INFLUENCE OF NITROGEN, PHOSPHORUS, POTASH AND LIME ON THE GROWTH AND YIELD OF STRAWBERRIES

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Little information is available on the influence of various fertilizer and liming materials on the growth and yield of strawberries as grown under Florida conditions. Brooks and Nolen (1935) stated that liming of low pH soils was beneficial in the central Florida area with the optimum pH being about 5.5. Matlock (1954) reviewed much of the research which has been done on the fertilizer and lime requirements of strawberries. Most of the previous studies have been conducted in other areas of the country and the results do not have specific application to Florida conditions since the cultural system in use in Florida is entirely different.

A pot experiment was conducted during the 1955-56 season to determine the influence of the major elements and lime on the growth and yield of strawberries. The object of the experiment was to obtain information that could be used as an aid in planning field-scale fertility experiments.

METHODS

The materials, rates in pounds per acre, and sources used were as follows:

Material	*Rate*	*Source*
Nitrogen	0, 50, 100	Ammonium nitrate
Phosphorus (P_2O_5)	0, 80, 160	Treble superphosphate
Potash	0, 70, 140	Muriate of potash
Lime	0, 1200, 2400	Calcium hydroxide

Two soil types were used: (1) a virgin Ona fine sand from the Horticultural Unit farm at Gainesville; (2) a Blanton fine sand from the Starke area that had been cropped for many years to vegetables and strawberries.

Each soil was screened, fumigated with methyl bromide, and turned three times. The fertilizer and liming materials were uniformly mixed with the soil. The soil was prepared during August and stored in the pots under cover until planting. The soil was moistened occasionally during the storage period but not enough to cause leaching.

The pots were placed on the ground out-of-doors and the plants set in them on October 6. Tap water was used for watering as required.

The experimental unit consisted of a single Florida 90 plant in a 10-inch clay pot containing 22 pounds of soil. A 3 X 3 X 3 X 3 X 2 factorial with three replications was used in a randomized block design.

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RESULTS AND DISCUSSION

Change in Soil pH

A composite soil sample was obtained May 2 by taking a 6-inch core from each pot for each lime rate in each replication. The applications of lime were effective in raising the pH (Table 1) of both soils, with the increase being greater the higher the rate of application of lime. The pH of the soil in the pots that did not receive lime increased approximately one-half unit during the course of the experiment and could have been caused by bases carried in the tap water.

Table 1.- The pH of Composite Soil Samples Taken on May 2, 1956

Rate of $Ca(OH)_2$	Replication	Ona Soil	Blanton Soil
0	1	5.40	5.85
	2	5.41	5.89
	3	5.48	5.87
1200	1	5.77	6.75
	2	5.82	6.89
	3	5.81	6.75
2400	1	6.21	7.23
	2	6.45	7.45
	3	6.29	7.21

Plant Growth

The ratings of the growth of the plants were not analyzed statistically, but some indications of the influence of the various materials can be noted (Table 2). Growth ratings were made at four times during the growing period, using a scale of one to five with one

The Soil Testing Laboratory reported the soils tested as follows:

Soil	pH	Pounds per Acre				
		CaO	MgO	P_2O_5	K_2O	NO_3
Ona	4.90	280	117	7	36	Very low
Blanton	5.45	575	67	34	187	Very low

indicating the poorest growth and five the best.

Nitrogen.—On the Ona soil, the plants receiving the 100 pounds per acre of nitrogen were larger than those receiving the 60 or 0 pounds per acre. There was no difference in growth of the plants receiving the two lower rates. On the Blanton soil, applications of nitrogen showed little effect until the last rating (2-20-56) when the plants growing in the soil which had received 100 or 50 pound rates of nitrogen were larger than when no nitrogen was applied.

Table 2.- Influence of N, P_2O_5, K_2O and Lime on the Growth of Strawberries.

Figures are the sum of ratings. Plants were scored with 1 = poorest and 5 = best growth.

Date	Ona Soil			Blanton Soil		
	N_o	N_1	N_2	N_o	N_1	N_2
12-7-55	167	176	196	222	213	229
12-20-55	154	153	182	222	208	227
1-27-56	134	130	156	205	205	218
2-20-56	167	169	188	210	218	240
	P_o	P_1	P_2	P_o	P_1	P_2
12-7-55	169	182	188	228	216	220
12-20-55	145	164	180	231	210	216
1-27-56	122	140	158	218	201	209
2-20-56	151	180	193	224	219	225
	K_o	K_1	K_2	K_o	K_1	K_2
12-7-55	183	177	179	224	218	222
12-20-55	165	160	164	222	217	218
1-27-56	140	142	138	214	206	208
2-20-56	173	175	176	226	224	218
	L_o	L_1	L_2	L_o	L_1	L_2
12-7-55	131	208	200	240	206	218
12-20-55	112	203	174	240	207	210
1-27-56	96	178	146	237	195	196
2-20-56	138	215	171	275	201	192

These results indicate that the previously cropped Blanton soil contained sufficient available nitrogen for good plant growth during the first four months of growth, whereas the virgin Ona soil was deficient in available nitrogen throughout the growing period.

Phosphorus.—The growth was increased by applications of phosphorus on the Ona soil but not on the Blanton soil. On the Blanton soil apparently there was sufficient residual phosphorus from previous fertilizer applications to maintain maximum growth of the plants.

Potash.—There was no effect of potash on plant growth on either soil.

Lime.—On the Ona soil, which had a pH of 4.90 at the start of the experiment, 1200 and 2400 pounds per acre of calcium hydroxide increased the growth compared with plants in pots receiving no lime. The plants in the soil which received the 1200 pound rate of lime grew better than those in the soil with the 2400 pound rate. On the Blanton soil, which had an initial pH of 5.45, plant growth was poorer with the 1200 or 2400 pound applications of lime than with no lime.

These results indicate that lime is beneficial when the pH of the soil is low but that overliming can be detrimental.

Fruit Yield

Twelve harvests of berries were made from February 27 to April 26. The analysis of variance for the main effects and the first order interactions are given in Table 5. The second and third order interactions were not significant and so for brevity are omitted from the table.

Nitrogen.—The average yield in grams for the 0, 50 and 100 pound rates of application to the soil were 34.39, 32.94, and 39.83 respectively. The L.S.D. required for the 0.05 level was 3.99 and for the 0.01 level 5.25. The yield increase by the 100 pound rate over the zero and 50 pound rates was highly significant. There was no difference in yield between the zero and 50 pound rates. Whether the 50 pound rate of application was too low to give a measurable response or whether another factor not controlled in this experiment was interacting with nitrogen cannot be determined from the results obtained.

Potash.—Yields were not affected by applications of potash. The average yield in grams for the 0, 70, and 140 pound applications were 37.80, 34.82 and 34.54 respectively. The lack of response to potash was unexpected, especially on the Ona soil which was low in potash. However, these yield responses are consistent with the work of Lineberry and Collins (1942) in which they obtained no response to potash in three out of four experiments.

Phosphorus. — The phosphorus-soil interaction was highly significant (Table 3). On the Ona soil, the application of either 80 or 160 pounds of P_2O_5 increased the yield of berries as compared with no addition of phosphorus to this soil type. There was no difference in yield with the 80 or 160 pound rates of P_2O_5. On the Blanton soil, the application of phosphorus did not influence the yield (Table 4). These results agree with the soil test. The plants on the Ona soil, which was low in P_2O_5, responded to phosphorus applications, whereas plants on the Blanton soil, which was higher in P_2O_5, did not.

Lime.—The lime-soil interaction was highly significant (Table 3). On the low pH Ona soil, the yield was significantly increased by the application of either 1200 or 2400 pounds of lime, but the 1200 pound rate of calcium hydroxide yielded significantly more than the 2400 pound rate (Table 5). On the Blanton soil, which had a higher pH, both the application of either 1200 or 2400 pounds of lime reduced the yield significantly. There was no difference in yield between the 1200 and 2400 pound rates. These results indicate that there is a distinct danger of overliming a soil for strawberries, but that an increase in yield may be expected if a low pH soil is properly limed.

Summary

A pot experiment was conducted to study the growth and yield of strawberries as influenced by nitrogen, phosphorus, potash and lime factorially compared on two soil types.

Table 3.— Partial Analysis of Variance of Strawberry Yields from Strawberry Factorial. 1956.

Source of Variation	Degrees of Freedom	Mean Square	F Value
Total	485	-	
Blocks	2	5,888	17.68**
Nitrogen	2	2,141	6.43**
Phosphorus	2	836	2.51
Potash	2	529	1.59
Lime	2	2,835	8.51**
Soil	1	50,110	150.48**
Nitrogen-phosphorus	4	547	1.64
Nitrogen-potash	4	236	0.71
Nitrogen-lime	4	666	2.00
Nitrogen-soil	2	504	1.51
Phosphorus-potash	4	116	0.35
Phosphorus-lime	4	57	0.17
Phosphorus-soil	2	1,866	5.60**
Potash-lime	4	91	0.27
Potash-soil	2	62	0.19
Lime-soil	2	23,582	70.81**
Error	322	333	

** Indicates the F valuo is significant at the 0.01 level.

Table 4.— Interaction Effect of Phosphorus and Soil Type on the Average Yield in Grams of Strawberries. 1956.

Soil type	Pounds per acre of P_2O_5: 0	80	160	Average for soil type
Ona	19.20	27.48	30.02	25.56
Blanton	47.18	45.30	45.14	45.87
Average for P_2O_5	33.19	36.39	37.58	

L. S. D. for interaction 0.05 level = 5.64

0.01 level = 7.43

Table 5. Interaction Effect of Lime and Soil Type on the Average Yield in Grams of Strawberries. 1956.

Soil type	Pounds per acre of $Ca(OH)_2$: 0	1200	2400	Average for soil type
Ona	13.88	37.93	24.88	25.56
Blanton	61.36	39.30	36.96	45.87
Average for $Ca(OH)_2$	37.62	38.62	30.92	

L. S. D. for interaction 0.05 level = 5.64

0.01 level = 7.43

One soil type was a virgin Ona soil and the other a Blanton soil which had been cropped for a number of years. Both soils were fumigated with methyl bromide prior to setting the plants.

The 100 pound rate of nitrogen yielded significantly more fruit and produced larger plants then the zero or 50 pound rates. There was no difference in yield or plant growth between the zero and 50 pound rates.

On the Ona soil, the yield was significantly increased and larger plants were produced by applications of 80 or 160 pounds of P_2O_5. There was no difference in yield or plant growth between the 80 or 160 pounds on the Ona soil. The P_2O_5 applications on the Blanton soil had no influence on yield or plant growth.

There was no yield or growth response to 70 or 140 pounds or potash on either soil.

On the Ona soil, which had a low pH, 1200 or 2400 pounds of calcium hydroxide increased the yield and growth as compared to no lime. The yield and plant growth were larger for the 1200 pound rate than for the 2400 pound rate. On the Blanton soil, both lime applications reduced the yield and growth. There was no difference in yield or plant growth between the two rates.

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LIME-INDUCED MANGANESE DEFICIENCY OF STRAWBERRIES

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A chlorosis was noted on the leaves of strawberry plants growing in two fields in the Starke area during the 1955-56 season. The chlorosis was most severe on the lower leaves. These leaves were usually a dark yellow with only the veins remaining green. The upper leaves were less chlorotic with the youngest leaves nearly a normal green. These symptoms appeared to be typical of those described by Lott (1946) for manganese deficiency. The fact that the soil in each field had been limed during the summer prior to planting also pointed to manganese deficiency as the cause of the chlorosis. Besides being chlorotic, the plants were generally stunted in growth.

The chlorosis and stunting were not general throughout the fields but were found in irregular areas. Many of these areas coincided with lighter colored phases of the soil or with slightly higher elevations.

A study was made of the relationship between the soil pH, the manganese content of the leaves of the plants, and the visual appearance of the plants. Samples for analyses were taken of both the plant leaves and the soil in the area in which the plants were growing.

Methods

Soil and leaf samples were taken from each of the fields on January 11, 1956. The lower leaves of a number of plants growing in the same area constituted a single sample. A corresponding soil sample was obtained for each foliage sample by compositing a number of cores taken throughout the same area. The predominating soil type of one field was Rex fine sand and of the other Blanton fine sand, shallow phase.

Twelve samples were taken from each field. Six soil and six foliage samples in each field were obtained from areas showing severe chlorosis and the other six samples were taken from the normal or near-normal appearing areas in the field.

The leaves were washed by tap water to remove soil particles before drying in a forced draft oven at 70° C.

Manganese was determined by the official A.O.A.C. method (1955). The pH of the soil samples was determined as outlined by Volk (1944).

Results

On both soil types moderate or severe chlorosis of the leaves was associated with a soil pH of 6.60 or higher and a manganese content of 16 ppm or less on a dry weight basis (Table 1). In the pH range of 5.90 to 6.30 there was no chlorosis or only slight chlorosis and the manganese content ranged from 20 to 64 ppm. In the pH range of 5.10 to 5.30 there was no chlorosis and the manganese content ranged from 94 to 222 ppm.

These results indicate that severe manganese deficiency of strawberries would be expected in such soils in the Starke area when they are limed to pH levels above 6.5. Slight manganese deficiency could be expected if the soil pH is in the range of 6.0 to 6.5.

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