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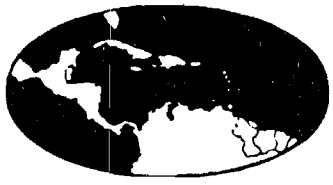

FOURTH ANNUAL MEETING

KINGSTON , JAMAICA

JULY 25 -- AUGUST, 1 1966

VOLUME IV

FERTILIZER RESEARCH ON FOOD CROPS AND VEGETABLES IN JAMAICA

Hugh Payne

ABSTRACT

Previous work on the fertilizer requirements of food crops and vegetables is reviewed, and an attempt is made to assess the present position in Jamaica with regard to research on the fertilizer requirements of these crops. A lack of balance in fertilizer research is manifested in an undue emphasis on certain crops e.g. Irish potatoes, and an almost total disregard of others e.g. sweet potatoes, red kidney beans, etc. The need for a balanced co-ordinated programme involving a wider variety of crops than formerly and for an intensification of fertilizer research is stressed.

INTRODUCTION

The purpose of this paper is to review previous work on food crops and vegetables and to try to reach an appreciation of the present position in Jamaica with regard to research on the fertilizer requirements of these crops.

The fertilizer requirements of crops cannot be divorced from other aspects of efficient crop production. However, the scope of this paper will be restricted to research on the fertilizer needs of food crops and vegetables, and to those trials involving crop varieties and systems of planting which were directly related to nutritional studies.

Crops Intensively Studied

A considerable number of investigations has been carried out on four crops - Irish potatoes, corn, yams, and tomatoes. A brief description of the experiments and of the main conclusions drawn from them is given below:

Irish Potatoes

(a) Investigations 1940-48

A series of eleven experiments with Cobbler and Green Mountain varieties was laid down during the period 1940-48 on the chief potato-growing soils of Manchester, St. Ann, St.Elizabeth and St. Mary. The experiments were mainly factorial ones designed to ascertain the quantitative requirements of potatoes for nitrogen, phosphorous and potassium and to compare local phosphate with 18% superphosphate.

No yield response was obtained from application of nitrogen, regardless of soil type. Since most Jamaican soils are deficient in nitrogen, it appears that under local environmental conditions Irish potatoes have a low requirement for nitrogen. This low crop requirement for nitrogen appears to be more important than the ability of the soil to supply this nutrient.

In contrast to nitrogen, the response to phosphate and potassium was closely associated with soil type. Good yield responses were obtained from application of phosphorous on soils developed over tuffs and acid limestone shales (Wirefence Clay Loam and Wait-a-bit Clay) and on the red bauxite soil, St. Ann Clay Loam. In general, local phosphate resulted in higher yields than 18% superphosphate, especially on the highly acid soil, Wirefence Clay Loam. Phosphorous, however, did not increase yields on the brown bauxite soil, Chudleigh Clay, and gave a variable response on the colluvial limestone soil, Lucky Hill Clay Loam.

Residual phosphorous increased the yields of follow-on crops of corn.

Potatoes responded well to application of potassium on both bauxite soils, gave a variable response on the limestone colluvial soil, and did not respond on soils developed over tuffs and acid limestone shales. The benefit of Humber Fish manure on brown bauxite soils was shown to be due entirely to the potash it contained.

Residual potassium increased the yields of follow-on crops of corn, peanuts and red peas.

(b) Investigations 1949-55

During the period 1949-55, eleven experiments and two series of observations trials were carried out in Manchester, St. Ann and St. Mary. The main varieties used were Cobbler and Green Mountain.

In contrast to previous trials, a response to nitrogen was obtained on Wirefence Clay Loam and Carron Hall Clay. A variable response was obtained on Chudleigh Clay. Two series of observation trials were therefore designed to test the effect of including nitrogen in the fertilizer mixture normally recommended for potatoes. It is perhaps unfortunate that all the observation plots were situated on the brown bauxite soil, Chudleigh Clay. The first series of trials showed no significant yield increase from the inclusion of nitrogen, while combined analysis of the second series revealed a significant yield response to nitrogen.

Apparently the fertility of the main potato-growing soils had decreased sufficiently by the early 1950's for a positive response to nitrogen to be obtained fairly consistently.

During this period two series of experiments were carried out testing up to five methods of placement of fertilizer. The results from both series showed that the best yield response was obtained from placing fertilizers in a continuous line along the base of the furrow before planting. The second series also indicated that the higher yield obtained from fertilizer placement was due to higher availability of phosphorus.

(c) Investigations 1958-63

Up to 1957, all fertilizer investigations had been confined to the central potato-growing districts of the island. The period 1958-1961 represented a shift in experimentation to the western potato soils around the Darliston Area of Westmoreland. The main varieties used in the NPK fertilizer trials laid down were Arran Consul and Sebago.

On the chief soil type in the Area, Windsor Stony Clay, excellent responses to phosphorus and potassium were obtained in two out of three trials, while a moderate response was given to nitrogen in only one of the three trials.

Discussion

As a result of a large number of experiments laid down since 1940, the nitrogen, phosphorus and potassium requirements of Irish potatoes are reasonably well-known for the major potato soils in Jamaica. The standard fertilizer mixtures recommended and also the standard methods of fertilizer placement appear to be generally satisfactory. Further experimentation along these lines cannot be regarded, therefore, as urgent, although expansion of potato-growing in new areas, e.g. Yallahs Valley, might alter the present picture.

Considering the low incidence of potato scab in Jamaica, perhaps liming experiments should be considered for the very acid soils over tuffs and acid shales of the Yellow Limestone Formation.

No local information is available on the use of foliar analysis in the diagnosis of the nutritional status of potatoes. In view of the increasing but variable response to nitrogen, and the low levels of this nutrient normally recommended, foliar analysis may be particularly useful in diagnosing a deficiency of this element without the necessity of laying down further extensive field trials. If diagnosis is early enough a side dressing of nitrogen may be beneficial; in other cases nitrogen could be incorporated in the fertilizer mixture for subsequent

crops. It has been suggested that an internal brown spot in potato tubers is due to boron deficiency or copper toxicity, and a leaf analysis survey might serve to locate possible trace element deficiencies or toxicities.

Considerable information might be obtained, therefore, from a leaf analysis survey of Irish potatoes growing on a variety of soil types. Leaf analytical data should also be obtained from any fertilizer experiments laid down in the future.

Maize:

Twelve experiments and a series of numerous observation plots have been carried out since 1940, using local J.S.Y. seed corn. Nearly all of these trials were located on the bauxite soils, St. Ann Clay Loam and Chudleigh Clay, although some information was also obtained for Carron Hall Clay (developed over soft or rubble limestone), Belfield Clay (developed over shale), and Newell loam.

It was early established that good yield responses were given by farm yard manure. Yearly applications of manure were found to be better than equivalent amounts applied once every two or four years. It was also found that a corn-soya bean rotation was not efficient in preventing a progressive decrease in corn yields despite fertilization or manuring.

Yield increases were obtained on Carron Hall Clay and Belfield Clay from the application of nitrogen and phosphorus. On Newell Loam, response was obtained from the application of phosphorus and potassium.

The main response on Chudleigh Clay was to potassium, with some response to nitrogen. On this soil type it was found that there was greater response to nitrogen in the Spring than in the Fall plantings. The red bauxite soil, St. Ann Clay Loam, always responded well to potassium applications, most response ocurring when the level of the soil potassium extractable by 0.5 $\underline{N}$ Acetic Acid was below 80 p.p.m. K_2O. The response to nitrogen and phosphorus, however, appeared to depend on the soil reaction. When the soil reaction was alkaline, there was good response to nitrogen, but response to phosphorus only ocurred when soil phosphorous extractable by 0.002 $\underline{N}$ H_2SO_4 was below 30 p.p.m. P_2O_5. When the soil was acid, corn responded well to applications of phosphorous but not to nitrogen.

One trial comparing the source of nitrogen indicated no difference between Urea and Sulphate of Ammonia, while in a second trial Sulphate of Ammonia gave higher yields.

In two trials on St. Ann Clay Loam, splitting of the nitrogen application was no more effective than applying all of the nitrogen at planting. However, no response to nitrogen was obtained in either of these trials, so that no firm conclusions can be drawn.

Since 1958, several field scale trials have been laid down in an attempt to determine whether recommended fertilizer programmes are adequate for high yields of corn. Despite good cultural conditions and insect control, relatively low yields were obtained. In trials comparing standard and very high fertilizer dressings (in some cases the latter also contained supplements of magnesium, manganese and other trace elements) there was no difference in growth or yield resulting from the different fertilizer treatments.

It may be concluded, therefore, that inadequate nutrition is not the main factor limiting corn production in Jamaica. Apparently the varieties available up to 1963 do not have the yield potential under local conditions to allow maximum yield response to fertilizer and to make corn production profitable.

Yams:

Fertilizer experiments with yams were started in 1948. In two trials with Renta yam (Alata Species) on St. Ann Clay Loam, the only nutrient to which a response was obtained was potassium, and this response was only significant when two years' data were analysed together.

In 1952-53, a series of non-statistically designed experiments on two soil types probably corresponding to Wait-a-bit Clay and Carron Hall Clay indicated a striking response to nitrogen and phosphorous, both in total yield and in ratio of yam to head.

Since 1957, there has been an intensification of work on yams designed to investigate - (a) Systems of Planting; (b) Time of application and placement of fertilizer; and (c) Types and levels of fertilizer.

Yellow Yam and Lucea Yam (Cayennensis Species) have been the main varieties tested.

(a) Systems of Planting

Seven trials have been carried out comparing the traditional method of planting yams in individual hills with planting in continuous ridges. The best system of planting appears to depend on soil type and on season. Higher yields were obtained on continuous ridges in four trials and on hills in one trial.

In two trials on Chudleigh Clay, yields were the same for each system.

Continuous ridges have been adopted as the recommended method of planting because of adaptability to mechanization and desirability as a soil conservation measure.

(b) Time of application and placement of fertilizer

In 1961 a trial on Chudleigh Clay indicated that applying and covering fertilizer in a circle around each plant gave a slightly higher yield than placing it in a depression between plants. However, another trial on the same soil type in 1962, showed that no difference in yield resulted from applying fertilizer in a circle around each plant, in a depression between two plants, or in furrows. In the latter trial, no difference in yield was found to result from applying fertilizer at time of planting, when vines were 6-12 inches long, or when vines had grown to the full length of the stake.

(c) Types and Levels of Fertilizer

In ten field experiments laid down since 1957, a positive yield response has been obtained five times for nitrogen, but only once each for phosphorous and potassium. In one trial, application of potassium was apparently associated with a decrease in yields. The only nutrient, therefore, which has increased yields fairly consistently is nitrogen. The influence of nitrogen was not closely associated with soil type, but varied from year to year and may have been related to seasonal growing conditions.

Discussion

In trials since 1957, yams have not responded to phosphorous on soils known to be generally deficient in this element. The amount of phosphorous used in these trials was generally around 27 lbs. P per acre, although as much as 80 lbs. P was used in one trial. In the 1952-53 observation plots, extremely large yield responses were obtained from application of phosphorous to similar soils. It is perhaps significant that in these early trials extremely high levels of phosphorous were used - 175 lbs. P per acre.

Yams occupy the ground for a relatively long period, and some advantage might be expected from splitting the nitrogen and perhaps potassium applications. The second application could be broadcast over the surface of the ridge.

Tomato:

During the period 1940-53, nine experiments were carried out with tomatoes, all of them in St. Elizabeth on the red bauxite soil, St. Ann Clay Loam. The variety used in these trials was Marglobe.

These experiments demonstrated that applications of phosphorous are essential to successful tomato production on this soil. Phosphorous increased the number of plants attaining maturity, the yield per plant and the quality of the crops. The optimum phosphorous dressing was around 36 lbs. P per acre, and superphosphate was more effective than local phosphate in increasing yields.

No yield response was obtained to potassium applications in any of these trials, while response to nitrogen was only obtained in the 1949-50 trials. Apparently, the nitrogen status of the soils of the area vay from one locality to another and from one season to another. In localities where nitrogen is deficient, about 30 lbs. N per acre should be ample.

Since 1953, the only nutritional work with tomatoes on St. Ann Clay Loam has consisted of observational trials. One series of trials was designed to evaluate the effect of increasing the proportion of potassium and decreasing that of phosphorous in the standard fertilizer dressing for Southern Sr. Elizabeth. A second series was planned to determine whether a reduction of fertilizer would be advantageous to the farmer, and involved comparison of the standard 5-12-6 mixture with an equivalent amount of 10-24-12 mixture. No conclusions were possible from either of these series of experiments because of poor cultural control of plots by the farmers involved.

In a 1952 trial, it was observed that applications of nitrogen increased the incidence of Blossom End Rot (B.E.R.) of tomatoes growing on St. Ann Clay Loam. In recent years, other experiments have been laid down for the control of B.E.R. specifically. The factors used in these trials were gypsum, superphosphate and calcium chloride sprays. In the experiment located on Maverly Loam, no statistical analyses were carried out because of low incidence of B.E.R. On Sydenham Clay, high rates of sypsum application appeared to increase the incidence of B.E.R.

Discussion

All of the N.P.K. fertilizer experiments on tomatoes have been carried out on the St. Ann Clay Loam in Southern St. Elizabeth. It is desirable that additional experiments be carried out on other soil types in other tomato producing areas, using standard varieties.

The control of Blossom End Rot is of major importance. It is perhaps unfortunate that all previous investigations into this problem have been located on soils high in calcium, since the chief nutrient tested in these trials has been calcium.

Crops less intensively studied:

Carrots:

A series of observation fertilizer plots in 1952-53, showed substantial yield increases from applications of nitrogen, phosphorous and potassium on the soil types - Llandewey Clay Loam, Hall's Delight Channery Clay Loam and Killancholly Clay.

Red Kidney Bean:

Greenhouse lime requirement experiments were carried out on three soil types, using ground limestone (99% Ca CO_3) crushed to pass a .60 mesh sieve.

Large growth responses were obtained from 1 - 1 1/2 tons per acre limestone on Flint River Sandy Loam and from 10 - 15 tons per acre limestone on Wirefence Clay Loam. No growth response was observed on Linstead Clay Loam, but the highest level of lime used did not raise the soil reaction appreciably.

In 1963, field experiments were laid down on Maverly Loam and Chudleigh Clay to evaluate the relative effectiveness of inocculum and chemical fertilizer in supplying the nitrogen requirements of the Red Kidney Bean.

There were highly significant yield increases from the application of 40 lbs. nitrogen to Chudleigh Clay, but the use of inocculum alone apparently resulted in a slight depression in yield which was not shown to be significant. The experiment on Maverly Loam formed part of a regional project sponsored by the U.S.D.A. and could not be analyzed separately. No results are available, therefore, for this experiment.

Watermelon:

In trials on Caymanas Sandy Loam during the period 1964-65, applications of gypsum, calcium chloride spray, superphosphate and Sun Farm Compost were shown not to have any marked effect on the incidence of Blossom End Rot on the varieties - Charleston Gray, Tom Watson, Dixie Queen and Sugar Baby.

Sweet Corn:

Only one fertilizer trial has been carried out, located on the alkaline recent alluvial soil, Caymanas Sandy Loam. The elements tested in this trial were zinc, phosphorous, manganese and magnesium. Yield increases were obtained from the application of Zinc, but visual deficiency symptoms of this element were not corrected. Phosphorus and magnesium appeared to depress yields, but this apparent effect was not shown to be significant.

Cauliflower:

No field trials have been carried out with this crop. In Greenhouse experiments using cauliflower as an indicator crop, yield responses to applications of nitrogen, phosphorus and potassium have been obtained on several soil types. Sulphur deficiency symptoms and greatly reduced growth were observed in greenhouse trials with cauliflower on the soils Flint River Sandy Loam, Valda Gravelly Sandy Loam and Tydixon Loam Sand.

Cassava:

No fertilizer trials have been laid down, but varietal trials have yielded some information on the chemical characteristic of cassava grown on soils differing in potassium status. Cassava varieties grown on the potassium-deficient soil, Chudleigh Clay, contained larger amounts of hydrocyanic acid (sig. at .001% level) than the same varieties growing on Lodge Clay Loam, a soil known to be high in potassium. These results appear to confirm those obtained elsewhere in the tropics indicating that the "Sweetness" or "bitterness" of cassava is not entirely a varietal characteristic but is greatly influenced by the potassium status of the soil.

Sweet Potato:

No formal fertilizer trials have been carried out. In 1958, six observation trials were laid down on farms in St. Ann, each trial consisting of one fertilized and one unfertilized plot. Individual plot size was 1 square chain. The application of fertilizer as recommended by the Agricultural Chemistry Division was economically advantageous, the average yield on fertilized plots being 243% greater than that on unfertilized control plots.

Peanut:

In 1948, the yield of peanuts was found to be increased by residual phosphorus and potassium following an Irish Potato experiment on St. Ann Clay Loam.

In 1949, a fertilizer trial was laid down on a Terra Rossa soil (probably St. Ann Clay Loam) in order to determine the

response of peanuts to applications of lime, nitrogen and potassium. No response was obtained from any treatment as a result of drought.

Sorrel:

In a fertilizer trial on Maverly Loam, moderate yield increases were obtained from the application of phosphorus.

DISCUSSION

A review of previous work reveals the lack of a balanced, long-term approach to fertilizer research embracing all the major food crops and vegetables. This lack of balance is manifested in an undue emphasis on certain crops, e.g. Irish potatoes, and an almost total disregard of others, e.g. sweet potatoes, red kidney beans, pigeon peas, cucumbers, etc.

The apparent reasons for this imbalance are:

(1) The considerable total value of most locally consumed crops was not easily demonstrated in comparison with export crops. Hence the importance of fertilizer trials involving these crops was difficult to illustrate.

(2) The more intensively studied crops were all concentrated in particular regions, e.g. Irish potatoes in the Christiana area, yams in Hanover, corn and tomatoes on the bauxite soils of St. Elizabeth, Manchester and St. Ann. For all of these crops, certain areas or certain soils could easily be recognized as representative locations for fertilizer investigations. No such ready identification was possible for such crops as cabbage, cassava, cucumbers, red kidney beans, sweet potatoes, etc. Hence these crops tended to be neglected because of difficulty in justifying the location of experimental sites.

An example of the influence of the above factors is given by tomatoes. Fertilizer investigations on tomatoes have virtually ceased since the collapse of the export market for Marglobe tomatoes and the consequent reduction in the pre-eminent position of Southern St. Elizabeth as a producer of tomatoes. Yet the importance of the large volume of tomatoes still consumed locally cannot be denied.

This lack of balance has also been manifested in an ad hoc approach to many trials and in an apparent emphasis on varietal rather than fertilizer or other trials. In the absence of a broad long-term project involving all the important staple crops, experimental emphasis may have been influenced too much by the individual preferences of the research worker and by general convenience in carrying out the investigations.

The experiments described in this review indicate the dominant role played by soil type in determining the fertilizer requirements of crops. However, they also show the danger in applying the results of trials with one crop to other crops. Thus, on the soil type St. Ann Clay Loam, potassium applications were necessary for efficient production of Irish potatoes, yams and corn, but did not influence the yield of tomatoes. On most soil types, nitrogen applications appeared essential for high yields of yams, but had a relatively small effect on the yield of Irish potatoes. Fertilizer trials on a particular soil type, therefore, should include as many of the crops grown extensively on this soil as available resources will permit.

It appears that more use could be made of fertilizer trials in attempting to establish tissue analysis as a means of diagnosing nutrient deficiencies of food crops and vegetables. It is realized that tissue analysis is not as valuable for relatively short-term crops as for perennial tree crops, but much useful information might be obtained from relatively little additional effort.

No planned attempt has been made to correlate soil test values with crop yield or nutrient uptake. Such correlations are essential pre-requisites of an efficient advisory service on fertilizer usage. The establishment of soil test correlation plots on the major soil types of the island must be regarded as one of the most important needs of fertilizer research.

A balanced fertilizer research programme would involve an increase of field trials with previously neglected crops. The location of experimental sites for these trials must be carefully considered so that the soil types are representative of the chief soils on which each particular crop is grown.