 30. Analysis of Variance on the Magnesium Content of the Leaves of Cantaloupe Plants Sampled September 1-10, 1947, (Experiment II).

Source	D/F	Sum Squares	Variance	F
Potassium	2	73.74	36.87	5.69**
Calcium	2	140.14	70.07	10.81**
Magnesium	2	3726.31	1863.16	287.52**
Boron	2	17.98	8.99	1.39
K x Ca	4	144.94	36.24	5.59**
K x Mg	4	52.55	13.14	2.03
K x B	4	20.21	5.05	.78
Ca x Mg	4	115.57	28.89	4.46**
Ca x B	4	16.64	4.14	.64
Mg x B	4	19.06	4.77	.74
Rows	8	47.04	5.88	.91
Columns	8	67.88	8.49	1.31
Error	31	200.95	6.48	
Total	79	4643.01		

APPENDIX TABLE 31. Analysis of Variance on the Boron Content of the Leaves of Cantaloupe Plants Sampled September 1-10, 1947, (Experiment II).

Source	D/F	Sum Squares	Variance	F
Potassium	2	43104	21552	6.33**
Calcium	2	33888	16944	4.97*
Magnesium	2	16835	8418	2.47
Boron	2	1934540	967270	283.91**
K x Ca	4	16545	4136	1.21
K x Mg	4	12899	3225	.95
K x B	4	73477	18369	5.39**
Ca x Mg	4	6945	1736	.51
Ca x B	4	38852	9713	2.85*
Mg x B	4	126424	31606	9.28**
Rows	8	17699	2212	.65
Columns	8	34067	4258	1.25
Error	30	102221	3407	
Total	78	2457496		

APPENDIX TABLE 32. Analysis of Variance on the Nitrogen Content of the Leaves of Cantaloupe Plants Sampled September 1-10, 1947, (Experiment II).

Source	D/F	Sum Squares	Variance	F
Potassium	2	409.98	204.99	38.82**
Calcium	2	173.98	86.99	16.48**
Magnesium	2	332.14	166.07	31.45**
Boron	2	17.80	8.90	1.69
K x Ca	4	144.18	36.04	6.83**
K x Mg	4	274.40	68.60	12.99**
K x B	4	32.18	8.05	1.52
Ca x Mg	4	121.30	30.33	5.74**
Ca x B	4	51.71	12.93	2.45
Mg x B	4	24.08	6.02	1.14
Rows	8	36.03	4.50	.85
Columns	8	90.35	11.29	2.14
Error	30	158.42	5.28	
Total	78	1866.55		

APPENDIX TABLE 33. Analysis of Variance on the Phosphorus Content of the Leaves of Cantaloupe Plants Sampled September 1-10, 1947, (Experiment II).

Source	D/F	Sum Squares	Variance	F
Potassium	2	9.0560	4.5280	74.84**
Calcium	2	.8315	.4158	6.87**
Magnesium	2	3.7866	1.8933	31.29**
Boron	2	.0843	.0422	.70
K x Ca	4	4.3588	1.0897	18.01**
K x Mg	4	4.9724	1.2431	20.55**
K x B	4	.3359	.0840	1.39
Ca x Mg	4	2.4610	.6153	10.17**
Ca x B	4	.3573	.0993	1.64
Mg x B	4	.3506	.0977	1.61
K x Ca x Mg	4	5.2275	1.3069	21.60**
Rows	8	1.2160	.1520	2.51*
Columns	8	1.2340	.1543	2.55*
Error	27	1.6334	.0605	
Total	79	35.9053		

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1. Stark, F. C. and C. H. Mahoney. A study of the time of development of the fibrous sheath in the sidewall of edible snap bean pods with respect to quality. Proc. Amer. Soc. Hort. Sci. 41:353-359. 1942.

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8. Stark, F. C. and I. C. Haut. Growing sweet corn for canning. (In press).

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