SUGARCANE IN CENTRAL AND EAST AFRICA
SOME OBSERVATIONS ON ITS HISTORY AND PRESENT POSITION
By A. McMARTIN

Summary
The Sugarcane plant has a very long history in Central and East Africa, having been known in the 12th Century on the East African coast.

The principal agents in its introduction were the Arab slave traders in the Lake Regions and the early Portuguese explorers along the Zambesi. From these points of entry it appears to have been widely disseminated by the Africans as garden canes.

The wild Saccharum spontaneum var. aegyptiacum occurs from Eritrea to Nyasaland. In some areas it is cultivated. The suggestion is made that natural hybrids between this species and introduced canes may exist. As in Natal, some early records confuse sugarcane with sweet-stemmed Sorghum.

An outline is given of the different ecological habitats in which commercial sugar production is now undertaken, the type of variety required and the diseases recorded.

Some observations are made on the maintenance of fertility for sustained cropping when the natural vegetation is removed for agricultural purposes, and an analogy drawn with the experience gained in Natal in sugarcane lands.

During the past two years the writer has had the opportunity of visiting many sugar estates and potential sugar producing areas in Central and East Africa, of seeing some of the work of agricultural experiment stations and departments and of discussing the problems relating to land utilisation and maintenance for agricultural purposes.

In what follows, an attempt is made merely to outline some of the aspects of the history and present position of this crop in these regions and to correlate some of the experiences of agricultural scientists in these areas with problems with which we are closely associated in Natal.

Sugarcane, as we recognise it in the cultivated forms grown either as garden canes or as commercial sugar producers, is not indigenous to Africa. There seems little doubt that it reached this continent from India via Arabia.

Dioscorides in his herbal compiled in the first century A.D. refers to the presence of sugar in Arabia, and the occurrence of sugarcane in Zanzibar was known in 1100 A.D., where it is considered to have been introduced by the Arab slave traders. The activities of the latter in penetrating into the interior are most likely associated with the spread of the plant into the Lake Regions, where it was found by some of the early European explorers over a century ago.

David Livingstone recorded its presence in Barotseland, while Burton, one of the first travellers into Somalia and the Lake Regions of Central Africa found this plant being offered for sale in 1860 in the bazaar at Ujiji on Lake Tanganyika—an area visited by the Arabs in 1840. Thornton in an unpublished diary in 1861 records the presence of sugarcane in a few places in East Africa including the foot of the Rare Mountains and on the eastern slopes of Mount Kilimanjaro. The latter record is of interest, since sugarcanes grown at present in African gardens on Mount Kilimanjaro have the appearance of some old "noble" type now no longer grown commercially.

While the Arabs, then, may be considered to be the principal vectors in the spread of cane from the coast to Lake Tanganyika, it is most likely that diffusion along the Zambesi was given an added impetus by the early Portuguese pioneers.

These early settlers brought cane in with them, which no doubt originated from the stock which had traversed the northern route across Africa and into Spain and Madeira.

It is interesting to speculate that there are thus probably two separate introductions of the same plant into the eastern coastal areas—first by the Arabs who were responsible for its spread inland and across the north of Africa to Europe, and then from the latter region back into the coast again.

Once established, its spread would be effected over a wide area when its value as a chewing commodity was appreciated. It is today carried long distances by the Africans when they go on journeys, constituting their equivalent of an "iron ration", which may have to last for several days. It is most probable therefore that these early introductions of cane have by now covered a very wide area of Central and East Africa.

Unfortunately it has not yet been possible to study any of the native-grown canes in order to establish their identity.

On the Elephant Marsh in Nyasaland some young stools of cane somewhat resembling China cane were seen, while in other cases some of the old "noble" types are most likely to be represented.

An example, however, of the ease with which a variety attains a spread from a point of introduction is the case of Co.290, of which a few trial plots were established some years ago on the Elephant Marsh and which is now the principal cane sold for chewing, in native markets and on the roadside.

Saccharum spontaneum var. aegyptiacum
The occurrence and distribution of this wild species of Saccharum was considered to be of interest in connection with the possible institution of a cane breeding programme for certain regions.
Accordingly, records have been collected from the herbaria of the Royal Botanic Gardens, Kew, England; the Cytodyon Museum Nairobi, Kenya; the Kawanda Experiment Station, Uganda; the Department of Agriculture, Zomba, Nyasaland and from a list kindly supplied by Mr. Carl Grassl (of the United States Department of Agriculture) of his own collecting. The following list shows the localities where this species has been recorded.

**Eritrea**  
Scimenzana.

**Ethiopia**  
Parma river, Disa, Takafiri, Tributaries of Tacazze river, Schebelli, Shore of Lake Heba.

**Kenya**  
Wewe river, North of Isiolo, Tana river, Voi river, Galana river.

**Nyasaland**  
West shore of Lake Nyasa.

**Sudan**  
Barbarus, (Blue Nile Province), Fung District, (Blue Nile Province), Dafur Province, Sennar Province, Bahre el Gebel, Juba river bank.

**Tanganyika**  
Pangani river, near Tukuyu, Tunduru, Rungwa.

**Uganda**  
Entebbe, by Lake Victoria, Mbarara, Ramurikize, Toro, Fort Portal, Toro, Kagadhe, Karamoja—river beds, Ankole—Lake George flats.

The writer has also been informed of a new record of this species from the Congo, but no details are available.

There is thus quite a wide distribution of this plant in these regions, and exploration would probably reveal its occurrence in more areas. The success attained by the use in cane breeding programmes of other forms of this species from different areas in the world suggests that a study of the African form or forms might be profitable when considering the production of varieties for local conditions. The use of certain forms of *S. spontaneum* in the production of commercial varieties resistant to mosaic is well known, but the recent discovery that mosaic resistance in this species might not be so widespread as at one time considered, and further that the new mosaic strain in Louisiana can infect certain *S. spontaneum* forms not affected by other mosaic strains would point to a desirability of an intensive examination of the reaction of local forms towards this disease. Among the susceptible *S. spontaneum* clones are some African ones.

The favoured natural habitat of this species seems to be on the banks of rivers in semi-arid areas, or on the shores of lakes, but in some areas the Africans have found a use for the plant and cultivate it.

The stems used are for hut construction in Tanganyika, while in Uganda it is stated to be eaten by stock.

The stem diameter is sometimes large for a *S. spontaneum* form, and this has led the writer to question whether in all cases the pure species is under consideration, or whether some natural hybridisation might have occurred with the introduced varieties of sugarcane.

Such naturally produced hybrids have occurred in other cane growing countries, well known examples of which are Kassoer, Toledo and Uba Marot.

It is also the opinion held by some that the species *S.sinense* (of which Uba is an example) and *S. barberi* (of which China cane is probably an example) owe their origin to natural hybridisation in India between local forms of *S. spontaneum* and introduced varieties of *S. officinarum* (the noble canes).

The wild cane produces seed very freely, and indeed there are localities in East Africa where sugarcane itself produces seed, for example on the shores of Lake Victoria and on the coast near Mombasa. It would be indeed a matter of great interest if it could be shown that in the regions under consideration natural hybridisation had occurred between the indigenous species and the introduced cultivated sugarcane.

**Sweet-stemmed Sorghum**

In the early history of sugarcane in Natal some confusion exists as to whether the plant referred to as being eaten by the natives was the true sugarcane or the sweet-stemmed species of *Sorghum*.

An early Zulu vocabulary gives sugarcane as 'himpheya'; but in another instance a large stemmed sugarcane was called 'moaba', and a thin stemmed one 'sinpha'. The latter is considered to be the present 'imfe' or 'imphe' and the former is the present day Zulu 'umoba'.

'Imphe' is the sweet-stemmed *Sorghum saccharatum* (syn. Holcus Sorghum var. saccharatus).

It is most likely that both sugarcane and sorghum were grown for chewing in these days, and that 'himpheya' was not the former but the latter. The same difficulty presents itself when attempting to piece together the history of sugarcane in East Africa.

Thus Burton, already referred to, tells in 1856 how the Somali natives ate the pith of the "African sweet cane", but refers this to the genus *Holcus*.

Also he refers to his journey through the Lake Regions where he found the natives at Usumbura making a fermented drink from sugarcane; he also states that in some other regions the only sweetening agent was honey, except where sugarcane grew. It would appear however from his other remarks that the plant he refers to is *Holcus*, which was known by the local name 'ikhi'.

That the genus *Sorghum* was widely cultivated in these regions by the natives is well known—both the sweet-stemmed and the grain forms. The latter also apparently contributed not only to the carbohydrate intake of these peoples but provided them with their alcoholic requirements; the grain was fermented into a brew known locally as 'buzah', a term which has been incorporated in the vocabulary of the English-speaking races as the familiar 'booze'.
It is interesting to note also that the importance of sweet-stemmed Sorghum as a commercial proposition was recognised by the U.S.A. a century ago, and introductions from Africa (including Natal) were among those that provided the start of the syrup industry in the Southern States.

Whether the same explorer, Burton, also was familiar with S. spontaneum var. aegyptiacum is of interest, as he refers to an expanse of the wild sugarcane plant, called from its appearance 'gugu-mbua'.

One African form of this wild species is today known as 'gugu' while 'mbua' is not dissimilar from 'umoba'.

It is not without the bounds of possibility then that these early explorers were familiar with wild cane, introduced sugarcane and sorghum.

**Link between East Africa and Natal**

Well authenticated records account for the introduction of some of the earliest sugarcane varieties grown in Natal from other sugar producing countries. The origin of two varieties, however, has remained somewhat obscure—Green Natal and China cane. The former (now known to be a cane of the Preanger series originating in Java) has been stated to have been grown by the natives, and the latter has been accounted for in one case by being native-grown, in another case by being found among flotsam and jetsam washed ashore from a shipwreck.

No definite evidence exists of the introduction of either of these varieties by Europeans.

A piece of significant history, however, is the knowledge that the Zulu King Dingiswayo established property of the King are attributed to the results of trade with the early Portuguese settlers in Delagoa Bay, and the presence in the Royal Kraal of sugarcane and bananas which were exclusively the property of the King are attributed to the results of this early establishment of a trade mission.

It is of interest further to learn that when the first European sugar producing venture was established on the Zambesi delta, the natives of that area were growing two varieties of cane, which were assumed to have been introduced by some of the earliest settlers from Madeira.

It is not unreasonable to suppose therefore that any native grown sugarcane seen in Natal by the sugar pioneers was the southern limit of a diffusion of this plant down the East coast, and that the two earliest varieties had originated from points of introduction in more northern regions.

**The variety position at present**

In the East African territories commercial sugar production from cane has had a varietal history somewhat similar to Natal—the initial growing of mainly noble canes, their replacement with Uba, and the subsequent replacement of the latter by the products of cane breeding programmes in other countries. Some estates, however, only commenced operations in the days when Uba was the main variety, while more recent enterprises have commenced operations with the newer varieties.

In Southern Rhodesia cane production was initiated after Uba had been discarded everywhere as a commercial proposition.

Marked differences are imposed upon the requirements of varieties for different areas, differences related to climatic and soil variations and the disease complex.

Climatic regions encountered range from semiarid areas with high evaporation and temperatures, where irrigation is a necessity, to humid or subhumid areas with a rainfall sufficient to support a cane crop. In some regions this rainfall has a bimodal distribution—the so-called long rains and the short rains, the latter being sometimes uncertain.

Frost is encountered in some regions in occasional years, while in other areas mists are prevalent as in the mist belt in Natal. A range in altitude occurs from about 200 ft. to 4,000 ft.

The soils vary from alluvium of different textural classes, volcanic ash or tuff, reddish brown loams with good internal drainage, colluvial loams and poorly drained clays formed from granitic rock, reclaimed swamp, soils with different degrees of laterisation, sandy loams of a very highly leached nature, and coastal sands.

The natural fertility varies from soils extremely high in minerals and requiring no added fertilizer (with the exception of nitrogen where irrigation is practised) to the leached soils which are extremely poor in plant foods and of very low pH value.

In some areas the soil is alkaline in nature and good management and adequate drainage is required; in extreme cases in regions of low rainfall salinisation and, if alkaline conditions have occurred naturally or caused by irrigation unaccompanied by sufficient drainage.

Among the major diseases recorded are mosaic, streak, ratoon stunting, red rot and smut.

Red stripe, eye spot, ring spot, brown spot, pokkah boeng, sooty mould, wilt, rind disease, red leaf spot, rust, and banded chlorosis have been recorded at different times in different areas.

Mosaic was identified on some of the old noble canes, and streak was prevalent on Uba.

The position of red rot is interesting in Southern Rhodesia. The variety grown in one of the native irrigation settlements is Co. 290, which is very vigorous and healthy, but when taken from there and planted in a nearby area at a much higher altitude it succumbed in the first crop to red rot, which killed it almost completely out.

Smut disease is becoming widespread, and under suitable conditions becomes an epidemic on a susceptible variety causing very severe economic loss. The variety Co. 301 had in a few years to be abandoned in more than one area, the ratoons being so completely riddled with the disease that no crop was cut. Development of this disease in Natal has never reached such proportions. It is significant that this serious
condition was attained in each case in dry areas where irrigation was a necessity. The fact that this disease is now being found for the first time within the last few years in different areas requires that its development be taken notice of in view of the possible development of new irrigation schemes.

Into the foregoing pattern of environment and disease, now, the adaptability of varieties becomes apparent. Under good conditions of soil and moisture (whether natural rainfall or irrigation) varieties with a high proportion of noble blood are more at home than in Natal.

In the equatorial regions in Uganda and Kenya P.O.J. 2878 and P.O.J. 2725 are still being cropped, together with some Barbados canes and with N:Co. 310 being increased. It is interesting, however, to note that one of the varieties which shows extreme vigour in small plots is N:Co. 79—in fact on the shores of Lake Victoria it is outstanding. This was one of the early attempts to produce a variety for Natal, but was not sufficiently good. It has a higher proportion of noble blood than N:Co.310, and evidently under equatorial-tropical conditions it is of much more promise. Co.331 is grown by some Asian farmers, where under conditions of poorer husbandry than that practised by the estates it apparently gives a satisfactory tonnage; the fact that their cane payment is not based on sucrose content does not encourage the cultivation of high sucrose varieties.

An extensively cultivated variety in East Africa is Co.421. It is cropped on the alkaline colluvial soils near Kisumu, Kenya, and is the principal variety on the irrigated soil of volcanic origin from Kilimanjaro in Tanganyika. It has been found by experience that under alkaline conditions it will yield more heavily than other varieties, and in fact under a certain degree of brak where other varieties will not grow Co. 421 is sufficiently tolerant to yield a satisfactory crop. It was at one time also largely grown in Portuguese East Africa, but now has been replaced by N:Co.310.

Reference has been made to the possibility of smut disease becoming serious under irrigated conditions, and it is therefore important to note that some new varieties introduced from Hawaii and Barbados—countries where this disease is unknown—have contracted it in as widely scattered localities as on the Zambesi in Rhodesia, and in Tanganyika.

N:Co.310 is popular in irrigated estates and high rainfall areas, but under dry conditions in higher altitude areas where a longer dry period is experienced Co.331 is considered better.

Many varieties exist on estates in Central and East Africa under various stages of propagation—canes from Mauritius, Natal, India, Java, Argentina, Puerto Rico, Barbados, Louisiana and Hawaii. (Over a hundred varieties have been received by the Federation in the last 15 years).

Variety introduction into East Africa is controlled by means of a quarantine station at Muguga, near Nairobi, in the grounds of the East African Agriculture and Forestry Research Organisation, and in Rhodesia the Sabi Valley Experiment Station is being used as a variety introduction and propagation station.

Land Development for Agriculture and Its Problems

The development of the Natal sugar industry along the narrow coastal strip owes its existence to the interplay of rainfall, humidity and temperature, a combination of factors which make possible the cultivation of a sub-tropical crop. It is of interest, now, to examine the climatic factors in relation to the natural vegetation which covered this land area, to relate these to similar vegetation types which exist elsewhere, and to see whether the agricultural problems of converting land from its natural cover to the artificial one of a cropping system have any common ground in different localities. The majority of land under cane in Natal was at one time coastal evergreen forest, or savanna, and it is of interest therefore to enquire into the distribution of these two vegetation types in the other regions under discussion.

The forest community is one of great importance in equatorial—tropical areas. It covers large continuous areas through West and Equatorial Africa to Uganda; whence eastwards and south eastwards it is represented by separated occurrences with long distances between. It is found as such separated examples in Kenya, Ethiopia, Tanganyika, Nyasaland, Rhodesia, Portuguese East Africa, and its southern extremity forms the narrow coastal strip in Natal.

In the equatorial-tropical subregions this forest has been developed under conditions of from 50-170 inches of rainfall, while in the subtropical regions the rainfall is from 25-50 inches. In the former zone the precipitation is almost continuous, with lower falls from January-February and June-August.

In the sub-equatorial areas at about 5°N. and S., a division into two distinct rainy and two dry seasons occurs; further still from the equator, however, these two rainy seasons merge, and as the distance from the equator increases the length of this rainy season decreases. The humidity is high, temperature high and relatively uniform except in highland areas and for periods in the subtropics.

It is mainly these factors which define the forest regions.

The savanna is a vegetation type of great diversity and occupies a large proportion of Southern Africa. Its range of types link the forest on the one extreme with the desert on the other; it expresses itself as sub-humid regions with a woodland or open woodland vegetation of more or less luxurious type, open savanna or grassland, and arid to subarid and sub-desert communities with scattered trees and scrub in the regions of low rainfall.

One factor to be considered in considering the savanna vegetation types is that while in some areas the vegetation is the natural expression of the interplay of climatic and soil forces, in others the grassland or open parkland is due to the interference of man. Thus the occurrence of savanna in the proximity to forest can be due to the influence of burning.
Within these major types of plant communities there of course exists many variations caused by local differences in physiography or soil. Thus alluvial fans on river deltas and swamps create local modifications; likewise the effect of altitude and rainfall are responsible for important alterations in the vegetation. The latter can sometimes be mapped according to altitude; it has been found in some areas that a correlation exists between the plant cover and a rainfall-altitude ratio in the form of number of inches of rain per 1,000 feet of altitude.

Aspect also imposes local modification. A northern slope in South Africa can have a vegetation of a more tropical nature than a southern slope, and it is considered in Natal a slope with an angle of 30 degrees to the horizontal and facing north is equivalent to a shift of 15 degrees of latitude northward.

Of interest now is to correlate the accumulation of knowledge of the ecology of these vegetational regions with past experience gained in their conversion into food producing areas, combined with research into climate, soils and crops, and to see whether such a study can show the way whereby past successes or failures can be of assistance in understanding the requirements of developing land into its full agricultural potential. Fortunately a colossal amount of data is available from many research centres and experiment stations in Africa South of the Sahara, and some generalisations derived from the work in other areas is of interest to the sugarcane agriculturist in Natal.

Of importance is an understanding of the natural fertility status of the land under its original cover, and of the processes set in motion when this cover is destroyed and replaced by different cropping systems.

With the forest regions, it is perhaps understandable if the luxuriant growth observed of some hundreds of tons of vegetation per acre gives a first impression of soils of great fertility. This in many cases however has been found to be illusory. Under conditions of steady and high rainfall considerable leaching of minerals has occurred, and at the same time the soils are often relatively shallow and exhibit different degrees of laterisation.

The forest community, however, apparently maintains a sufficiency of nitrates, phosphates, potash and other salts in its feeding horizon by replenishing these from lower soil layers, and at the same time returning to the surface layer, by means of fallen leaves and broken woody growth, an organic matter supply from which the minerals are released.

The picture then is of a plant cover which as it developed has removed large quantities of minerals from an impoverished soil and stored them in an immobilised form in its own structure. Thus as the forest develops less reliance is placed upon the soil minerals and more upon photosynthesis.

An appreciation of this type of balance between plant and environment helps us now to understand the consequences of different types of conversion of this community into agricultural pursuits.

It will be realised that under natural conditions the maintenance of fertility is largely dependent on organic matter, and that any conditions which cause a loss of this material will also cause a loss of available minerals, losses which will be more acute as the rainfall increases.

The traditional African agriculture is of the shifting cultivation system in which the cropped area is allowed to return to “bush fallow” after a number of years. After clearing, the soils are moderately fertile for about 3 to 5 years, after which they must revert to secondary growth for a period at least 3 times that length, except alluvial soils which can be cropped much longer.

In this secondary growth of the “bush fallow” an accumulation of minerals recommences in the vegetation, which again can be returned to the soil for another short period.

Thus a type of rotation is established, which is sufficient simply for the production of subsistence crops for a limited density of population. When however, the population increases so that the cleared areas are cropped for a longer period, or unsuitable land is brought under cultivation, changes are brought about on the soil which lead to impoverishment if not destruction.

The nitrogen status of many forest soils is sufficient for a medium level of production for up to 8 years, but by longer exposure the clearing of larger areas and heavier cropping a nitrogen deficiency becomes apparent, especially if perennial crops are attempted.

Phosphate is usually higher in forests than in savanna, and sufficient for the natural vegetation, but after exposure a rapid loss may occur especially in sandy soils in the higher rainfall areas. Burning of the cleared vegetation adds temporarily to the phosphate content but this soon becomes unavailable, and very rapidly a marked phosphate deficiency occurs; response to phosphatic fertilizers becomes immediately apparent.

Potash is rarely deficient, except on light soils experiencing high rainfall. Under conditions of excessively long cropping, however, a deficiency becomes apparent, especially in the case of carbohydrate crops—maize, sweet potato, yam, cassava. Usually, by the time a response to potash fertilizers has become apparent phosphate and nitrogen deficiencies have been much more conspicuous.

Also associated with potash deficiency is the lack of some suspected minor elements.

In the case of savanna communities, the organic matter status varies with the density of vegetation, and is low in the hotter, drier areas.

The nitrogen content is less, and sometimes very much less than in forests, and is usually quite inadequate for any cropping except at a low level of subsistence. A marked reduction in this element occurs shortly after clearing, and for sustained cropping the application of nitrogenous fertilizers becomes essential.
A marked and extensive deficiency of phosphate occurs, much more so than in forest soils. A resting period under "bush fallow" of up to 10 years is required to return sufficient of this element to the soil for cropping, unless phosphatic fertilizers are applied.

An interaction between nitrogen and phosphate is commonly experienced, in that no response to one in the absence of the other is obtained.

The potash status is usually higher than in forest soils, except in light, heavily leached soils. Depletion with continued cropping eventually expresses itself however.

It is obvious, therefore, that an understanding of the soil-climatic-vegetation relationship is a prerequisite to the transformation of virgin land into a successful agricultural enterprise. Damaging factors are extensive and continued exposure to the elements, mechanized clearing which destroys soil structure and profile, and the attempt to replace the natural vegetation type by a cropping system for which the land is totally unsuited. It is obvious, also, that provided a suitable soil management and cropping system can be found, fertility can be maintained or increased by the correct fertilizer use, and it is of interest to note that experience in other areas has confirmed the findings with sugarcane in Natal—the immediate response on virgin soil to phosphatic fertilizers (with the exception of alluvial areas), with a deficiency of organic matter showing at a later stage of development. The response to nitrogen is closely linked to the organic matter status of the soil, but appears also to be associated with the mineral status, in that response can be masked by an insufficiency of some other elements.

Of interest also are the findings that nitrogen response can be determined by the effect of moisture on organic matter.

Under continuously moist conditions humus decomposition and the release of nitrates takes place slowly, but when dry soil is wetted suddenly, a large release of nitrogen takes place initially and then decreases. Thus it has been found in Tanganyika that the soil is more productive during the earlier part of a rainy season than later on. This factor could be of importance in accounting for the response, or lack of response, to added nitrogen.

It is of interest also to sugar growers to reflect on the suitability of sugarcane as a crop for converting virgin bush or savanna into a stable form of agriculture. Reference has been made to the regeneration of forest soils by means of the "bush fallow" and it is of importance to note that one of the first pioneer plants of value in the rehabilitation process is elephant grass or Napier fodder. In fact it was the study of the effect of this grass on the soil structure on bush clearings which led to its use as a soil improving crop. The similarity in habit and root development between Napier fodder and sugarcane is apparent, and confirms the opinion that the latter, properly used, is not conductive to soil deterioration, but indeed acts as an improving agent.

Mr. J. L. du Toit (in the Chair) stated that the author had gone further than merely surveying the Sugar Industry in East Africa and had given details of varieties, soil and vegetation of those regions, which were most revealing. It was interesting to see that the history of fertilizer practice in those areas followed almost exactly what had happened in this country. First phosphate, then nitrogen, potash, and finally trace elements. He was interested also to see it recorded that cane was grown at a pH as low as 3.8-4.0. He asked if the cane grew well at this pH.

Dr. A. McMartin said that at 3.8 to 4.0 pH there was much wrong with the growth but it was difficult to attribute this to low pH alone as there was an acute phosphate deficiency. It had been fertilised with 600 lbs. of ammonium sulphate but the phosphate deficiency had been neglected. 8.3 to 8.5 pH was taken as the upper limit, and if above this, other conditions should be looked for and the necessary precautions taken.

Dr. H. H. Dodds said that when the Co.421 x 312 cross was obtained from India it was remarkable that neither variety was of use in this country, but the cross proved very good. Co.421 had been very successful in the large tropical areas of India and very tolerant to "brak", while Co.312 was the best cane in the sub-tropical area. Co.421 was on the down grade in East Africa, generally.

He stressed the importance of the interaction between P₂O₅ and nitrogen. He knew of a case at Triangle Estates where neither fertilizer super phosphate or ammonium sulphate was of value by itself but there was a wonderful response when applying a mixture of the two.

Mr. J. W. Main asked why it was that the variety N:Co.310 with high sucrose characteristic should come from low sucrose canes like Co.421 and Co.312.

Dr. A. McMartin thought that one could not explain this phenomenon except that with the large number of seedlings of great variability produced from this cross, it was really a matter of luck that N:Co.310 had resulted. In India this cross had been looked upon with disfavour.