SOIL POTASH—POTASH INVESTIGATION—POTASH DEFICIENCIES

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Introduction.

The intrinsic desire of man is a thirst for more and deeper knowledge of all the processes which go on around him, and the unravelling of problems which bring all manner of races and creeds together onto common ground.

Research is an expensive undertaking, and vast sums are voted and spent each year in great efforts to perfect conditions in order to make life easier, healthier and more comfortable for mankind.

The data obtained from all the work done each year can be divided and subdivided into innumerable categories and classes, some being fundamental, others more in the nature of routine analyses of material which is the outcome of hypotheses or theories and an effort to collect sufficient evidence to establish the fact.

A great deal of scientific literature appears which is meaningless to those who are not specially trained to understand the terms, or possibly to any individual who does not happen to specialise in the particular subject under discussion.

It is always possible to popularise science to a certain extent even right from the point of departure or fundamental principles, so as to give the layman an idea of what is being done and enable him to utilise findings in his own immediate interests.

It is in this connection that it becomes very difficult at times for the agricultural scientist and practical agriculturist to meet on common ground, for very often a popular version of scientific reasoning may appear ambiguous, and in this case it would appear better to sacrifice the facile version (since the layman can always get an interpreter to explain if he is sufficiently interested) than to avoid using the precise terms which explain the situation, and tell the whole story even though a half truth may be more palatable to the average individual mind. The economic aspect of many problems often makes it particularly difficult to interpret technical agriculture in terms of what should be done in practice, but depending on the efficiency of the interpreter, means can be found to narrow down the ratio scientific agriculture to practical agriculture to a very narrow margin.

The thoroughness which agricultural investigation exacts is as great as that demanded by any other branch of science. The breadth of vision required by the agricultural worker is possibly greater than is needed by a specialist working a narrow field. The scope of agriculture is tremendous and the complexity of it is such, that at least a working knowledge of a great many subjects is essential before even the rudiments of the case can be explained.

The reason for this is because of the number of scientific subjects connected with agriculture in the first place, and secondly the importance of interactions between them which at times may be very subtle both from a scientific and economic point of view, and which escape detection unless watched with a practiced eye.

Before discussing the experiment which is the real object and forms the nucleus of this paper, it is intended to discuss soil potash in a little detail first, because this aspect of soil fertility appears to be almost entirely over-looked and misunderstood by the majority of both scientific workers as well as practical men on the sugar belt of Natal.

The Soil.

We have an excellent example of what has just been said about the intricacies of agricultural research in the soil itself. "The soil, situated at the limit of the lithosphere and the atmosphere, appears as a result of both. It is part of the biosphere, and on this account, biological factors also count very largely in its evolution. The following serves as a general definition: The soil is the natural surface formation, of loose structure and variable thickness, resulting from the transformation of the underlying parent rock under the influence of different physical, chemical and biological processes. It is convenient here to take the expression "parent rock" in its broadest sense since such rock can also be of loose formation. Regarding agricultural soils, they are the outcome of the transformation of natural soils, by the application of agricultural methods, for purely economic purposes, the production of crops. As a result of this interference the morphology, composition and properties of the medium are modified. The soils thus deprived of their individuality have been diversified to a countless extent; the complexity of the study of them has consequently been considerably increased.

Proceding from the general to the particular we shall first study the soil, leaving it the character of its natural formation. This aspect of the question will assure us the broadest possible speculative understanding of the inner nature of the soil. But it can only form a preface so to speak, our fundamental purpose being the understanding of reactions of which the soil is the seat, we would say even its "metabolism" which evokes an image of a living organism or more precisely of its internal dynamics. In the final analysis the soil will remain for us a cultural milieu in the biological sense of the word, the most important in fact for the existence of humantiy."[1]

"It must be recognised that, while in each climatic belt the soil material is progressing in its evolution towards the type characteristic of that zone, not every soil has been able to attain to that final state. It will be gathered accordingly, that many soils are only in an immature or intermediate stage of development; indeed it is probable that in South Africa such imperfectly developed types are quite as abundant as "end product" soils."[2] This is sufficient to show that soils occur in very different conditions which vary according to innumerable outside influences. For a very long time it was thought that a superficial chemical analysis of very often only the first few inches was sufficient in every case to discover all the properties of the soil. In addition to this a physical analysis was done to add a little information regarding the visible composition of the soil. With time people have realised the necessity to study the soil as an individual unit, and devote time to a pure science of the soil. Pedology has been the outcome which is the study of the soil in relation to its environment. Ecology, which is an analagous study affecting animal and plant physiological reactions in their natural habitat, must also be taken into consideration, since there are in evidence indications of a close connection which may bring the two together.

"Of the environmental factors affecting soil development, the following four—or four groups—are the most important:—

Intrinsic: The nature of the parent and underlying rock.

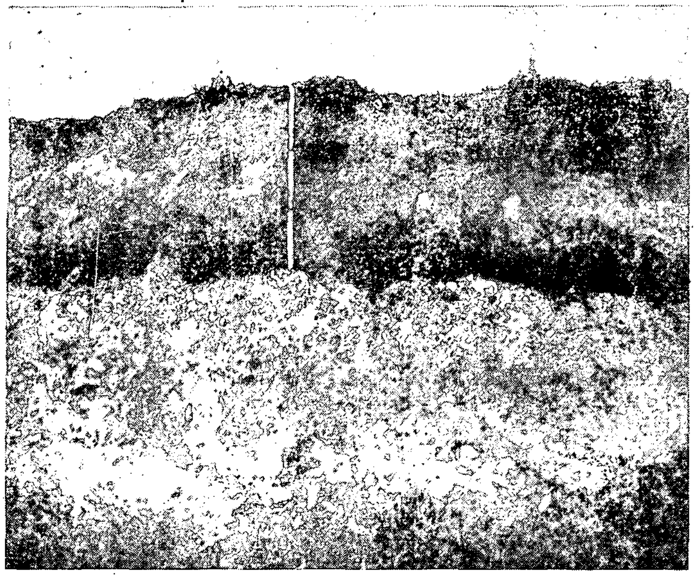
Extrinsic: The climate.

Intrinsic and Extrinsic (dependant on geology and climate).

(a) Physiochemical: The movement of precipitation and ground waters.

(b) Biotic: The whole flora and fauna, macroscopic and microscopic; particularly the vegetation."[3]

In affecting a proper inspection of the soil prior to sampling for laboratory analytical purposes, it is necessary to carry out a careful examination of the different horizons created by the progress in the evolution of the soil under the influence of climate, etc. Samples from each horizon and subhorizon must be collected for scrutiny in the laboratory.



The above photo shows clearly the different horizons A, B, and C. The soil was formerly covered by oak trees, now under a cover of couch grass (Triticum repens); in the neighbourhood of old oaks; some hundred paces further oak forest; slightly sloping land.

A: 12 inches; crumbly sandy loam; grey brown. containing carbonate of lime.

B_1: 2 inches; reddish-brown sandy loam.

B_2: 8 inches; reddish-brown sandy loam shading from dirty red-brown to black; hard; containing carbonate of lime; soil particles prismatic,

C: 40 inches and more; light coloured; weathered limestone; friable. white lime horizon.

(The amount of carbonate of lime in solution in the A and B horizons probably increased after deforestation).

The horizons have been divided as follows:—

A. Eluvial—Horizon from which materials are leached either by chemical or mechanical means.

B. Illuvial—Horizon into which materials are leached. (Hard pans, deposited material, etc.).

C. Parent material from which overlying soil has been produced.

and described in detail in "Proceedings of the 7th Annual Congress of the South African Sugar Technologists' Association."[4]

It already will be clear that, for reliable results, soil studies must be entrusted to specialists who understand the significance of all the different factors. Laymen are apt to lose patience with the slow going scientist for not being able to obtain quick results, and often would like to step in and hasten matters to a rapid close so as to be able to commercialise results. Research is a slow process of computation and elimination by careful investigation of the subject carried out progressively, and any interuption of this scheme by the layman is obviously as much of a menace to progress as would be a scientist who overlooks the slightest details when making pronouncements on scientific subjects.

With further reference to pedology "The old Russian school of soil scientists thoroughly worked out the principles of genetic pedology based chiefly on morphological and but partly on chemical properties of soil horizons. In more recent years, as a result of investigations in the United States, in England, in Germany and elsewhere, on the role of micro-organisms in the soil, an extensive and very fruitful biological trend was created in soil science, while by ascertaining the role and importance of the soil absorbing complex, a new branch of science, which can easily be termed soil physiology, has been created. The surface vegetation has been, so far, studied mainly by botanists, and consequently, its importance as a factor in soil formation has appeared to be of less significance than it really is. Because soils were studied independently from plants we failed to appreciate the laws governing the close relationship between plants and soil, which exists in nature. And since all problems of agronomy may eventually be reduced to the question of the relationship between plants and soil, the importance of the said branch of science becomes most obvious."[5]

Thus having described briefly the soil from the geological and pedological point of view with the governing factors, it becomes essential to discuss the mineral side in a little more detail since we are going to study particularly the potash question of soils and try to elucidate why certain effects are sometimes obtained in the field which are contrary to what the casual observer thinks should occur.

The breakdown of minerals is a most important process. The major part of the decomposition is attributed to water. The most important agencies in breaking down the rocks and rocky material on the globe's surface are:—water; ice; air in circulation; sun's rays; plants and animals. Much study has been carried out on the effect of the action of water and solutions on the decomposition of minerals. Following the action of water in contact with practically any mineral it is well known that some of the constituents are brought into solution. With a rise in the temperature, the dissolving properties of water are enhanced. It is also obvious that the dissolving properties of water are increased for certain minerals if it contains carbon dioxide taken up from the atmosphere or soil. The same applies again between pure water and water already containing other salts.

It is the type and amount of minerals in solution in the soil which ultimately governs the fertility of soils, and in this connection it must be borne in mind that there are so many factors which influence the amount of minerals in the soil solution, that great care must be taken before coming to any conclusions concerning this point. One might imagine for instance that an aqueous extract of the soil would give a proper insight into the state of affairs in soil solutions, but it must be remembered that the quantity of potash in water extracts of soil can only furnish approximate information concerning the amount of potash present. "In fact the potash content of the extract also depends as much on the momentary concentration of nitrates, chlorides and sulphates as it does on the soil potash. Following the fixing properties of soil colloids, and the fact that the dissolved salts are not dispersed uniformly in the soil water, one cannot in this way obtain, even from a comparative point of view, a true picture of the natural soil solutions."[6]

This brings us directly to the absorption powers of soils with special reference to potash. An experiment may be put down on a soil which has high fixation powers with regard to potash and thus may not, at first, show any response to this ingredient. This is not because the soil is rich enough in potash but because the degree of saturation of the soil colloids regarding potassium is too low to allow any apparent effect at that level of application. One can at the same time imagine the possibility of an insufficient application of potash to sugar cane put in the furrow having an effect on the first crop. This may be explained by positional availability and in addition localised chemical availability for a short period. The rooting of cane being a rapid process the cane is thus able to utilise the small amount of extra available potassium in the soil to advantage. Subsequent top or side dressings of insufficient amounts would never get anywhere near the feeding roots but remain fixed in the upper few centimetres of soil.

An example of fixation is given by an experiment carried out on clay containing a supply of calcium and on clay without any bases, both treated with chloride solutions alone or mixed.[7]

Limey Clay.

Milliequivalents, grammes % grammes.	Ammonium, Chloride.	Potassium Chloride.	Sodium Chloride.	Ammonium +Potassium Chloride.	Ammonium +Sodium Chloride.	Potassium +Sodium Chloride.	Ammonium +Potassium +Sodium Chloride,
Lime displaced	41.8	42.0	35.7	42.7	42.5	42.3	43.2
Ammonia fixed	42.3	—	—	20.5	37.4	—	20.4
Potassium fixed	—	41.4	—	23.4	—	34.2	19.3
Sodium fixed	—	—	35.7	—	5.0	6.6	3.6
Total	42.3	41.4	35.7	43.9	42.4	40.8	43.3

Clay deprived of exchangeable bases.

Milliequivalents, grammes % grammes.	Ammonium Chloride.	Potassium Chloride.	Sodium Chloride.	Ammonium Lime.	Potassium Lime.	Sodium Lime.
Cations fixed	42.4	42.1	41.2	24.1, 19.8	26.1, 18.4	34.0, 9.0
Total	42.4	42.1	41.2	43.9	44.5	43.0

Equilibrium is always finally established. The higher the lime contents of the clay the more energetic is the potash fixation.

The displacement of bases by carbonic acid gas was described by Andre in 1921 quoting from experiments carried out in 1911. A hydrated silicate was treated with water charged with carbon dioxide. The composition of the silicate, excluding the water contained, was as follows:—

Silica	46.6%
Alumina	29.3%
Potash	22.7%
Soda	1.4%

After the action of the carbonic acid gas the composition was modified as follows:—

Silica	54.0%
Alumina	39.6%
Potash	5.3%

The major part of the potash was therefore dissolved under the influence of an excess of carbon dioxide. If this silicate which has become modified is put into contact with a potash solution, its composition becomes:—

Silica	46.6%
Alumina	35.6%
Potash	17.7%

The silicate has therefore taken up all the material which the carbonic acid gas made it lose, but treated with water, it again loses a portion of its potash. It becomes obvious, following this, that the variations of composition of the original silicate, depend on the amount of water used on the one hand, and the quantity of potash on the other. The original silicate treated with ammonium chloride, exchanged practically the whole lot of potash against the ammonia; it then shows the following composition:

Silica	56.1%
Alumina...	34.6%
Potash	0.9%
Ammonia (NH_3)	8.3%

The results show that 8.3 of ammonia has replaced 22.7 — 0.9 = 21.8 potash.[8]

Thus it is seen that the soil minerals are not stable but can enter and be thrown out of solution by a phenomenon base exchange which is in itself a most complicated series of reactions in an ever varying medium, and in practice nothing so simple as has just been described occurs, although the principle holds good and allows us now to realise that soil exhaustion can follow not only from cropping without applying sufficient fertiliser, but actually accelerated by using an ingredient (unbalanced fertiliser) which can be partially fixed itself releasing thereby a certain amount of so called partially unavailable material, for immediate requirements.

Further research has revealed that whilst work was undertaken in soil potash investigation under the assumption that all the K (potash ion) added to the soil would be recoverable by leaching the soil with ammonium acetate, that actually, contrary to statements in literature and data established according to field observations to the effect that fixation in a non-replacable form would take place but probably be slow, it was found that appreciable quantities of K were fixed by certain soils very rapidly and perhaps immediately. "In a few instances, the major part of the K (potash ion) added was so fixed, the amounts involved corresponding to a range of light to very heavy fertiliser applications. During the progress of these experiments, the report of Sears (20) was published. Incidental to a general investigation of an infertile Illinois soil, Sears found that this soil was capable of fixing large amounts of K (potash ion) in non- replacable form. The Illinois soil contained high amounts of $CaCO_3$ (calcium carbonate) but our results show that such fixation may occur in soils not containing appreciable amounts of carbonate."[9]

Soil 37 discussed, and forming part of the experiment carried out by the same authors shows the following analysis according to their figures:—

No.	Classification.	Origin.	pH	Re-placeable K in soil. p.p.m.	Total K %	Replaceable bases, M.E. per 100 gm. soil. Ca.	Mg.	K.	Na.	Total.	NH_4 absorbed.	Relative proportion of bases. Per cent. of total. Ca.	Mg.	K.	Na.	Fixing power (basis of 1 : ½ H_2O extract) K added to soil	K fixed %
37.	Nord fine sandy loam	Chico	8.2	60	0.6	15.27	15.2	0.15	0.39	31.01	29.75	49.2	49	0.5	1.3	p.p.m. 396	98

"Soil 37 showed an especially marked deficiency in ability to supply K to plants (barley, tomatoes, maize, lucerne. prune trees and other plants), and also possessed a very striking power of fixation. After addition of soluble K salts, even in amounts far exceeding those used in ordinary fertiliser practice, 97 to 99% of the added K did not appear in the displaced soil solution."[10]

In 1936 work was done on the same problem in France. Twenty different soil types were under test and were put in contact with a solution of potassium chloride corresponding to 50 milligrammes of K_2O per 100 grammes of soil. Two weeks later, the exchangeable potash was displaced by washing with an ammonium acetate solution. In thirteen out of twenty soils 10—29% of the quantity of potash applied to the soil was in non-exchangeable form. Further a sandy clay soil was tested which has received an annual dressing of 250lb. of K_2O per acre per annum for eight consecutive years. Every year in November samples were taken and checked for exchangeable potash with the following results:—

Dates of sampling.	K_2O content milligrammes K_2O per 100 grammes of soil.	K_2O % of exchange capacity at pH7.	Annual rise in potash content in exchangeable potassium.
November, 1929 ...	13.7	2.2	—
November, 1930 ...	15.4	2.5	1.7
November, 1931 ...	17.3	2.8	1.9
November, 1932 ...	20.1	3.2	2.8
November, 1933 ...	22.4	3.6	2.3
November, 1934 ...	24.7	3.9	2.3
November, 1935 ...	30.9	4.9	6.2

The annual rises in exchangeable potash up to 1934 are very much smaller than the quantities applied—since the losses of potash in the drainage waters are negligible—these differences cannot be explained otherwise than by the fact that a considerable fraction of the potash applied reverted to a non-excangeable form. At the end of the experiment the exchangeable potash content of the soil increased in such a way that all the potash applied was in exchangeable form.[11]

Another example of soil "potash hunger" is given by Dr. Hissink, Director of the Soil Institute, Groningen, Holland, in a note written in November 1935.

It was found that in certain clay soils of Holland an ordinary dressing of potash is not sufficient to overcome potash deficiency symptoms. In this case it was not deemed necessary to consider the high fixing power of some clay soils as a reason for this condition, but the low quantities of potash in exchangeable or absorbable form.

Two soils under pasture were examined. One of the pastures was very poor and incidentally has never received potash applications, and the other good and potash is applied regularly. It transpired that the soil which is treated is actually high in total potash content as well as potash in exchangeable form. The exchangeable potash in the poor pasture soil is low.

The two soils were identical in their capacity to fix potash or adsorb it in a more or less unavailable form. The only difference between them is that the good pasture soil contains per acre 25 centimetres 1,280 lb. of potash *in an exchangeable form* (2,133 lb. KCl.); whereas the poor pasture soil only contains 300 lb. (500 lb. potassium chloride), which makes a difference of roughly 1,000 lb. of K_2O per acre. It becomes quite obvious therefore that the soil poor in exchangeable potash must be allowed to fix (adsorb) 1,000 lb. of K_2O per acre in the clay comlpex before it can be on a par with the good soil.

Consequently heavy clay soils with a high clay content, low in *exchangeable potash*, have to fix large quantities before their store of easily available potash for plants is at a satisfactory level. Therefore, taking into consideration the potash taken up by plants and possible or actual loss in drainage water, to enable the top layer of such soil to fix 1,000 lb. of K_2O per acre, a great deal more than 1,000 lb. K_2O per acre must be applied.[12]

This is of extreme importance from an agricultural point of view since it shows that the so-called "soil hunger" for potash **must be satisfied before** the soil **can supply adequate quantities for high yields and general results can be expected.**

Statements made about the "enormous reserves" of potash in the soil should only be made with extreme caution and certainly never without qualification.

It has been calculated that 12,000 lbs. K_2O per acre[13] is the minimum amount of potash necessary to enable good agriculture to be practiced. Thus taking into consideration the high fixing powers of mineral and organic soil complexes, in addition to already partially chemically unavailable material, great care must be taken before a soil is pronounced to have adequate potash reserves so that no applications of potash fertiliser are necessary, because, as must be clear already, the exchangeable fraction is the only one which is of immediate importance.

For years now officials have recommended phosphate and practically nothing but phosphate applications as being adequate to meet the needs of the Sugar Cane crop in Natal. In any case **no reserves are inexhaustible** and we must try to **make up our minds as to whether we are going to farm up to a standard by maintaining and increasing the fertility of our soils, or down to a standard** and move on to the next place when the work of soil exhaustion is completed.

Fertility.

Fertility is a condition of the soil which must be maintained at a certain level for the production of crops. The state of fertility varies from 0—100 with climatic influences reducing or adding to actual percentage values.

We have developed methods to test fertility in such a manner as to be able to classify certain soils as very fertile, others as medium, and those which are termed poor. There are many different soils under each heading but they are not all there for the same specific reason.

The analysis of a soil may be either to determine its chemical value, physical condition (proportions of stones, coarse sand, fine sand, clay etc.) or to examine it from a biochemical point of view, or again perhaps only to study the microflora or microfauna of the soil. The direct applicability to the field of findings in the laboratory depends on the methods used. Some appear to come nearer the actual state of affairs reigning in the soil for certain conditions than others. The ultimate value of an analysis depends on the capability and experience of the interpreter, for it is his job to know how to make findings in the laboratory and field conditions combine.

In the laboratory deficiencies can be detected and totals determined—availables, however, are still questionable. It is certain that all the information obtainable is of the greatest value to decide what questions will be put in the field in order to get answers which will throw light on treatments necessary. Here it is essential to point out the necessity for a proper plan of campaign. Field experiments must be planned with a view to getting answers, as far as possible, to certain questions and not just in order to fire random questions at the soil, or plant or both and hand all ultimate figures over to the statistician for him to discover what you wanted to know. No amount of statistical analysis will make up for faulty technique or lack of knowledge regarding the fundamental principles of agronomy in the first place when the experiment was being planned.

It is essential to educate the public and teach the proper use of ertilisers so as to ensure that maximum results are obtained. The education of a rural population is a slow process, although great strides have been made in recent years, especially with regard to the better use of fertilisers. "In nearly every country to-day there is a general opinion that agriculture can only be made to pay by the intensive use of all auxiliary methods which science can place at the disposal of the practical farmer. In countries where the area of cultivated land is relatively small, the realisation of the above point is shown by the fact that every possible acre is raised to the highest degree of productivity by the use of the best pedigree seeds or plants, thorough cultivation, careful regard to drainage and the the judicious and liberal use of commercial fertilisers. Where cultivated land is unlimited in extent, as in many overseas countries, agricultural science is rendering it possible to detach unsuitable districts from the agricultural area proper and to devote them to afforestation and other purposes, while more practical and scientific attention is paid to smaller areas which are better adapted to agriculture, instead of cultivating superficially too large tracts of land. Both in the latter countries and in countries of limited agricultural land one of the results of the spread of agricultural science has been a more liberal and intelligent use of artificial fertilisers in the actual agricultural areas. The result of the breeding of superior types of plants, which has led in the last decade to better crops and larger yields, has been the evolution of new varieties which require and utilise larger quantities of nutrients than the old sorts which could subsist for a time on farmyard manure and the small supplies of the plant foods in the soil. In several overseas countries, where for historical reasons the term "commercial fertiliser" was for years considered synonymous with phosphatic fertiliser, the dissemination of results of scientific research has led to the use of fertiliser mixtures containing all of the essential plantfoods, particularly increasing quantities of potash."[14]

Through the misuse of fertilisers, or through the application of an unbalanced artificial manure year after year, even though that or those ingredients may be considered to be the limiting factors at the time, soil reserves are being taxed and the extreme stage of exhaustion is getting nearer when deficiency symptoms will set in. When this state of affairs arises the remedy is much more expensive than would have been the logical commonsense policy of systematically applying quantities of the material **to replace what has been taken out.**

Unfortunately, due to lack of knowledge or faulty technique in the field and initial conception of soil management, a great many inaccurate statements are continually being made regarding the use of fertilisers in general and potash in particular. Returns must govern expenditure on fertilisers as well as the amount in lb. per acre to be used. Quantities of 800 to 1,000 lbs or more of a mixture may appear high to the uninitiated but it must be borne in mind that some soils have to be built up first before large increases of yield can be obtained, whereas others will respond to smaller dressings having a naturally richer soil solution.

Planters must acquire a proper working knowledge of fertilisers to appreciate their value both from the soil and crop point of view as well as their value regarding plant food content.

Sales policies and the reactions of the farming community have probably influenced a large number of mixtures on the market to-day. Keen competition between different firms and lack of knowledge on behalf of the farmers will account for the low plant food content in a great many mixtures.

If the planters would give themselves a little trouble to master a few arithmetical equations in connection with fertilisers all would be well and more time could be usefully spent considering the condition of the crop and soil.

Regarding what may be termed adequate dressings of potash, per acre, one must remember that this incurrs a quantity which ensures a sufficient supply of potash to give the maximum yield of cane and sucrose per acre and does not allow the crop to encroach on the natural reserves of potash in the soil but leaves the soil after cropping in as fertile a condition as is consistent with good agricultural practice. This quite obviously also applies to all the other ingredients concerned in plant growth. The choice of quantities and quality of material to be used should only be crystallised after due consideration of the necessity for an adequate balance of ingredients based on results obtained from field trials carried out on a sound basis.

Results of a Field Trial.

The investigation of the effects of a single ingredient on crop yield cannot be adequately carried out without some reference to the others. It must be one's endeavour to pursue a course of work as consistent as possible with findings in the agricultural and generally scientific world.

Years ago it was considered sufficient to put down a few plots, calculate the averages and act accordingly in the field on a larger scale. Little or no attention was paid to soil variation which was regarded as inevitable.

In the discussions of results put before you on previous occasions it has been pointed out that lack of effect of any single ingredient may have been due at times to too little of it alone or lack of ability of an element to respond on account of an insufficiency of another in the soil. This was the case in 1936 when the results of an experiment reported on seemed to show a depressing effect from nitrogen. Accompanying these effects it appeared that potash overcame the depressing effects of nitrogen. Applied in extra large quantities compared with local practices the potash used did not appear to overcome the effects of the nitrogen. This was explained by assuming the potash to have been absorbed by the upper layers of the soil especially since it was given in several top dressings of relatively small amounts.

Throughout there has been close co-operation between the men in the laboratory and the field with the result that assumptions based on final data were a combination of laboratory and field results which allow of a much clearer view than could be obtained from either taken separately.

This experiment put down in 1933 on a white wind blown sand fully described at the 1937 Congress of this Association[15] was harvested again as first ratoon in 1937. No further fertiliser dressings were applied so as to test possible residual effects of previous treatments.

The total rainfall on the ratoon was 86.77 inches, distributed as follows:—

	1935	1936	1937
January	—	6.16	2.07
February	—	10.29	10.88
March	—	7.95	1.52
April	—	1.28	4.79
May	—	8.38	0.00
June	—	0.71	2.22
July	—	0.64	0.99
August	—	0.16	1.33
September	—	2.13	0.61
October	—	4.76	2.59
November (from 18th, 1935	0.71	10.95	1.26
December to 13th, 1937)	2.21	2.18	—

It will be noticed that with a total of 99.59 inches of rain the plant cane received 12.82 inches more than the first ratoon.

The original fertiliser dressings were as follows:

FORMULA.	TREATMENT.	N		P_2O_5		K_2O	
O	No Fertiliser	—	Total	—	Total	—	Total
P	200 Super 19.1%	—		38.2 w.s.		—	
NP	200 Super 19.1% .. .. .. 84.5 Sulphate of Ammonia .. .. 165 Whale Guano No. 1	— 17.41 17.32	34.73	38.2 w.s. — 45.2 c.s.	48.25	— — —	
NPK	200 Super 19.1% .. .. .. 84.5 Sulphate of Ammonia .. .. 165 Whale Guano No. 1 .. .. 100 Muriate of Potash 60% .. .. 124 Sulphate of Potash	— 17.41 17.32 — —	34.73	38.2 w.s. — 45.2 c.s. — —	48.25	— — — 60.1 60.12	120.22
FPNPK ..	200 Super 19.1% .. .. .. 84.5 Sulphate of Ammonia .. .. 165 Whale Guano No. 1 .. .. 100 Muriate of Potash .. .. 124 Sulphate of Potash .. .. 20 tons Filter Press Cake	— 17.41 17.32 — — 308.00	342.73	38.2 w.s. — 45.2 c.s. — — 640.00	688.25	— — — 60.1 60.12 —	120.22
FP_2NPK ..	200 Super 19.1% .. .. .. 84.5 Sulphate of Ammonia .. .. 165 Whale Guano No. 1 .. .. 100 Muriate of Potash 60% .. .. 124 Sulphate of Potash .. .. 40 tons Filter Press Cake	— 17.41 17.32 — — 616.00	650.73	38.2 w.s. — 45.2 c.s. — — 1280.00	1328.25	— — — 60.1 60.12 —	120.22
N_2PK	200 Super 19.1% .. .. .. 179 Sulphate of Ammonia .. .. 330 Whale Guano No. 1 .. .. 100 Muriate of Potash .. .. 124 Sulphate of Potash	— 36.87 34.64 — —	71.51	38.2 w.s. — 51.8 c.s. — —	56.5	— — — 60.1 60.12	120.22
NP_2K	400 Super 19.1% .. .. .. 84.5 Sulphate of Ammonia .. .. 165 Whale Guano No. 1 .. .. 100 Muriate of Potash .. .. 124 Sulphate of Potash	— 17.41 17.32 — —	34.73	76.4 w.s. — 83.8 c.s. — —	88.25	— — — 60.1 60.12	120.22
NPK_2	200 Super 19.1% .. .. .. 84.5 Sulphate of Ammonia .. .. 165 Whale Guano No. 1 .. .. 200 Muriate of Potash .. .. 248 Sulphate of Potash	— 17.41 17.32 — —	34.73	38.2 w.s. — 45.2 c.s. — —	48.25	— — — 120.2 120.28	240.48
$N_2P_2K_2$	400 Super 19.1% .. .. .. 179 Sulphate of Ammonia .. .. 330 Whale Guano No. 1 .. .. 200 Muriate of Potash .. .. 248 Sulphate of Potash	— 36.87 34.64 — —	75.51	76.4 w.s. — 90.4 c.s. — —	96.5	— — — 120.2 120.28	240.48
FP $N_2P_2K_2$ ..	400 Super 19.1% .. .. .. 179 Sulphate of Ammonia .. .. 330 Whale Guano No. 1 .. .. 200 Muriate of Potash .. .. 248 Sulphate of Potash .. .. 20 tons Filter Press Cake	— 36.87 34.64 — — 308.00	379.51	76.4 w.s. — 90.4 c.s. — — 640.00	736.5	— — — 120.2 120.28 —	240.48
$FP_2N_2P_2K_2$ ..	400 Super 19.1% .. .. .. 179 Sulphate of Ammonia .. .. 330 Whale Guano No. 1 .. .. 200 Muriate of Potash .. .. 248 Sulphate of Potash .. .. 40 tons Filter Press Cake	— 36.87 34.64 — — 616.00	687.51	76.4 w.s. — 90.4 c.s. — — 1280.00	1376.5	— — — 120.2 120.28 —	240.48
$N_3P_2K_2$	400 Super 19.1% .. .. .. 179 Sulphate of Ammonia .. .. 330 Whale Guano No. 1 .. .. 150 Nitrate of Soda .. .. .. 200 Muriate of Potash .. .. 248 Sulphate of Potash	— 36.87 34.64 24.00 — —	95.51	76.4 w.s. — 90.4 c.s. — — —	96.5	— — — — 120.2 120.28	240.48
$N_2P_3K_2$	600 Super 19.1% .. .. .. 179 Sulphate of Ammonia .. .. 330 Whale Guano No. 1 .. .. 200 Muriate of Potash .. .. 248 Sulphate of Potash	— 36.87 34.64 — —	71.51	114.6 w.s. — 129.0 c.s. — —	136.5	— — — 120.2 120.28	240.48
$N_2P_2K_3$	400 Super 19.1% .. .. .. 179 Sulphate of Ammonia .. .. 330 Whale Guano No. 1 .. .. 334 Muriate of Potash .. .. 412.5 Sulphate of Potash	— 36.87 34.64 — —	71.51	76.4 w.s. — 90.4 c.s. — —	96.5	— — — 200.0 200.0	400.0
$N_3P_3K_3$	600 Super 19.1% .. .. .. 179 Sulphate of Ammonia .. .. 330 Whale Guano No. 1 .. .. 150 Nitrate of Soda .. .. .. 334 Muriate of Potash .. .. 412.5 Sulphate of Potash	— 36.87 34.64 24.00 — —	95.51	114.6 w.s. — 129.0 c.s. — — —	136.5	— — — — 200.0 200.0	400.0
FP $N_3P_3K_3$ ..	600 Super 19.1% .. .. .. 179 Sulphate of Ammonia .. .. 330 Whale Guano No. 1 .. .. 150 Nitrate of Soda .. .. .. 334 Muriate of Potash .. .. 412.5 Sulphate of Potash .. .. 20 tons Filter Press Cake	— 36.87 34.64 24.00 — — 308.00	403.51	114.6 w.s. — 129.0 c.s. — — — 640.00	776.5	— — — — 200.0 200.0 —	400.0
$FP_2N_3P_3K_3$ ..	600 Super 19.1% .. .. .. 179 Sulphate of Ammonia .. .. 330 Whale Guano No. 1 .. .. 150 Nitrate of Soda .. .. .. 334 Muriate of Potash .. .. 412.5 Sulphate of Potash .. .. 40 tons Filter Press Cake	— 36.87 34.64 24.00 — — 616.00	711.51	114.6 w.s. — 129.0 c.s. — — — 1280.00	1416.5	— — — — 200.0 200.0 —	400.0

The first ratoon yields were as follows ;—

	O	P	NP	NPK	FP NPK	FP$_2$NPK	N$_2$PK	NP$_2$K	NPK$_2$
Tons cane per acre	22.664	21.08	20.824	29.024	33.732	33.164	26.364	26.60	24.412
Increase or decrease over controls	—	−1.584	−1.84	6.36	11.068	10.5	3.70	3.936	1.748
% increase or decrease over controls	—	−6.989	−8.119	28.062	48.835	46.329	16.325	17.367	7.713
Sucrose % cane	14.32	14.54	14.64	14.82	14.78	14.36	14.34	14.66	14.68
Tons sucrose per acre	3.249	3.073	3.054	4.323	4.987	4.773	3.809	3.921	3.589
Increase or decrease over controls	—	−0.176	−0.195	1.074	1.738	1.524	0.56	0.672	0.34
% increase or decrease over controls	—	−5.417	−6.001	33.056	53.493	46.907	17.236	20.683	10.465
Juice ; Brix	21.32	21.53	21.73	22.10	21.97	21.46	21.34	21.74	21.93
Purity	93.34	93.74	93.66	93.14	93.44	92.76	93.3	93.66	92.78
Value (total) of sucrose per acre at £5.4303 per ton	£17 12 10	£16 13 9	£16 11 8	£23 9 6	£27 1 7	£25 18 4	£20 13 8	£21 5 10	£19 9 9
Value of increase or decrease over controls	—	−0 19 1	−1 1 2	5 16 8	9 8 9	8 5 6	3 0 10	3 13 0	1 16 11
Half Cost of fertiliser treatment	—	0 3 0	0 11 7	1 3 1	2 17 1	4 7 1	1 12 1	1 6 2	1 14 8
Nett gain or loss over controls	—	−1 2 1	−1 12 9	4 13 7	6 11 8	3 18 5	1 8 9	2 6 10	0 2 3
Standard error in tons between treatment at 19 : 1 odds	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
% standard error between treatments	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Value of standard error between treatments	£3 3 0	£3 3 0	£3 3 0	£3 3 0	£3 3 0	£3 3 0	£3 3 0	£3 3 0	£3 3 0
General mean in tons sucrose	4.29	4.29	4.29	4.29	4.29	4.29	4.29	4.29	4.29
% of yield in tons sucrose on general mean of sucrose per acre	75.734	71.632	71.189	100.769	116.247	111.235	88.788	91.399	83.660
Nett gain or loss over controls, both seasons	—	−£0 18 9	−0 3 1	£12 6 0	£16 16 6	£12 12 4	£4 11 4	£5 8 10	£0 15 5
Value of standard error between treatments over both seasons	£5 10 10	5 10 10	5 10 10	5 10 10	5 10 10	5 10 10	5 10 10	5 10 10	5 10 10

	N$_2$P$_2$K$_2$	FP N$_2$P$_2$K$_2$	FP$_2$N$_2$P$_2$K$_2$	N$_3$P$_2$K$_2$	N$_2$P$_3$K$_2$	N$_2$P$_2$K$_3$	N$_3$P$_3$K$_3$	FP N$_3$P$_3$K$_3$	FP$_2$N$_3$P$_3$K$_3$
Tons cane per acre	27.672	34.296	36.772	26.576	29.70	32.70	25.796	34.716	41.50
Increase or decrease over controls	5.008	11.632	14.108	3.912	7.036	10.036	3.132	12.052	18.836
% increase or decrease over controls	22.096	51.323	62.248	17.261	31.045	44.282	13.819	53.177	83.110
Sucrose % cane	14.62	14.48	14.26	14.78	15.04	14.84	14.62	14.8	14.42
Tons sucrose per acre	4.051	4.991	5.240	3.933	4.491	4.870	3.763	5.138	5.974
Increase or decrease over controls	0.802	1.742	1.991	0.684	1.242	1.621	0.514	1.889	2.725
% increase or decrease over controls	24.684	53.616	61.280	21.053	38.227	49.892	15.820	58.141	83.872
Juice ; Brix	21.83	21.68	21.43	21.98	22.38	22.03	21.80	22.11	21.64
Purity	93.02	92.86	92.28	93.3	93.26	93.68	92.82	92.88	92.52
Value (total) of sucrose per acre at £5.4303 per ton	£21 19 11	£27 2 1	£28 9 1	£21 7 2	£24 7 9	£26 8 11	£20 8 8	£27 18 0	£32 8 10
Value of increase or decrease over controls	4 7 1	9 9 3	10 16 3	3 14 4	6 14 11	8 16 1	2 15 10	10 5 2	14 16 0
Half Cost of fertiliser treatment	2 6 8	4 0 8	5 10 8	2 13 3	2 9 9	3 2 1	3 11 8	5 5 8	6 15 8
Nett gain or loss over controls	2 0 5	5 8 7	5 5 7	1 1 1	4 5 2	5 14 0	−0 15 10	4 19 6	8 0 4
Standard error in tons between treatment at 19 : 1 odds	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
% standard error between treatments	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Value of standard error between treatments	£3 3 0	£3 3 0	£3 3 0	£3 3 0	£3 3 0	£3 3 0	£3 3 0	£3 3 0	£3 3 0
General mean in tons sucrose	4.29	4.29	4.29	4.29	4.29	4.29	4.29	4.29	4.29
% of yield in tons sucrose on general mean of sucrose per acre	94.429	116.317	122.144	91.678	104.685	113.520	87.716	119.767	139.231
Nett gain or loss over controls, both seasons	£5 4 0	£14 13 6	£14 15 6	£4 0 9	£12 1 4	£12 16 11	£2 16 8	£13 2 2	£18 17 7
Value of standard error between treatments over both seasons	£5 10 10	5 10 10	5 10 10	5 10 10	5 10 10	5 10 10	5 10 10	5 10 10	5 10 10

It is of interest to note that the controls and P gave slightly higher yields than they did as plant cane, although the differences are not significant. Also the controls yielded slightly less than P as plant cane but more than P as first ratoon.

P_2 does not appear effective against the depressing effect of nitrogen, which seems to carry its effect particularly when in a state of unbalance with other ingredients into the ratoon crop.

P_3 again stood for an increase, although not a significant one, over $N_2P_2K_2$. The increase was significant in plant cane.

The depressing trend of N by increasing N to N_2 in NPK appears to be maintained in the ratoon, although it is not a significant figure as it was in the case of plant cane.

N added to P in NP appears negative, as does N_3 in $N_3P_2K_2$ compared with $N_2P_2K_2$, although there appear to be indications of interaction between N and K in this connection if one studies the $N_2P_2K_2$ series and then the effect of K_3.

K added to NP has given a very significant increase from residual effects as well as it did on the plant cane. K_2 depressed the yield of the ratoon as well as the plant cane, both figures were significant. N_2 with K and K_2 with N appear to be an undesirable set of combinations, and it is interesting to observe the combined effect which again suggests interaction because N_2P_2 and K_2 was 0.1 ton of sucrose higher than NP_2K, which had the least depressing effect, 0.4 tons sucrose higher than NPK_2 and 0.2 tons higher than N_2PK.

K_3 increased the yield significantly on both the plant cane and the ratoon. The increase on plant cane was 1.03 tons and on the ratoon 0.82 tons over $N_2P_2K_2$.

There is a significant difference on both plant cane and ratoon when 20 tons of filterpress cake was applied to the plant cane in addition to NPK. A further 20 tons added to NPK, giving a total of this fertiliser plus 40 tons of filterpress cake per acre actually depressed the yield over FP NPK. A further examination of the results also shows that $N_2P_2K_2$ plus FP and FP_2 does not augment the yield significantly, nor does $N_3P_3K_3$ plus FP. FP_2 plus $N_3P_3K_3$ actually gives the highest yield in the experiment, exceeding any other treatment by at least 0.6 tons of sucrose per acre.

This experiment is one of the last of a series of random blocks put down some time ago. We feel we have obtained all we can from experiments of this type which have served their purpose in their time in a very efficient manner. It is our intention in the future to make use of more complex layouts in order to get more data than we have been able to obtain in the past and especially to examine the point so often mentioned to you of interaction between various ingredients used. Knowledge of interactions is certainly not new but we have as yet to investigate the different effects under our conditions.

Potash Deficiencies.

Little has been done regarding the investigation of the deficiency symptoms of Sugar Cane, but nevertheless there are some data available. It is fully realised that it is quite possible that the different varieties might not necessarily exhibit exactly the same symptoms and also that the requirements of one variety for the particular ingredient might be higher than for another. At any rate some reference to potash deficiency symptoms, according to different workers, will be of value.

It has been found that the roots of Potash Deficient cane only form a few side roots all in the region of the root base and that they die prematurely.[16]

C. E. Hartt observed that the stalks of sugar cane suffering from Potash Deficiency were covered with a mass of aerial roots. According to another author Potash Deficient sugar cane plants develop a good tap root but very few side shoots. Root rot is also enhanced by the absence of sufficient Potash. Typical of Potash Deficiency is the browning of sugar cane leaves which die from the tip inwards.[17]

According to Honert[18] studying Potash Deficiency Symptoms on P.O.J.2878:

"5. When the tips dry up typical small red spots appear on the midrib. First the white air-filled tissue of the mid-rib takes on a dirty yellowish discoloration in strips here and there and when these discoloured parts die off the red spots appear alongside them. The spots later become brown.

6. The spots and the drying up of the leaves from the tips downwards are typical potash deficiency symptoms.

7. The spots caused by potash deficiency remain visible even after the death of the leaf.

8. The number of shoots **formed** was apparently not affected by potash deficiency but the young ones often died off early.

9. After the death of these weak shoots one or two strong ones often appear suddenly; the greater the degree of potash deficiency the later do they appear.

10. As the cane became older the symptoms on the leaves became less obvious and at the time of cutting they were visible only on a few leaves.

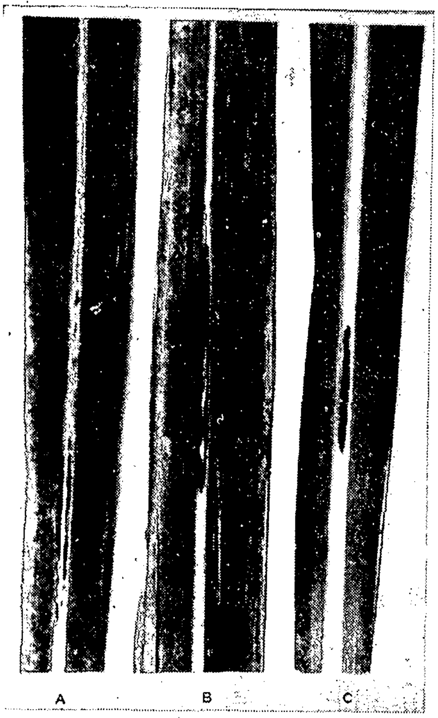


Photo 4.
Potash Deficiency Symptoms along the mid-rib of the sugar cane leaf. The severity of the symptoms increases from left to right.
Photo P. O. J. Pasoeroean.

Photo 5.
Discolorations on the mid-rib of the sugar cane leaf caused by insect damage. The symptoms are exteriorally similar to Potash Deficiency Symptoms.

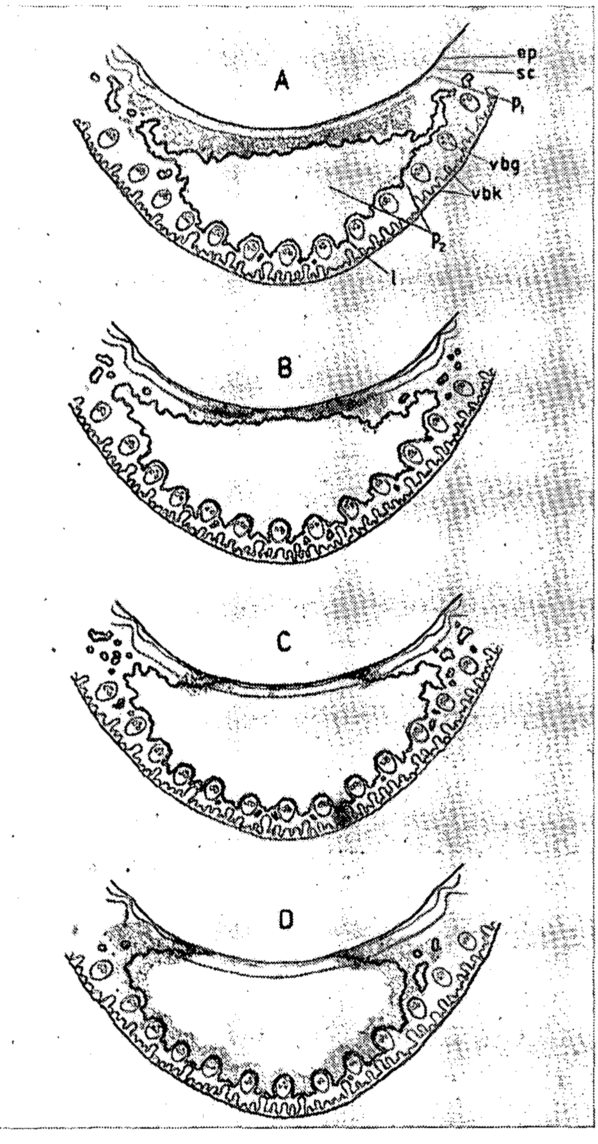


Photo 6.
:ross Section through the mid-rib of the sugar cane leaf, enlarged nd diagrammatic. A, B, and C show Potash Deficiency whilst D is ıot Potash Deficiency. (The shaded portion indicates reddened reas).

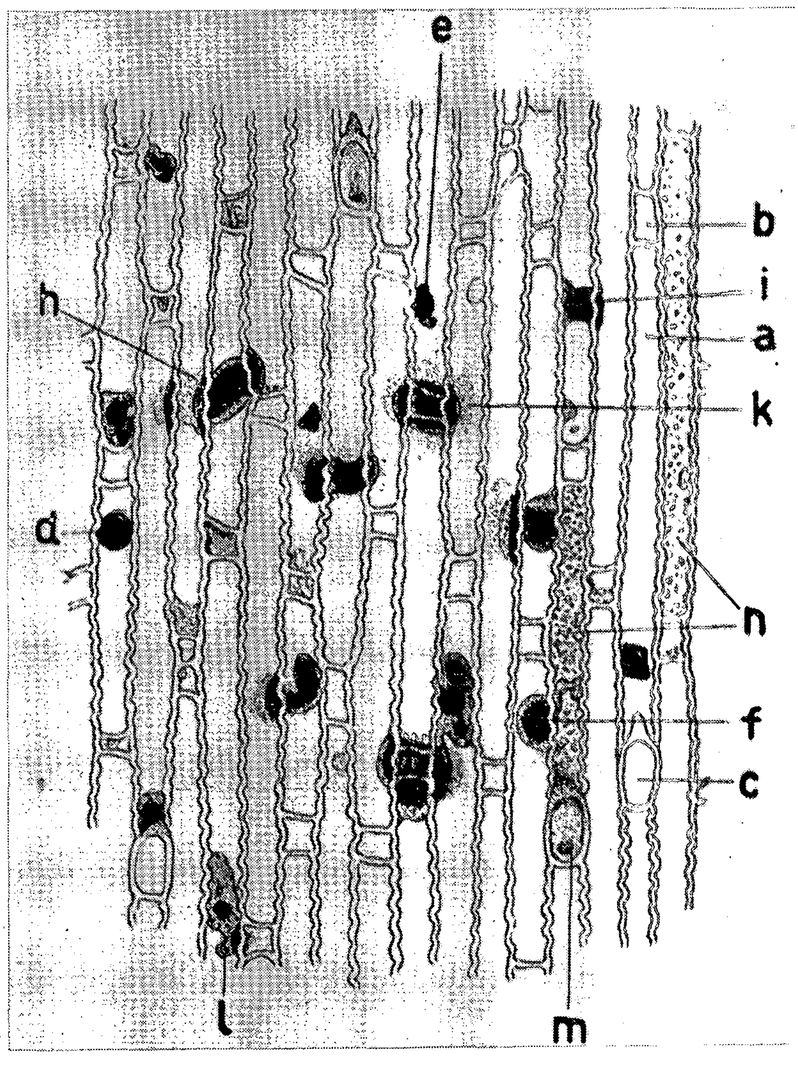


Photo 7.
Drawing of the epidermis of the mid-rib of a sugar cane leaf showing the rubbery bodies the long epidermal cells. Slight potash deficiency usually results in the formation of sm regular round bodies in the long epidermal cells (c, d, e, f) whilst severe deficiency caus these bodies to assume a less regular shape as in 1. Should the whole cell be even discolored as in n, this is not a sign of Potash Deficiency.

Photographs 4—7 published by courtesy of Dr. T. H. van den Honert. (See Reference No. 18).

11. The appearance of discolouration along the mid-rib is dependant on:

    (a) The degree of potash deficiency.

    (b) The age of the leaf.

    (c) The age of the cane.

    (d) The breadth of the leaf which is again dependant on the thickness of the cane.

12. The greater the deficiency the more did discoloration appear on the older shoots.

13. The symptoms were more obvious on the older shoots.

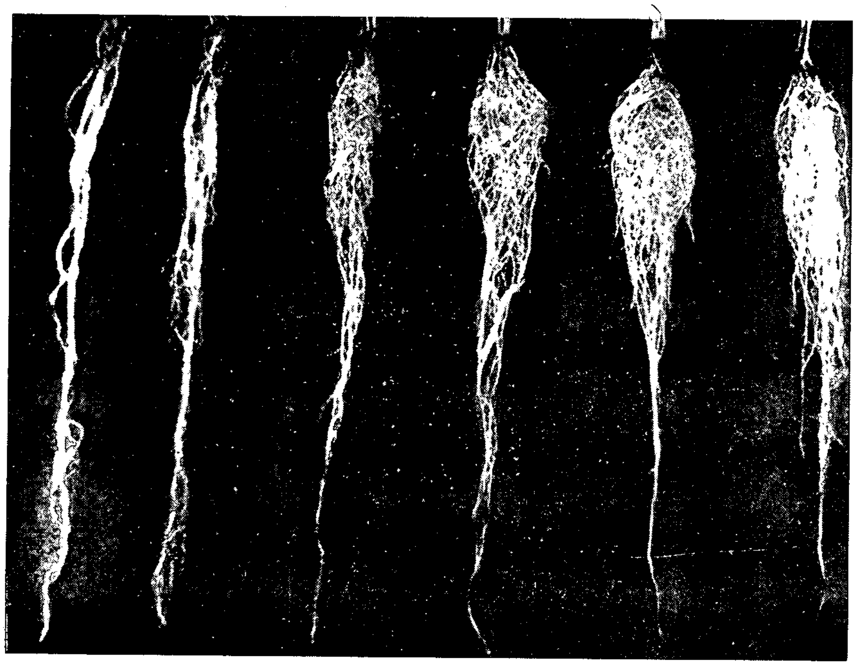
14. The cane was consistently thin and weak.

15. The sugar percentage apparently declines sharply under potash deficiency."

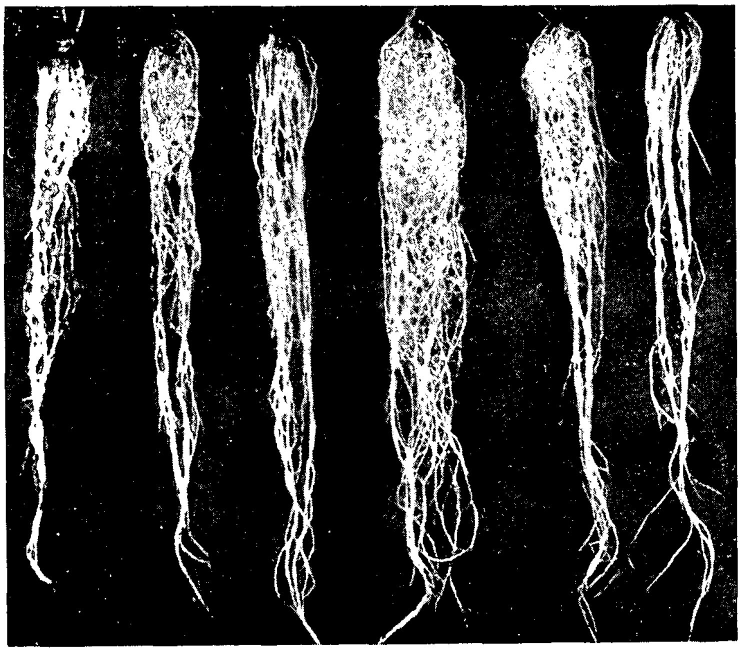
Regarding whether these symptoms can be taken as reliable evidence of potash deficiency in the field because sometimes on soils rich in potash spots occur which at first sight appear to be potash deficiency symptoms, but are in reality due to insect damage, Honert[19] showed that one can detect the deficiency with sufficient certainty by cutting the leaves through at the mid-rib at the point where the spots occur. The spots due to potash deficiency are confined to the upper side of the leaf and discolorations which penetrate right through to the underneath side are not consistent with potash deficiency. With the leaf cut through the discolouration can be perceived with the naked eye and with the aid of a microscope one can always tell whether the symptoms are due to potash or not.

The curve of the production of root material as a function of the concentration of potash rises from 0 to the optimum concentration for the plant under observation.

BARLEY



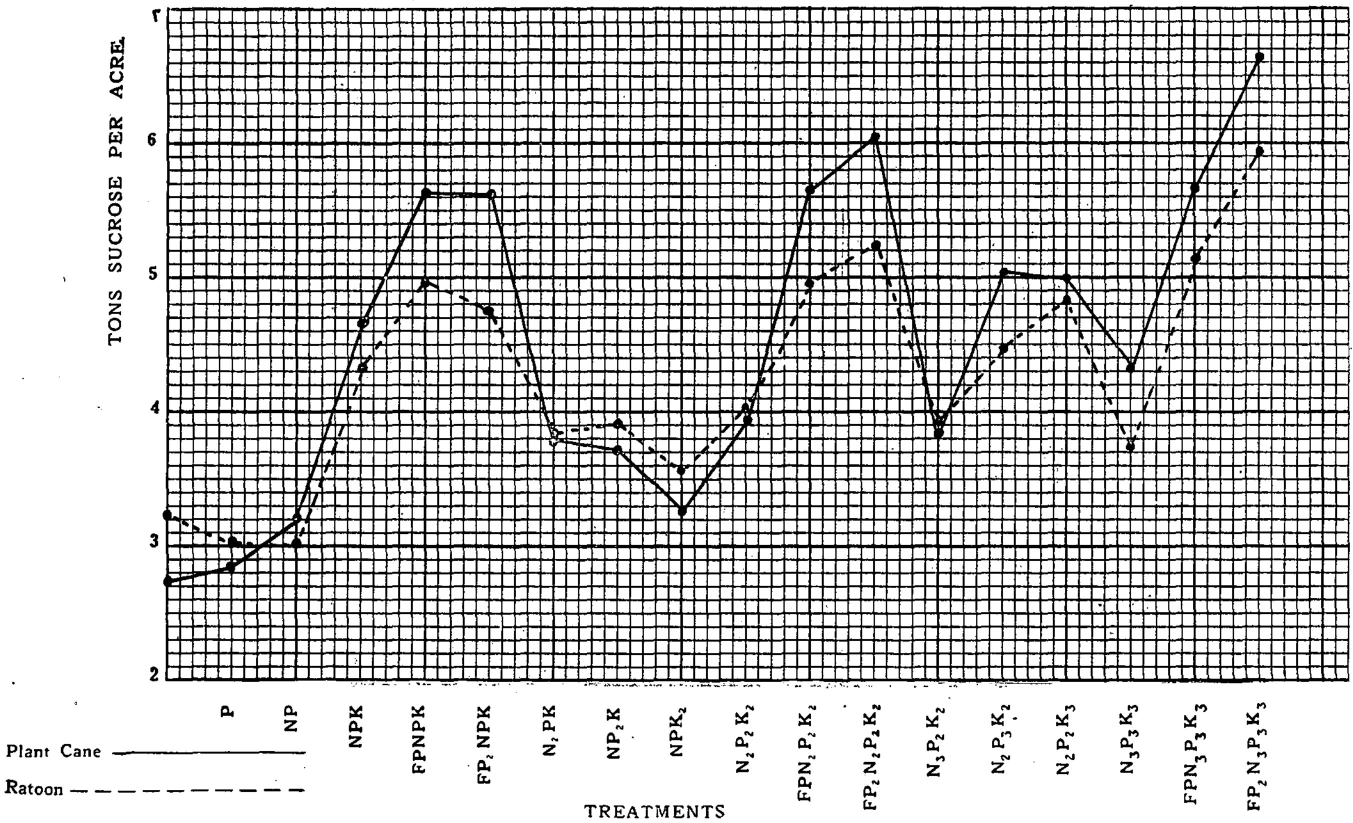
A 0.0% KCl. B 0.000109% KCl. C 0 000547% KCl. D 0.00547% KCl. E 0 0547% KCl. F 0.1094% KCl



A 0.0% KCl. B 0.000109% KCl. C 0.000547% KCl. D 0.0547% KCl. E 0.1094% KCl. F 0.2188% KCl.

Other effects observed in experiments carried out at the Hawaiian Sugar Planters' Association Experiment Station, Honolulu, on H109 with varying concentrations of potassium have been accumulation of iron in the nodes of potash starved cane. Certain quantities of the accumulated iron tended to pass up to the leaves when potash was supplied and it was thought that this effect was due to an increase in the upward movement of the transpiration stream and an increase in turgidity of the leaves. Again it is thought by the same authors that the reddening of the mid-rib may possibly be a secondary influence of potassium deficiency arising from an association of phloro-glucin and sufficient sulphate when present simultaneously in the plant. It has been suggested that the source of phloro-glucin is the decomposition of tannic acids which may be the result of a potassium deficiency. Further it has been stated "Brown discolourations of the sieve tubes and companion cells in the mid-ribs of the plants deficient in potassium indicated a necrosis of the phloem."[20]

Hartt[21] has also pointed out that the synthesis and the translocation of proteins are diminished by potash starvation and that "the relationships between the sugars in the stems depended upon the degree of potassium deficiency. The stems of the plants partially starved for potassium contained higher percentages of reducing sugars and lower percentages of sucrose than the controls; while the stems of the plants more completely deprived of potassium were very low in reducing sugars as well as sucrose. There was a positive correlation between the amount of potassium supplied and the total sugar stored." The same author states that at this moment it is not possible to assign one particular process as the special role of potash in the physiology of plants since it is probable that it affects most plant processes either directly or indirectly.



Discussion.

Viewing the situation as a whole it appears evident that when soil fertility is being considered a very great many possibilities are frequently absolutely overlooked.

In view of what was said in the beginning of this paper it is of great interest to compare some of the statements made with actual findings in the field experiment quoted.

In the report on the same experiment in 1937 it was pointed out that the soil was:—

(a) Low in organic matter.
(b) Low in nitrogen.
(c) Low in potash.

The potash content is of course very low, but may well be the condition of many of the windblown sands of the coast which have been successively cropped and only had small applications of some form of phosphate to replenish exhausted fertility.

The effect of $FP_2N_3P_3K_3$ is one of the outstanding features of the experiment and forms an irrefutable argument in favour of a heavy dressing of material to satisfy deficiencies and augment the general fertility of the soil. It proves that such a practice can be perfectly economical. The necessity for high potash to balance the effects of the nitrogen is brought out very clearly. It also appears that fertiliser balance is actually of greater importance than the amount of filterpress cake applied with the fertiliser. These remarks naturally refer to the soil under study in the Tongaat experiment.

Of greatest importance in the production of cane is the primary establishment of a good stand. The effects of initial treatment are borne through several crops. This is borne out by the graph which was published last year on measurements of the cane in its young stages. If the present graph is studied carefully, one can see that the ratoon crop follows exactly the same trend from the effects of the fertiliser dressings as the plant cane, with two exceptions—the $N_2P_2K_2$ level and control and superphosphate at 200 lb. per acre. It will be remembered that the $N_2P_2K_2$ level and the combinations of it in the plant cane gave a negative response, therefore there is every reason to believe that there should be proportionately more residual effect.

Honert was quoted saying that the sugar percentage of cane declines rapidly with a potash deficiency. Referring to this problem Kerr[22] says: "Considering now the results of the trials which have been harvested during the past four years, we find the following mean c.c.s. values:"

Treatment	Mean c.c.s.
No Fertiliser	15.48%
NP	15.19%
NK	15.32%
NPK	15.26%

On analysis the figures gave the following:

N	.. ..	Decrease 0.23 unit
P	.. ..	Decrease 0.06 unit
K	.. ..	Increase 0.07 unit

It is quite clear from these figures that nitrogen reduced the c.c.s. by a considerable amount, phosphate in the form of superphosphate also reduced the c.c.s. whilst potash augmented the sugar content of the juice.

Similar results are referred to by C. E. Beauchamp[23] who quoted authorities who have put forward various theories and explanations in this connection. An instance is quoted where it was found in Hawaii that when potash was applied to cane on certain potash deficient soils the sucrose was increased so that it actually required less tons of cane to produce one ton of sugar.

Although we have, as yet, not been able to locate such an effect from data obtained from field trials here, we believe that such studies should be confined to centres where finer technique can be applied and the cane under constant observation for fluctuations which can be missed so easily in an isolated field experiment.

In conclusion it is hoped that the position regarding the application of potash has been slightly elucidated. At any rate it is clear that this is a question regarding which one cannot jump to hasty conclusions and the study of it requires the intimate co-operation of the chemist, field man and statistician.

In summing up it may be said that in considering the necessity for potash one must bear in mind:

(a) The total potash reserves of the soil.
(b) The available potash reserves in the soil.
(c) The exchangeable potash of the soil.
(d) The fixing capacity of the soil.
(e) The total plant nutrient balance of the soil.
(f) The maintenance of sufficient available quantities of all factors including potash.
(g) Deficiency symptoms indicate a very bad soil condition which must on no account be allowed to occur.
(h) Potash applications must be governed by uptake and available supply of potash in the soil.
(i) Exhausted soils are expensive and difficult to bring back to a high state of fertility.
(j) Quantities to be applied are dependant on all the foregoing points.

When potash deficiency symptoms are found, the supply of unavailable potash in the soil is very low, and in the great agricultural countries of the world the problem of growing future crops becomes a question of supplying the needed potash. In this connection a recent pronouncement by representatives of the Illinois Agricultural Experiment Station, one of the most important grain growing centres in the world, may be quoted: "The old belief that Illinois soils contained plenty of potash which could be made available by proper farming methods has now been definitely discarded. Much of the potash in our soils is "inexhaustable" only because it is too tightly locked up and the plants cannot obtain it in amounts sufficient for good growth. No system of farming or treatment practice is known which will markedly affect the yearly rate at which more potash becomes available to crops. Many farmers, not understanding their potash deficiency, have decided to let well limed and phosphated land revert to pasture or weeds, whereas the use of a little potash would make those fields the richest on their farms."

Do not let us in South Africa overlook the possibility of our soils becoming depleted by adopting what amounts to short-sighted farming methods, but follow out a logical and well planned scheme to raise the fertility of our soils to a high level for we too are responsible for supplying food for the world and not for to-day only but we will come more and more to the fore and we cannot afford to meet the future with depleted soils.

Summary.

1. Necessity for careful investigation according to modern methods is pointed out.
2. The chemical aspect of soils regarding potash is considered with special reference to exchangeable material.
3. The ratoon yield of an experiment on white wind-blown sand and Uba cane at Tongaat is discussed together with comments on the effects of the fertiliser on the plant cane and conclusions are drawn from final figures treating both crops.
4. Potash Deficiency Symptoms are described according to different workers as is the effect of potash on physiological processes.

Thanks are due to the Chemical and Field Staff of the Tongaat Sugar Milling Co. for assistance rendered.

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[13] "La Potasse Assimilable dans les Roches"—"Le Phosphate et les Engrais Chimiques," 15th November 1931, 334.

[14] Eckstein, Prof. Dr. O.: "Potash Research," **11,** 23.

[15] Lintner, J.: "Some Fertiliser Trials on Sugar Cane," Proc. S.A. Sugar Tech. Assoc. **11,** 1937.

[16] Rohde, Dr. G.: "The Importance of Potash in the development of the root system of Plants," 2.

[17] Bunro, Eckstein, and Turrentine: "Potash Deficiency Symptoms," 36 (Hartt, C. E., The Bot. Gaz. 1929, Mo. 3, 229).

[18] van den Honert, Dr. T. H.: "New Research on Plantfood Deficiency Symptoms of Sugar Cane," Mededeelingen v.h. Proefstation v.d. Java-Suikerindustrie, 1932, No. 23, 2.

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[21] Hartt, C. E.: "Some effects of Potassium upon the amounts of protein and amino forms of Nitrogen, Sugars, and enzyme activity of Sugar Cane," Plant Physiology 1934, **9,** No. 3, 453.

[22] Kerr, Dr. H. W.: "Some Factors influencing the Sugar content of Cane," Cane Growers' Quarterly Bull. April 1934.

[23] Beauchamp, C. E.: "Effects of Fertiliser Elements on Sugar Cane Juice," Gilmore's Puerto Rico Sugar Manual, 1932-33.

The PRESIDENT: Congratulated Mr. Lintner on his paper which treated the problem of soil fertility from a philosophical as well as scientific angle. He also drew the attention of the listners to the fact that soil study was extremely complex and to beware against jumping to hasty conclusions.

Dr. McMARTIN: Congratulated Mr. Lintner on presenting a paper in which the problems of sugar cane nutrition were presented against the background of soil science. He drew attention to the following quotation by Dr. Ekstein: "The result of the breeding of superior types of plants, which has led in the last decade to better crops and larger yields, has been the evolution of new varieties which require and utilise larger quantities of nutrients than the old sorts which could subsist for a time on farmyard manure and the small supplies of plant food in the soil." Had we, because one variety produced greater bulk than another, to add more nutrient to the soil to produce the difference? Assume that in a particular soil a crop of pasture grass required 1,000 lbs. of fertiliser to produce the maximum yield, and that on the same soil the maximum yield of sugar cane was produced also with 1,000 lbs. of fertiliser (examples not out of the bounds of reason). Here we had the same plant food added and different bulk produced. Substitute two varieties of cane yielding different tonnage for the two different crops. The accepted view was that the high yielding variety required much more plant food than the other, whereas in reality it should be regarded as a more efficient machine for converting the same amount of plant food into greater bulk than a lower yielding less efficient variety. This view was really no more speculative than the accepted view.

Mr. LINTNER: In reply said that although with improved varieties one expected to obtain increased efficiency he thought the greatly increased bulk would certainly make heavier demands on soil nutrients, especially with such a heavy feeder as cane is known to be.

Mr. DEENIK: Said that Mr. Lintner's paper had come at a very opportune moment because more interest was being taken now than ever before in the history of the Industry in fertiliser practice. He confirmed the author's point of view that generally speaking insufficient attention was paid to many of the most important aspects concerning potash in soils when interpreting results of fertiliser experiments, and that the high fixing powers of some soils as against the possibility of this ingredient being leached out of those with a low fixing capacity could easily explain some results. He also pointed out that the fact that more than 700 lbs. nitrogen, 1,400 lbs. phosphoric acid and 400 lbs. potash, including the use of 40 tons of filter cake with no less than 2,000 lbs. fertiliser per acre, would provide food for thought to those who considered the economic limit of fertiliser applications to be in the region of 20-40 lbs. nitrogen, 100-150 lbs. phosphoric acid and 40-60 lbs. potash per acre. He also wanted to know whether potash was likely to be less available when applied in conjunction with large quantities of organic matter.

Mr. LINTNER: Said he had heard of instances where apparently potash had been fixed by the organic complex when mixed with an organic compound. In the soil also, should the organic content be very high, there was a possibility of potash being fixed by the organic colloidal complex.

Mr. B. CAMPBELL: Wanted to know Mr. Lintner's opinion on methods of applying potash. He pointed out the tendency of many people to believe that potash should not all be applied with the planting material but in two or more top dressings. In heavy soils there is every liklihood that the potash will be fixed in the top few inches whereas this would not occur to the same extent on a light soil.

Mr. LINTNER: Expressed the opinion that he thought the problem raised by Mr. Campbell of utmost importance in potash manuring. In his experience he said he had not found any advantage in splitting the dressing and giving it in several applications on heavy soils. The whole amount given in the furrow at once in the case of plant cane and the whole amount given in one dose as a side dressing to the ratoons had given the best results. In the case of light soils although he had not tested it out Mr. Lintner thought it quite possible that better results would be obtained by splitting the potash dressing than by applying it all at once.

Mr. DODDS: Complimented Mr. Lintner on his instructive paper and said that after years of work the Experiment Station was still unable to evolve a theory of fertiliser applications to the more representative soils. All that could be done to-date was to point to the obvious and immediate results of field experiments without attempting to form any general theory. He went on to say that contrary to Mr. Lintner's remark in the middle of the first column on page 82, he had never thought mere phosphate applications adequate. Phosphate applications had given response, but only where the original available soil phosphate had not been sufficient. Instances of response to nitrogen and potash had been comparatively few, due perhaps to their not having been applied in the best way. He hoped that complex experiments would soon enable them to go into the different elements simultaneously. He referred to the paper by Messrs. Beater and du Toit, which showed the amount of elements taken out of the soil.

Mr. LINTNER: In reply to Mr. Dodds said he had meant the statement mentioned by him to be taken generally. He pointed out that nevertheless the statement held good in the majority of cases, and for an example of wrong information from every angle except possibly superphosphate, he referred to the section dealing with the "Fertilising of Sugar Cane" in the Handbook for Farmers in South Africa, recently published.

Mr. B. CAMPBELL: Speaking again mentioned that the results of his experiment suggested NK interaction. The figures for NK were not, however, significant above 17 to 1. There was actually a depressing effect from potash with low levels of nitrogen.

Mr. LINTNER: Said he was very interested to hear of the results obtained by Mr. Campbell regarding the NK ratio, because there had been evidence of similar effects in some of his experiments.

Mr. ROSENSTRAUCH: Appreciated the fact that a detailed study of the soil had been taken into consideration in laying out the experiments and studying the results. He thought the system of soil classification discussed by Mr. Lintner unnecessarily intricate. A much more simple system would serve the purpose just as well in the Natal Sugar Belt.

Mr. LINTNER: Replying said it was his intention to classify the soils of his experiments as described in the paper as far as possible. Should a reliable simplified method be definitely adopted by the Department of Agriculture that method would be adopted by him.

Mr. DYMOND: Wanted to know whether potash deficiency was not almost always associated with a lack of organic matter, or humus, in the soil, and would this not explain why such excellent results were nearly always obtained in this country when filter cake was used.

Mr. LINTNER: Referred to experiments in England where grassing of orchards had been resorted to. The grass was cut and allowed to decompose when it lay on the ground, and it had been found that responses were obtained from fertiliser applied which were not obtained before. He said the explanation appeared to be a mobilisation of plant nutrient materials in the soil by organic acids. It was possible that filter cake produced similar effects at times.

Mr. COLEPEPER: Wanted to know Mr. Lintner's opinion regarding the effect of season on the uptake of plant nutrients. Was it not possible, he asked, for deficiency symptons to become acute during periods of drought? He was particularly interested in this point on account of the considerable variations in the potash content of juices.

Mr. LINTNER: Said he was inclined to agree with Mr. Colepepper that seasonal variations and climatic conditions might quite easily be responsible for fluctuations in the available nutrient supply.

The PRESIDENT: Concluded by thanking Mr. Lintner for his paper, and expressed his appreciation of the large attendance.