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# PINEAPPLE FERTILIZER RESEARCH IN PUERTO RICO

1955-66

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## INTRODUCTION

Pineapple ranks as the most important cash crop among the fruits of Puerto Rico. In 1963-64, its estimated farm value was $2,999,000 with a production of 68,000 tons of fresh fruit. It exported in the same fiscal year fresh pineapple with a value of $2,494.331 and canned pineapple with a value of $1,636,205.

Most of the pineapples are grown in an area along the north-central coast of Puerto Rico extending westward from Vega Alta to Arecibo - a distance of about 42 miles from east to west and 16 miles from north to south. Almost nine-tenths of all commercial pineapples grown in Puerto Rico are produced in this area.

It has been the custom of pineapple growers in Puerto Rico to use large quantities of fertilizers in split applications. The fertilizer is supplied to pineapples in commercial production in from four to six applications per crop, using hand labor, with placement at the base of the plant to leave a good portion in the axils of the leaves. The average application per plant is about 1 ounce of mixed commercial fertilizer which, on a basis of 12,000 plants per acre, amounts to 750 pounds of fertilizer per acre per application. This amounts to 3,000 pounds of fertilizer for four applications and to 4,500 pounds for six.

Until work had been carried out on the control of biological parasitic factors it was the general opinion of many pineapple growers and research workers that, at least under Puerto Rican conditions, the pineapple plant had a poor root system, rooted very slowly, and was a poor feeder. Hence it must be fertilized heavily if good yields were to be obtained. However, this concept has since changed. We now realize that heavy nematode infestation and other insect and disease damage may weaken pineapple plants so that they no longer give a true picture of their own actual nutrient requirements.

It has been shown that pineapple yields can be doubled by treating soils against nematodes and soil-borne insects and by

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treating the plants against mealybugs (1). Fertilizer experiments have revealed that optimum yields of pineapples can be obtained with much lower rates of fertilizer than were formerly used, if soils and plants are properly treated for control of insects (7).

The purpose of this paper is to present the results of pineapple fertilizer research in Puerto Rico since 1955 when control of biological parasitic factors has allowed a full expression of the fertilizer needs of the pineapple.

## MAJOR ELEMENT REQUIREMENTS

### NITROGEN

#### Amounts

Nitrogen fertilizers produce the greatest increase in yields of pineapples as compared to any of the other fertilizer nutrient elements applied (Table 1). Rates varying from 168 to 600 pounds of nitrogen per acre gave relative yields from 115 to 165 percent as compared to 100 for no nitrogen application. The Bayamón sandy clay, which represents the major soil type of the pineapple area, showed best response to 300 pounds of nitrogen per acre, the use of 600 pounds of nitrogen gave no significant increase over the 300 pounds of nitrogen per acre rate (Table 1).

The former high rates of nitrogen application of up to 800 pounds per acre is not necessary when proper control of biological parasites are maintained with pineapples. An average rate of 350 pounds of nitrogen per acre appears to be the optimum economical rate of nitrogen needed for pineapples in Puerto Rico.

#### Forms

Many nitrogen sources have been evaluated for pineapples. The ratings of the vaious nitrogen sources evaluated under experiments are given in table 2.

Ammonium sulfate has been the major nitrogen source for pineapples. Recently, urea has come into use as a nitrogen source. Urea offers many advantages over ammonium sulfate in price per unit of nitrogen, less warehouse and field costs in application, greater solubility and less phytotoxicity when applied in foliar sprays, and lower residual acidity in the soil.

TABLE 1 - The Influence of major element fertilizers (N-P-K) on the relative yields of Red Spanish pineapples

| Soil | Rate of fertilizer used per acre | | | Relative yields[1/] of pineapples per acre for fertilizer element applied | | |
|---|---|---|---|---|---|---|
| | N | $P_2O_5$ | $K_2O$ | Nitrogen | Phos-phorus | Potassium |
| Bayamon sandy clay | 300 | 75 | 300 | 131 | 99 | 104 |
| | 600 | — | — | 132 | — | — |
| Coto clay | 480 | 80 | 80 | 165 | 101 | 133 |
| Lares clay | 168 | 56 | 56 | 129 | 112 | 114 |
| Vega Baja clay | 200 | 75 | 300 | 115 | 98 | 105 |
| Average | 350 | 72 | 184 | 150 | 103 | 110 |

1/ Relative yield where no nitrogen, phosphorus, or potassium has been applied was rated at 100.

TABLE 2. - Influence of various nitrogen sources on Red Spanish pineapple yields

| Nitrogen source | Nitrogen Content Percent | Relative yields of pineapples per acre |
|---|---|---|
| Ammonium sulfate | 20 | 100 |
| Urea | 45 | 98 |
| Ureaform | 38 | 100 |
| Ammonium nitrate | 33 | 96 |
| Ammonium sulfate nitrate | 26 | 98 |
| Calcium nitrate | 15 | 74 |
| Calcium ammonium nitrate | 20 | 94 |
| Potassium nitrate | 14 | 81 |
| Aqua ammonia | 20 | 95 |
| No nitrogen | 0 | 49 |
| L. S. D. 5% | | 20 |

Method of Application

Normally fertilizer is applied to pineapples by hand to the soil at the base of the plant. Inasmuch as pineapple fields are being sprayed regularly for insects, weeds, and iron chlorosis control, the inclusion of fertilizer in the spray solution would be an inexpensive means of fertilizing the pineapples. Experiments have shown that fertilizing pineapples by spray solutions is effective and economical (Table 3).

Urea proved to be much more efficient then ammonium sulfate in spray application. Spray applications of urea used one half the amount of fertilizer than did soil applications (see Table 3) to produce equal yields. Thus 100 pounds of nitrogen as urea spray was just as effective as 200 pounds of nitrogen per acre applied to the soil. Spray applied urea also produced larger fruit sizes than soil applications. This was not so for ammonium sulfate.

## PHOSPHORUS

Amounts

It has been shown that the response to phosphate fertilization is very limited for pineapples in Puerto Rico. In fact, pineapple yields can be decreased by large applications of phosphate (6). This is shown quite graphically in figure 1.

At present, phosphate rates above 75 pounds per acre of $P_2O_5$ is not advised in Puerto Rico. The poor responses to phosphate can be seen in table 1. Except for the Lares clay most responses to phosphate were negative.

Forms

Although responses to phosphates has been minimal, experiments were performed to determine if the phosphate source may have invluenced this response. The phosphate sources used were: simple superphosphate (0-20-0), triple superphosphate (0-45-0), raw rock phosphate (0-32-0), ammonium metaphosphate (16-52-0), diammonium phosphate (20-52-0), calcium metaphosphate (0-62-0), dicalcium metaphosphate (0-48-0), potassium calcium pyrophosphate (0-42-25), and potassium metaphosphate (0-47-28). None of the phosphate sources applied at 100 pounds $P_2O_5$ per acre gave any significantly better yields than the no phosphate treatment. Yields were significantly lowered over the no-phosphate treatment when diammonium phosphate was used as a phosphate source.

## POTASSIUM

### Amounts

Pineapples show a response to potash fertilizers which varies according to the soil. As can be seen in table 1 responses were low in the Bayamón sandy clay where the majority of the pineapples are planted but were quite high in the Coto clay a potential area for new pineapple plantings. Responses to potash fertilizers are not always measured by yields per acre, quality is also effected. It has been shown that potassium deficiencies decrease fruit size and increase weight of top (2), delay ripening, and reduce sugar (Brix) content.

The use of 300 pounds of $K_2O$ per acre appears to be the most acceptable rate at present in relation to fruit yields and quality.

### Forms

Potassium is normally applied as the sulfate rather than the chloride. The reason for this is that both experience and research (5) has shown that color of the fruit, taste, and growth is more favorable when the sulfate rather than the chloride of potash is used.

## OTHER ELEMENTS

## CALCIUM

Pineapples prefer acid soils and thus liming has not been a general practice. Soil $p^H$ values from 4.5 to 5.5 are prefered for the Red Spanish pineapple; whereas the Smooth Cayenne can tolerate somewhat higher $p^H$ values to 6.0 and 6.5. The lower $p^H$ values are preferred more because of the available iron supply in the soil. Higher $p^H$ levels above 5.5 mean less available iron in the soil and greater needs for applying iron sprays. It appears that the $p^H$ needs are associated more with available iron needs than calcium requirements. Calcium is indeed needed by pineapples as an element; however, its needs must be supplied as a neutral salt in the component of a fertilizer rather than in a liming material which will raise the soil $p^H$.

## MAGNESIUM

Definite responses have been obtained to magnesium applications in pineapples both as soil or spray applications (4). The use of 15 pounds of magnesium sulfate per acre applied as a spray in 100 gallons of water has become a standard practice where magnesium deficiencies are suspected.

## IRON

The minor element which has the greatest influence on pineapple production is iron. The iron requirements for pineapple are very high as compared to most agricultural crops. The use of acid soils for pineapples is related more to the available iron supply in the soil than any other factor. It can also be said that the failure to grow pineapples in near neutral to alkaline soils is due more to the lack of available iron to the plant than any other nutrient factor.

The use of iron sprays as ferrous sulfate, $FeSO_4$, has been the most practical and economical manner of overcoming iron deficiency in pineapples. Normally 6 to 8 pounds of the commercial salt is dissolved in 100 gallons of water and applied as a very fine spray over the pineapple plants (3). Multiple sprays of iron are used by many growers especially with the Smooth Cayenne variety. However, research has shown that one or two sprays of iron is sufficient for Red Spanish pineapples when soil $p^H$ is below 5.5 and control of biological parasites is adequate.

## NUMBER OF FERTILIZER APPLICATIONS

After seeing that pineapple plants could grow vigorously and with less fertilizer, if properly treated, it was only natural for the grower to wonder how many fertilizer applications were necessary for good pineapple yields. Experiments have shown that the quantity of fertilizer rather than the number of applications made appears to be more important factor for increasing pineapple yields.

An example of the influence of number of fertilizer applications is given in table 4. We can see that the same amount of fertilizer when applied in 1, 2, or 3 applications (treatments 4, 5, and 8, table 4) gave no significant differences in yields. Yields were increased by increasing amounts of fertilizer regardless of number of applications.

The use of one application of solid fertilizers appears to be sufficient for pineapples as for sugarcane. This, of course, applies to those soils the texture of which is heavy enough, or their exchange capacity is high enough, that excessive leaching of plant nutrients does not occur.

TABLE 3. - Spray vs. soil application of nitrogen fertilizers on yields of Red Spanish pineapple

| Treatment[1/] Nitrogen, pounds per acre | Method of Application | Yield of fruit per acre: Ammonium sulfate | Yield of fruit per acre: Urea | Mean weight of fruit: Ammonium sulfate | Mean weight of fruit: Urea |
|---|---|---|---|---|---|
| | | Tons | Tons | Pounds | Pounds |
| 0 | — | 8.1 | 8.1 | 2.02 | 2.02 |
| 100 | Soil | 13.7 | 12.9 | 2.56 | 2.48 |
| 200 | Soil | 13.7 | 15.9 | 2.83 | 2.96 |
| 25 | Spray | 11.1 | — | 2.29 | — |
| 50 | Spray | 11.3 | 12.5 | 2.59 | 2.76 |
| 100 | Spray | — | 15.3 | — | 3.04 |
| 100<br>50 | Soil<br>Spray | — | 16.8 | — | 3.03 |
| L.S.D. 5% | | 1.59 | 1.59 | 0.16 | 0.16 |
| 1% | | 2.03 | 2.03 | .21 | .21 |

1/ All treatments received phosphate and potash at a rate of $P_2O_5$: $K_2O$ of 1:5 with amounts of potash equal to the rate of nitrogen application.

TABLE 4. - Influence of time and number of fertilizer applications on the yields of a plant crop of Red Spanish pineapples at Arecibo, 1954-55

| Treatment No. | Treatment in pounds per acre: N | $P_2O_5$ | $K_2O$ | Time and number of fertilizer applications | Mean fruit weight | Yield of fruit per acre |
|---|---|---|---|---|---|---|
| | | | | | Pounds | Tons |
| 1 | 100 | 20 | 75 | All at time of planting | 2.75 | 16.1 |
| 2 | 150 | 30 | 113 | do. | 2.94 | 17.2 |
| 3 | 200 | 40 | 150 | do. | 3.11 | 18.2 |
| 4 | 300 | 60 | 225 | do. | 3.19 | 18.6 |
| 5 | 150 | 30 | 113 | 1/2 at planting, 1/2 months | 2.63 | 15.3 |
| 6 | 200 | 40 | 150 | do. | 2.86 | 16.7 |
| 7 | 300 | 60 | 225 | do. | 3.08 | 18.0 |
| 8 | 300 | 60 | 225 | 3 applications at 1,4, and 8 months | | |
| Least significant difference needed between treatment at: | | | | | | |
| 5-percent level | | | | | 0.19 | 1.11 |
| 1-percent level | | | | | .25 | 1.46 |

## SUMMARY

Fertilizer applications for pineapples in Puerto Rico showed varying and often conflicting results until 1954 when control of root-knot nematodes and soil-borne insects was initiated. From this date, research in pineapple fertilizers took a significant stride forward.

Nitrogen is the fertilizer element which has given the most response in yields of pineapples. Optimum rates vary from 200 to 400 pounds per acre, depending on previous soil fertility. Responses to various nitrogen sources have been limited and ammonium sulfate or urea are considered the standard nitrogen fertilizers.

Yield responses to phosphates have been very limited and significant depression in yields of fruit have been obtained when rates of $P_2O_5$ per acre have exceeded 56 pounds. Various phosphate sources have not shown to be effective in increasing yields.

The response in yields to potassium are not as great for nitrogen, but there is a response to potash has caused small fruit with large tops and poor flavor due to lower sugar content.

Fertilizer applications can be limited to one or two with solid fertilizers as compared with four to six previously used. Where spray applications are used monthly applications of urea at one-half the total nitrogen have given yields equal to and better than urea or ammonium sulfate applied to the soil in solid form.

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