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FERTILIZER STUDIES WITH PINEAPPLES IN PUERTO RICO

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INTRODUCTION

The pineapple growers of Puerto Rico claim that with Red Spanish pineapples planted from native stock the yearly fruit and slip productions gradually decrease. They attribute the production decrease to a "run-down" or degeneration of the stock. It is an observed fact that if Cuban slips are planted beside native grown slips on Puerto Rican soil the former show a considerably greater vigor from the very start and will outyield by an appreciable extent the Puerto Rican stock; yet the present grown native stock originally came from Cuba. It has been observed also that Cuban stock brought in only a few years ago shows signs of degeneracy through poorer vigor and yields.

Since only vegetative propagation through slips and suckers (see figure 1) is used it would be difficult to account for the degeneration on a genetic basis. No degenerative disease such as a mosaic seems to be present. It seems that some nutritional derangement gradually decreases the vigor of the plants; perhaps a minor element deficiency. This nutritional derangement might have arisen through a chemical or physical change in the soil due to fertilizer practices or to faulty crop rotation. Indeed, it is claimed that on virgin soil the falling off in yields for Cuban slips is not so rapid as on soil which has been used several years in pineapple production.

In order to investigate the nutritional aspect of the problem two field experiments were set up in September 1939. The one field was near

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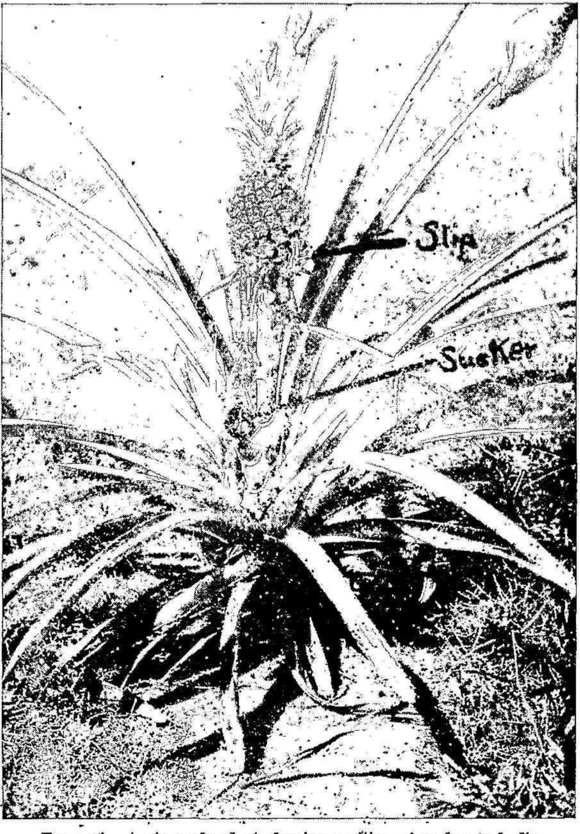

FIGURE 1. *A pineapple plant showing position of sucker and slip.*

Manatí and was of a reddish Bayamón Fine Sandy Loam. In this field crop rotation was practiced and it presumably was in excellent shape for a pineapple crop. The other field was near Río Piedras, commonly called the Laguna field because of the nearness to a lagoon and was of a Sabana Seca Sandy Clay Loam. This field was considered unfit for a new pineapple planting because the preceding crop had been pineapples.

The Laguna field was limed with finely ground calcium carbonate at the rate of 2 tons per acre before planting. It was planted on a 3-row bank system. The Manatí field was not limed and a 2-row bank system was used. Fifteen plants were used in each row of a plot to make up a single replicate treatment and two plants were used as border plants between plots. Thus in the Laguna plots 45 plants and in the Manatí plots 30 plants were used for each replicate treatment. The spacing between banks and plants was such that the Laguna field had 10,900 plants per acre, while the Manatí field had 9,650. Slips were used in each case for planting. The fields were planted by the growers, then turned over to the author for selection of the layout and fertilizer applications.

The fertilizer treatments used in both fields were the same except for treatments 10 and 17. For the Laguna field these treatments are given in Table 1, column 2. The full nutrient plots had nitrogen equivalent to 390 lbs. NH_3 (added in the form of ammonium and nitrate compounds, so that the equivalent weight ratio, NH_3 to NO_3 was 1:3); 280 lbs. K_2O; and 170 lbs. P_2O_5 fertilizer per acre for the crop. The growers' formulas (treatment 17) differed very slightly from the full nutrient in the amounts of fertilizers used except that in the former all the nitrogen added was from ammonium sulfate in both experiments. Treatment 10 in the Laguna field consisted of single minor elements plus full nutrient while in the Manatí field lime ($Ca\ CO_3$) at the rate of 4 tons per acre was added to the plots receiving also full nutrient. The minor elements Mn, Cu, Fe, and Zn were added at the rate of 25 lbs. per acre as the respective sulfate. Aluminum sulfate was added 10 lbs. per acre and boron as borax, 5 lbs. per acre. The fertilizers were added to the plots in four equal portions, the first early in September 1939, the second early February 1940, the third early June 1940, and the last early November 1940. They were mixed in the laboratory from the individual salts. The amounts for each of the eight replicates of a treatment were put into individual paper bags so that the field workers could apply the fertilizers without error.

The Laguna field was "smoked" with a carbide treatment to force

TABLE 1. *Yield of fruit and slips from plants grown under different fertilizer conditions on the Laguna Farm.*

TREATMENT NUMBERS	TREATMENTS FOR REPLICATED PLOTS	AV. NO. SLIPS PER PLANT	POUNDS WEIGHT OF FRUITS* FROM RESPECTIVE PLOTS IN BANKS								YIELDS OF FRUITS IN TONS PER ACRE	SIGNIFICANCE** OF YIELDS "BETTER THAN"
			1	2	3	4	5	6	7	8		
1	Check (no fertilizer)	0.75	69.8	74.9	63.0	77.7	89.0	54.9	65.1	78.5	8.65	
2	Full nutrient (FN)	2.70	117.1	123.8	125.4	108.1	156.1	130.4	118.4	123.5	15.21	4,3,1
3	FN except no N	1.60	102.9	118.3	94.9	92.1	94.3	105.3	99.0	112.9	12.38	1
4	FN except no K	2.05	123.6	117.4	104.0	96.8	104.9	86.4	116.0	83.4	12.58	1
5	FN except no P	2.76	91.6	127.7	110.5	108.0	125.9	144.5	136.9	119.3	14.56	4,3,1
6	FN except double N	3.32	161.4	127.5	141.9	140.9	122.0	102.9	155.6	131.9	16.40	5,16,15,13,4,3,1
7	FN except double K	2.94	119.5	148.3	130.0	108.5	146.5	130.1	122.7	124.4	15.59	4,3,1
8	FN except double P	2.72	137.1	149.5	112.1	89.0	129.6	140.1	130.8	118.9	15.22	4,3,1
9	FN plus 2 T. lime x	2.90	133.9	118.8	121.9	101.3	137.3	139.8	145.7	129.3	15.52	4,3,1
10	FN plus minor elements as shown in Fig. 3	2.72	147.5	117.4	111.7	113.3	114.2	149.5	145.6	113.8	15.32	4,3,1
11	FN plus 25 lbs. MgO x	3.15	130.0	131.8	110.4	125.1	153.4	143.4	138.8	117.1	15.90	13,4,3,1
12	FN plus 100 lbs. MgO x	2.96	125.3	112.4	130.8	125.3	148.8	106.5	135.5	139.4	15.50	4,3,1
13	FN plus ½ T. sulfur x	2.67	128.2	144.3	124.4	85.1	133.3	101.0	112.1	101.0	14.02	1
14	FN plus Mn and Al	3.02	139.1	138.2	122.1	108.5	157.2	125.9	134.2	122.7	15.81	13,4,3,1
15	FN plus B and Cu	2.68	133.7	112.3	122.5	117.1	96.2	113.9	134.1	105.3	14.12	1
16	FN plus Fe and Zn	2.53	121.0	109.4	114.1	113.1	137.1	126.7	102.1	123.0	14.30	3,1
17	Growers' formula	2.59	123.2	122.2	117.6	117.3	122.6	133.6	132.1	113.8	14.82	4,3,1

* The fruits were picked in the "shipping-green" stage, which is approximately two weeks before the plant ripened stage.

** The author is indebted to Dr, G. A. Lebedeff for making these statistical analyses.

x Per acre.

FIGURE 2. *Method of weighing individual fruits in the field.*

early fruiting, the Manatí field was not. This treatment consisted in applying to the crown of the plant a small quantity of a solution made by adding 2 ounces of calcium carbide to 5 gallons of water in a closed tank.

The Manatí field was sprayed with an iron sulfate solution two times prior to fruiting to overcome a chlorotic condition of the plants. The Laguna field did not turn yellow prior to fruiting and was not sprayed with iron sulfate. However, as will be mentioned later, the plants in the Laguna field turned quite yellow following a dry spell during January and February.

Because of the nearness of the Laguna field to the Experiment Station and the fine cooperation of the manager and field foreman there, this experiment was given the more careful study. The two experiments will be taken up separately and the results compared in the discussion.

THE LAGUNA EXPERIMENT

This experiment was laid out according to a randomized plan illustrated in Figure 3, right side. It is to be noted that each of the eight banks has all seventeen treatments, making eight replications.

In order to make possible the weighing of individual fruits so that correlations between yield of fruit and slip production could be made the plants were "smoked" All the plants that were "smoked" on a certain day matured to the "shipping green" or picking stage on the same day about 21 weeks later regardless of fertilizer treatment or eventual size of fruit. The plants of banks 1 and 5 (see Figure 3) were "smoked" on October 1, 1940; banks 2 and 6 on October 17; banks 3 and 7 on November 13; and banks 4 and 8 on December 3. The harvesting dates of the respective banks in the same order as given above were February 24, March 10, April 7, and April 21.

A brief description of the appearance of the plants during the experiment is valuable in explaining the results. After about one year of growth the plants of the checks and minus nitrogen plots were light green in color and smaller than average in size. The minus potash plants were green but smaller than average. The double nitrogen and added magnesium plants were greener and larger than average. The minus phosphorus plants were normal and had as good, or a better appearance than those receiving double phosphorus. There was no obvious difference between the sulfured and limed plots which were normal, as were all the remaining.

There was a prolonged dry spell during the late period of development of the fruits of banks 1 and 5, i.e., during January and February. During this dry spell all the plants of the experimental field turned yellowish. The dry spell was broken just after the harvesting of banks 1 and 5, but the subsequent moist conditions did not bring the plants back to their former green color.

The Effect of the Different Treatments on Yields of Fruits

Since yield of fruit is the most important phase of this work from the growers viewpoint, a careful study of it was made. With only 2 banks (6 rows) of pineapples maturing at a time the weights of individual fruits could be taken and recorded. The method of weighing with an accurate spring balance set up in the field is shown in Figure 2. Adequate field help made possible the harvesting of two banks of maturing "pines" in the same day. The summarized yields are given in Table 1. The summarized yields instead of weights of individual fruits are given to conserve space. Fertilizer application increased the sizes of fruits from the best and weakest plants to about the same extent. For example, plants of treatment 6 in bank 2 had fruits ranging between 4 lbs., 0 oz. to 1 lb., 13

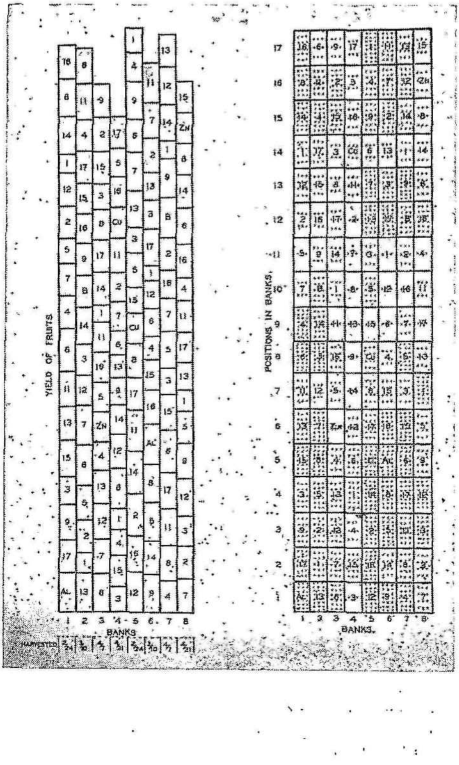

FIGURE 3. *Relative yields of the different replicated plots in the Laguna field.*
Left side—*The actual yield of fruits from the respective plots shown proportionally. The longer rectangles represent the greatest plot yields and the shortest the least.*
Right side—*The relative yields from the best to the poorest from plots receiving the same treatment. One set of dots (three dots) indicates the poorest, while eight sets indicate the best plot for any treatment in question.*

oz. while those of treatment 1 of the same bank ranged between 2 lbs., 13 oz. to 0 lb., 7 oz. In some of the best plots there were a few fruits weighing over 5 lbs. each.

Several points should be observed from the data in Table 1: (1) the checks yielded far poorer than any of the other treatments especially the full nutrient treatments; (2) the plots lacking nitrogen and potash yielded significantly lower than those receiving same in 11 out of 14 cases, while the lack of phosphate did not greatly decrease the yield; (3) the high nitrogen and added magnesium increased the yields slightly above those of full nutrient; (4) the addition of nitrogen as nitrate or ammonia (treatments 2 and 17) did not affect the yield differently in this field; (5) the limed plots tended to yield better than the sulfured plots; (6) none of the minor elements used seem to cause significant yield increases. The relative yields of all the replicated plots are shown graphically on the left side of Figure 3.

A striking observation that can be made on Figure 3 is that the yields from the first harvest (i.e. from the youngest plants) were better than those of the later harvestings. This fact is still more striking since the plants harvested after February 24 had some favorable moisture conditions while those harvested on that date had dry weather throughout most of the period of fruit development. An explanation of this behavior will be given in the discussion.

The right side diagram of Figure 3 shows to some degree of accuracy the fertility layout of the experimental field. It can be seen that the central part of the field had the poorest fertility or growing conditions. In this poor area of the field "buckshots" or small lumps of hard rock could be found. According to Dr. J. A. Bonnet of the Soils Division, these probably were of an iron and manganese phosphate composition. The reason that banks 3 and 4 yielded poorer than 7 and 8 probably lies in the fact that more of the plots of 3 and 4 lay in the poor soil area.

It is commonly believed among growers that a large plant with a thick flower stalk will yield a large fruit and that these measurements can be used to predict the size of the subsequent fruit. This estimation is theoretically sound because a large flower stalk is capable of a greater storage of food for fruit production. However, this estimation did not hold completely in this experiment when plots from one harvesting period were compared with plots of a later harvesting. This can be seen in Figure 4. The plot shown in A was poorest and gave the poorest yield. However, plot C which had the best appearance did not produce the best

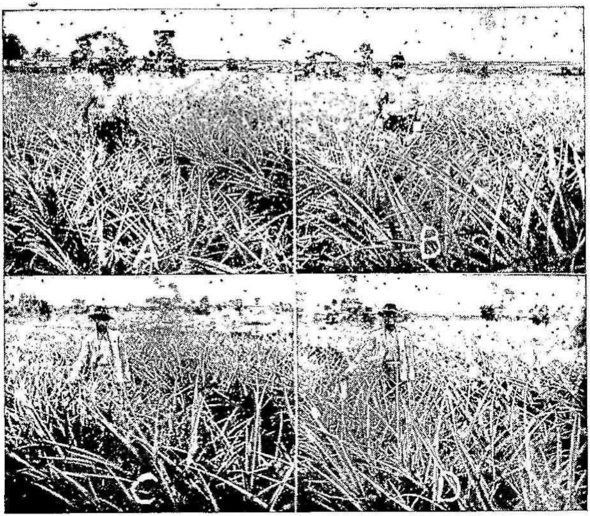

FIGURE 4. *Relation between size of plants and yield of fruit. Observe height of plants by comparing with waist-line of man. The relative order of yielding capacity according to height of plants and diameter of flower stalks was C, B, D, A. The actual yields were:*
B - treatment 6 bank 1 yielded 161.4 lbs. fruit
C - treatment 17 bank 6 yielded 133.6 lbs. fruit
D - treatment 3 bank 6 yielded 105.3 lbs. fruit
A - treatment 1 bank 1 yielded 69.8 lbs. fruit

yield. It is probable that in the same field with the same treatments given to each plant the relative sizes of the fruits can be predicted fairly accurately by the relative measurements of plant and flower stalk size. This is in agreement with the observations of Henricksen (1927).

THE EFFECT OF THE DIFFERENT TREATMENTS ON THE YIELD OF SLIPS

The summarized results of the numbers of slips produced by plants given different fertilizer treatments are given in table 1, column 3. These data show a striking positive correlation between yield of fruit and the number of slips produced. In other words the plants that produced the largest fruits tended to produce the greatest number of slips. The lack of vigorous slips is one of the factors limiting pineapple production in Puerto Rico. Consequently it is of special interest to know that if the yield of fruit can be increased the slip production will be improved at the same time.

Effect of the Different Treatments on Quality of Fruit

Chemical analysis for sugars and acids were made of fruits from some of the plots. The methods of analysis were the same as those described in a former publication (Schappelle: 1941). The fruits were picked in the shipping green stage and stored in the laboratory until ripened. Expressed juice from the ripened fruit was used for the analysis. The results are given in Table 2. For each determination given,

TABLE 2. *Quality of fruit from plants grown under different fertilizer conditions on the Laguna farm.*

TREATMENT NUMBER	TREATMENT	ACIDITY OF JUICE* AS PER CENT CITRIC ACID	TOTAL SUGARS IN JUICE* AS PER CENT GLUCOSE	TASTE
1	No fertilizer	0.522	9.1	fair
2	Full nutrient (F. N.)	0.670	9.6	good
3	F. N. except no N.	0.705	9.3	good
4	F. N. except no K.	0.517	8.8	poor
5	F. N. except no P.	0.671	9.3	good
6	F. N. except double N.	0.619	9.1	good
7	F. N. except double K.	0.735	9.7	excellent
8	F. N. except double P.	0.630	8.8	good
12	F. N. plus 100 lbs. MgO	0.735	9.5	excellent

* Average value of 30 fruits.

the average analyses of 30 fruits were used; taken on each of the last three harvestings. At each harvesting 10 fruits (5 from each replicate plot) constituted the sample, but a separate analysis was made of each individual fruit.

The most significant observation from this study is that the plants grown in the absence of potash produced a poor quality fruit. This poor quality is due to lower concentration of both sugars and acids compared to that of normal fruit. The poor quality of the minus potash fruits could readily be detected by a taste test.

A study of the keeping qualities of fruits grown under different fertilizer treatments was also made using the same fruits as were used in the quality study. There was no observable difference in the lots studied. The high nitrogen or any other treatment did not produce a "soft" fruit which deteriorated sooner than the others.

THE EFFECT OF DIFFERENT TREATMENTS ON GUMMOSIS OF THE FRUITS

Gum formation in fruits is an important factor in reducing the value of fruits from certain sections of Puerto Rico. The cause of the gummosis is unknown at the present time. A study of the gumming tendency of fruits grown under the different fertilizer treatments was made. A trace of gummosis was found in a few fruits from each of the treatments, but no definite trend could be seen. Consequently, it was concluded that gummosis was not caused (directly at least) by fertilizer treatments.

Gummosis could be effected by applying certain toxic salts to the surface of the fruits. Five per cent solutions of $AgNO_3$, $SnCl_2$, $BaCl_2$, $Fe_2(SO_4)_3$, $CuSO_4$, $HgCl_2$, and $PbCl_2$ were applied in narrow streaks with a brush. The salts causing the greatest injury and gummosis were those of Hg, Ag, Fe, and Cu in the order given. The other salts showed no toxic effects on the fruits.

THE EFFECT OF DIFFERENT TREATMENTS ON "MACHO" PRODUCTION

In pineapple fields there usually appear abnormal plants known commonly as "machos" or male plants. Usually the "machos" produce an abundance of slips and an aborted and irregular shaped fruit with or without a crown. It is worthless for marketing. The numbers of "machos" in the different plots were tabulated but the results showed no relation between fertilizer treatment and "macho" production. There was some indication, however, that the "macho" tendency was genetic in nature.

THE MANATI EXPERIMENT

This experiment was laid out according to the same randomized plan as that of the Laguna field except that the banks were 8 plots long and there were 17 banks. If the diagram shown on the right side of Figure 3 is turned clockwise 90 degrees the arrangement of the plots is obtained. This arrangement was used to secure a more uniform experimental area in this particular field.

Twice during the growing season the plants became yellowish in appearance and were sprayed each time with an iron sulfate solution. It was quite noticeable that the plots of treatment 17 had the largest and greenest plants throughout the entire growing period. These plots received only ammonium nitrogen but otherwise received about the same amounts of fertilizer as those of treatment No. 2.

The plants in this field were not forced into early bloom consequently the fruits did not mature to the shipping green stage at the same time. The entire experimental field was harvested at weekly intervals beginning on April 23 through May 20, 1941 when observations were discontinued. Instead of weighing individual fruits as before the fruits of shipping green maturity from each respective plot were weighed together. This meant 17 times 8 or 136 weighings at each harvesting period. No record of slip production was made in this field, but observations showed a similar correlation between fruit weight and number of slips per plant as was seen in the Laguna experiment.

The Relation Between Size of Fruit and Earliness of Maturity Under Natural Conditions

The plants in the Manatí field were allowed to flower and mature under natural conditions. The fruits matured to the shipping green stage at different dates throughout a period of about 2 months. Instead of the first matured fruits (i.e. from the youngest plants) being the smallest the reverse was true. This can be seen in figure 5 where the results of two of the best and two of the poorest fertilizer treatments are shown. Apparently with pineapple the strongest and most vigorous plants have a tendency to mature first. This behavior had been observed previously by the growers in commercial fields but as far as the author is aware no measurement had been made previously to determine the actual magnitude of the size decrease.

The Effect of Different Treatments on the Yield of Fruit in the Manatí Field

Since all the fruits had not matured to the shipping green stage when observations were discontinued, May 20, estimations on the weights of the unharvested fruits had to be made in order to obtain yield values in tons per acre. The estimated yields were obtained by multiplying the average weights per fruit harvested on May 20 from the respective treatments by the total number of unharvested fruits of the same treatment.

The records are given together with the yield data of the harvested fruits in table 3. The method of calculation for weights of unharvested fruits probably gives yield values somewhat higher than they probably would be in light of the relations shown in Figure 5. However, there is no great error introduced between treatments because the number of unharvested fruits did not vary much from the average of 47 fruits, except perhaps for treatments 1 and 3. The calculated yield of the unharvested fruits from these two treatments can be considered as comparatively too high.

The most important observations that can be made from the data in table 3 are: (1) the relatively small difference between the check yields and those of the other treatments indicating that the field was fairly fertile; (2) the grower's formula (treatment 17) using only ammonia nitrogen was better than that where double nitrogen, (treatment 6) was used (but where both nitrate and ammonia nitrogen was applied); (3) the yields in general were poorer than those of the Laguna field (compare with Table 1); (4) the application of phosphate had little or no value for increasing yield; (5) the application of lime tended to increase the yield above that obtained from the sulfur applications.

DISCUSSION

The original plan was to perform the two experiments as nearly alike as possible but several factors of difference entered in. Some of these differences were due to the fact that the growers did all the work of planting, cultivating, and harvesting and followed their individual methods in general. However, the most essential factor of the experiment, that of the amount and type of fertilizer added, could be kept constant.

One of the striking results of the experiments was that the Laguna field in spite of its "worn-out" soil outyielded the Manatí field which was apparently in good condition for a pineapple crop from the standpoint of fertility. This is evidenced by the fact that the check plots at Manatí gave fair yields compared to the plots receiving full nutrient while in the Laguna field the checks had poor yields compared to the full nutrient plots.

A second significant result was that in the Laguna field the yields of the first harvested banks (i.e. from the youngest plants) were greater than from those harvested later. The plants in the Laguna field were "forced" into bloom so that the normal fruiting behavior as illustrated in Figure 5 did not account for this.

TABLE 3. *Yield of fruit from plants grown under different fertilizer treatments on the Manati farm.*

TREATMENT NUMBER	TREATMENT	FRUITS HARVESTED BY 5/20/41	FRUITS NOT HARVESTED BY 5/20/41	WEIGHT OF HARVESTED FRUITS	AVERAGE WT. PER FRUIT HARVESTED ON 5/20/41	TOTAL WT. OF FRUITS NOT HARVESTED BY 5/20/41*	TOTAL WT. OF HARVESTED AND UNHARVESTED FRUITS	YIELD IN TONS PER ACRE
				(lbs.)	(lbs.)	(lbs.)	(lbs.)	
1	Check	160	80	349.8	1.68	135.0	484.8	9.7
2	Full Nutrient	189	51	464.0	2.06	105.0	569.0	11.4
3	F. N. minus N	169	71	405.4	1.92	136.0	541.4	10.9
4	F. N. minus K	181	59	429.8	1.85	109.0	538.8	10.8
5	F. N. minus P_2O_5	197	43	514.6	2.06	88.5	603.1	12.1
6	F. N. plus double N	197	43	500.1	2.00	86.0	586.1	11.8
7	F. N. plus double K	198	42	499.5	2.07	87.0	586.5	11.8
8	F. N. plus double P_2O_5	204	36	539.6	1.92	69.2	608.8	12.2
9	F. N. plus 2T. Ca Co_3	186	54	484.3	2.15	116.0	600.3	12.1
10	F. N. plus 1T. Ca Co_3	182	58	442.1	1.98	115.0	557.1	11.2
11	F. N. plus 25 lbs. MgO	211	29	551.7	2.06	59.8	611.5	12.3
12	F. N. plus 100 lbs. MgO	195	45	502.9	2.15	96.8	599.7	12.0
13	F. N. plus ½ T. sulfur	192	48	474.6	1.98	95.1	569.7	11.4
14	F. N. plus Mn & Al	192	48	472.4	2.00	96.0	568.4	11.4
15	F. N. plus B & Cu	199	41	493.4	1.96	80.5	573.9	11.5
16	F. N. plus Fe & Zn	216	24	538.6	2.01	48.2	586.8	11.8
17	Grower's formula	214	26	566.0	1.94	50.5	616.5	12.4

* Obtained by multiplying values in column 4 by those in column 6. See text for explanation.

In both the Manatí and Laguna fields the reductions in yield were associated with a chlorotic condition of the plants. In the yellowed vegetative plants the food manufacture was probably slowed up, thus, the plants at Manatí had two decided "set-backs" which reduced the potential yield. In the yellowed fruiting plants of the Laguna field the fruits from the first harvested banks had matured before the slowing up in food manufacture became acute. The yields of fruits from the second, third, and fourth harvestings were reduced due to the competition of the fruits with the yellowed vegetative part for stored foods. The reduced yields of the checks and minus nitrogen plots in the Laguna field were probably due to the chlorotic condition of the vegetative plants.

It was demostrated by the author (1939-1940) that chlorosis of pineapples grown in Puerto Rico was possible even if iron was applied in the nutrient solution when excessive manganese was also present. An experiment with water cultures seemed to support this view.

The reason that fields become "worn-out" for pineapple production may lie in either or both of two factors which are operative in Puerto Rico: (1) the soil is gradually becoming more acid due to present fertilizer practices; (2) the organic matter of the soil is gradually decreasing. Until some method is found by which the conditions of the soils where chlorosis occurs are improved it is perhaps advisable to spray the plants with iron sulfate solution as diligently and regularly as applications of fertilizers are made, that is, apply the sprays before chlorotic symptoms appear. The first iron spray could be applied as soon as the slips are planted.

Pennock (1939) in a pineapple fertilizer experiment conducted near Arecibo found only a fair response to nitrogen and potash. Since he also had to spray the field twice with iron sulfate to overcome a chlorotic condition the results of that experiment probably were influenced by the same factor or factors as those of the present reported Manatí experiment. González (1919) conducted a pineapple fertilizer experiment near Río Piedras and found a good response from applications of nitrogen and potash. This is in good agreement with the present findings in the Laguna field which also is located only about 2 miles from Río Piedras.

A third striking result was that in the Manatí field the plants responded better to ammonia than to nitrate nitrogen while in the Laguna field the two forms were of about equal value. González (1919) did not find organic constituents superior to inorganic but did not use nitrate in his fertilizers. The above results do not directly substantiate the claim

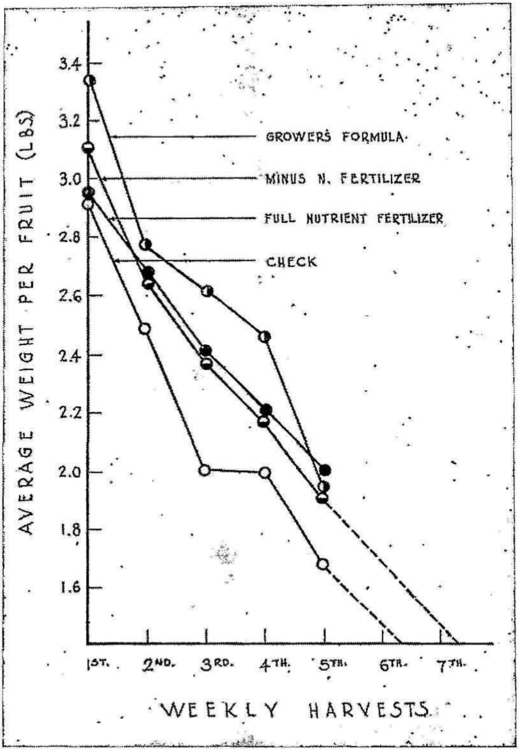

FIGURE 5. *Relation between size of fruit and earliness of maturity. The weight used in each respective case was the average weight of all the fruits harvested from the eight replicates on that date. The first and fifth harvests were made on April 23 and May 20 respectively.*

by Henricksen (1925) that the pineapple plant prefers its nitrogen in the form of nitrate and that it seldom if ever takes up ammonia from a water solution. It was observed at Manatí that the plots of treatment 17, receiving only ammonia nitrogen were consistently greener and more vigorous than those of any of the other treatments. It seems possible that the ammonia form of nitrogen is better than the nitrate in preventing the chlorotic condition of some fields.

In the present experiments no significant beneficial effects from the applications of phosphate could be found. González (1919) and Pennock (1939) found that low or minus phosphate applications actually caused greater yields and larger fruits than when used in the fertilizer. Henricksen (1925) states that phosphates as commonly used are either unsuitable for pineapple plants or they do not need much phosphate. One aspect of the phosphate problem has not adequately been worked on in any of the studies on pineapples mentioned, namely, the availability of phosphorus in acid soils such as are used mostly in Puerto Rico for this crop. Since phosphate applications show no beneficial response in yields it would seem advisable to reduce the amounts or omit them entirely from fertilizer formulas, temporarily at least.

In the present findings and in those of Pennock (1939) no relation between fertilizer applications and occurrence of gummosis could be seen.

ACKNOWLEDGMENTS

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SUMMARY

1. If pineapple plants become even slightly chlorotic during the growing period or the early part of the fruiting period a reduced yield results.

2. The plants in areas where there is a tendency for chlorosis to occur should be sprayed with iron sulphate sprays as diligently and regularly as applications of fertilizers are made.

3. The phosphates as used at the present time can be reduced to 50 lbs. P_2O_5 or less per acre without affecting the yield greatly.

4. Ammonia nitrogen seemed to be better than the nitrate form to prevent the chlorotic condition in the Manatí field.

5. Slip production and yield of fruit are both favored by vigorous plants so that if one is increased the other will be increased also.

6. There was no observable effect of fertilizer treatment on "macho" production.

7. Forcing strong plants to early maturity with carbide treatments is a profitable procedure.

8. The relative sizes of pineapples can be predicted fairly accurately by measuring the sizes of the flower stalks only if all the plants in question had the same treatments and growing conditions.

9. If potash is omitted from the fertilizer the quality of the pineapples is poorer judged by acidity, sugar concentration and taste.

10. The keeping qualities of the fruits were not affected by high or low applications of any of the nutrients tried.

11. A favorable fertilizer treatment caused increases in the sizes of both the smaller and the larger fruits proportionally.

12. Applications of lime to raise the pH values of the soil to approximately 5.0 seemed to favor increased yields of pineapples in both experimental fields.

13. If pineapples are allowed to mature naturally those yielding the largest fruits tend to mature the earliest.

14. Applications of small amounts of magnesium tended to favor increased production in both experimental fields.

15. Gum formation on the fruits was not obviously affected by any of the fertilizer treatments used.

16. Nitrogen and potash applications as used gave significant increases in 11 out of 14 cases above those not receiving these fertilizers.

SUMARIO

Estudios con Abonos en la Piña en Puerto Rico

1. Una condición clorótica en la planta de la piña que puede ocurrir durante el período de crecimiento o durante facies iniciales del período de floración, puede ocasionar una reducción en producción.

2. En aquellas zonas donde aparece la clorosis con regularidad debe recurrirse a la aspersión de las plantas con soluciones de sulfato de hierro y se debe usar con la misma diligencia y regularidad con que se hacen las aplicaciones de abono.

3. De acuerdo con los resultados experimentales en dos tipos de suelo prominentes en la zona de siembra de la piña, hemos llegado a la conclusión de que la aplicación de ácido fosfórico puede reducirse a 50 libras de P_2O_5.

4. En la región de Manatí el nitrato amoniacal aparentemente resultó mejor que los nitratos, evitando la clorosis.

5. Tanto la fruta como los "hijos" resultan muy favorecidos con la aplicación de abono que produce plantas vigorosas.

6. La aplicación de abono aparentemente no tuvo efecto en la producción de "machos" o plantas improductivas.

7. La aplicación de carburo para acortar el desarrollo de la piña da buenos resultados.

8. Siempre que las plantas reciban el mismo tratamiento puede predecirse el tamaño realtivo de la fruta de la piña mediante la medición de los tallos de la flor.

9. La calidad de las frutas fué menor, en términos de acidez, concentración de azúcar y gusto, en aquellos tratamientos en que se omitió la potasa.

10. La aplicación mayor o menor de los elementos nutritivos no afecta en forma alguna las cualidades de la fruta respecto a su poder de duración una vez colectadas.

11. Con la aplicación de abono se consigue un aumento en el tamaño de las frutas.

12. Con la aplicación de cal para subir el valor pH del suelo hasta aproximadamente 5.0 aparentemente se aumenta la producción de piñas.

13. En condiciones normales las frutas mayores se maduran primero que las menores.

14. El magnesio aparentemente tuvo un efecto favorable en el aumento de producción de piña.

15. La formación de goma en la fruta no pudo evitarse mediante tratamientos de abono.

16. La aplicación de nitrógeno y potasa resultó en mayores y significativas producciones de fruta en 11 de 14 tratamientos.

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