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The Ripening of Sugarcane

BY

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(Presented by Mr. H. R. Strang)

INTRODUCTION

Sugarcane cultivation has a great economic importance in Martinique and in Guadeloupe. Whereas some gently undulating windward areas have a fairly marked dry season (Grande Terre, Marie Galante, South Martinique) most of the other areas get frequent and abundant downpours during harvest. In 1966, this period has been particularly rainy and the observations made cannot thus be compared with those of other years.

Following these rains, which occurred during the reaping season, a decrease in the sugar content has often been observed although not systematically. This decrease varies in magnitude.

These unfavourable climatic conditions for sugarcane cultivation are not common in the other sugarcane countries. Therefore, the improvement of sugarcane maturation is a very important part of our research programme.

EFFECT OF NITROGEN

Many results of factorial experiments carried out in both islands for many years show that if nitrogen increases both in tonnage and the sucrose content as occurs when deficiencies in this element are severe, supplementary applications to bring the yields in tons of cane/acre to near the optimum, tend to lower the sugar content even when further increases in tonnage are still possible. As a result of climatic variations, optimum dosages of nitrogen vary from year to year. It is, therefore, very difficult to establish permanent recommendations for nitrogen applications.

In certain elevated areas with overcast skies, heavy rains and soils with a higher organic matter content, experiments seem to show that less nitrogenous fertilisers are needed than in lower areas, and more so in the case of first ratoons. An increase in the application of nitrogen to successive ratoons seems necessary, particularly in heavy soils.

Whereas an excessive potash application, which can be checked by the K levels in the juice, in the soil and in the third leaf of the previous crops, leads to unnecessary export of K in juice and may cause some losses of sugar at the factory it seems impossible in a given area to forecast the quantity of nitrogen to be applied at planting or just after reaping. Depending on the climatic conditions the latter can be either insufficient to achieve optimum yields or excessive thus causing a drop in the sugar content.

Thanks to aerial application of urea, it seems possible to reduce the basal dressing of nitrogen to the minimum average dose required and to correct the possible deficiencies afterwards when the cane is well developed.

One of the aims of the trials was to determine if such high yields could be obtained whether nitrogen was applied on the soil or in urea solution in water on the leaves. Another object was to find out under which conditions nitrogen could have depressive effects on the sugar content and whether it could be responsible for those sudden drops in quality or cessation of sugar increase which have been noted from time to time during the harvest.

SOIL NITROGEN

The study of the mineral nitric and ammoniacal nitrogen variations during a number of years in the French West Indies in the sugarcane and banana soils, shows that fertiliser applications were followed in some cases by a very moderate increase in mineral nitrogen levels and in other cases by an increase which could be much higher than the quantity applied.

Furthermore, in soils regularly fertilised, sudden increases of mineral nitrogen levels have been observed during some periods of the year and particularly when rains occur during the so-called dry season. These increases can be very important sometimes in soils heavily dressed. Annual variations are of very little importance in non-fertilised soils.

A low mineral nitrogen level in the soils does not necessarily mean that the soils cannot supply any nitrogen to the plant. It is the case when the plant uptake reaches or goes beyond the speed at which the mineral nitrogen of the soil is renewed. On the other hand, a high level of nitric nitrogen indicates with certainty the possibility for the plant to find readily available nitrogen in the soil if the uptake conditions by the root system are favourable. This is what happens when the rains are frequent enough during harvesting for the resumption of growth.

It seems that the way to prevent these important increases in nitrogen consists in limiting, as much as possible, nitrogen applications to the soils. This nitrogen can be transformed into the organic form by the soil micro-organisms and re-mineralised by way of very complex processes.

Through foliar applications of nitrogen, it seems possible to avoid, except during the first weeks of growth, important applications of nitrogen to the soils and thus to maintain during harvesting a very low mineral nitrogen level in the soils.

METHODS

(i) Uptake of soil nitrogen by the cane

As a result of some preliminary experiments, it has been possible to relate the variations in soil nitrogen to those of certain forms of nitrogen in the plant. The graphs of Figure 1 show that an increase in nitric nitrogen levels in the soils is followed by an increase of the nitrogen obtained through simple distillation in presence of magnesia of the sugarcane juice extracted with a Waring blender. This method has, therefore, been provisionally chosen for the first experiments until more precise and varied determinations can be undertaken.

The semi-quantitative paper chromatographic determinations of the various amino acids undertaken in 1966 by Mr. Yot show that a close connection exists between variations of soluble nitrogen obtained by distillation and those of the principal amino acids. Some delay in securing the necessary ingredients has made it impossible to make use of the new techniques already available.

(ii) Experimental designs

The experiments comprise six repetitions of:

(*a*) Plots on which the nitrogen is applied to the soil in one or two applications after plantation or after reaping.

(*b*) Plots getting only 30 kgs. of N/Ha on the soil at the beginning of the growth, then three or four sprays of urea solution on the leaves amounting to 90 kg./Ha from August to November.

Each plot is split in two halves. One half is not reaped and is used for sampling during the ripening period, the other half is weighed and analysed after harvesting.

During the ripening period, cane is sampled every 8 or 15 days in each plot. Three portions of stalk are prepared for analysis, *viz.* three internodes from the basal part, three internodes from the middle part and the 8-10 internodes. Sucrose was determined by polarimetry. Reducing sugars, soluble nitrogen and the moisture content of 4-5 internodes were also determined.

Soil samples were also taken at the same time in each plot for the determination of nitric and ammoniacal nitrogen and moisture content.

RESULTS AND DISCUSSIONS

(i) Soil mineral nitrogen

In 1965, in most of the experiments laid out on plant cane, the soil nitric-nitrogen level remained somewhat lower during the harvest in the plots getting nitrogen on the leaves than in those to which nitrogen was applied on the soil.

This was the case in the following experiments: Grand Ravine, Grand Cesar, Girard, Loison, Fonds Boyer and Plateau.

In the following experiments the levels remained practically identical: Ravine Negresse, Lemoine and Dattier.

In 1966, probably because of very heavy and steady rains occurring from the beginning of February, the mineral nitrogen levels remained fairly constant and identical in the plots with foliar or soil application.

In Martinique very few differences were observed. It seems, however, that certain occurrences of high mineral nitrogen level during some periods cannot be altogether eliminated.

(ii) Nitrogen/sugar relation

An important increase of the soil moisture following heavy rains in 1966, was immediately followed by an increase of soluble nitrogen in the stalk. This increase can affect the three parts of the stalks: low, middle and 8-10 internode simultaneously, or of one of these parts, only far more intensively.

A sudden increase of the soluble nitrogen in the stalk is, in nearly all cases, followed either by a drop of the sucrose in the cane or by a slowing down of its accumulation. 8-10 internodes seem particularly affected. Sucrose of these internodes has constantly decreased in certain fields from the first rain in February to the end of the harvest. In some other plots, the accumulation of sucrose slowed down during a certain period but increased again for a few weeks.

Examples:

Loison—February rains causing an increase of the soil moisture and of the soluble nitrogen and a slowing down of the sugar formation in the lower and middle part of the stalk followed by a resumption of the accumulation. In May there was a new peak of soil moisture and of the soluble-nitrogen in the cane, and a marked slowing down of sugar formation in the lower and middle part of the stalk accompanied by a drop in the 8-10 internode.

Ride—An appreciable increase of soluble-nitrogen following the February rains caused a stoppage in the accumulation of sucrose in the three parts of the stalk, particularly in the lower part and in the 8-10 internodes, with very little accumulation in the middle section. The 4-5 internode moisture content remained over 90 per cent from mid-February to mid-April and over 89 per cent up to the end of the harvest.

Plateau—High soluble nitrogen level caused a drop of sucrose in the three parts of the stalk. From the beginning of March, although the 4-5 internode moisture was over 90 per cent, the accumulation increased again.

A new increase in the soluble-nitrogen of the stalk in April was followed by a general slowing down in the accumulation of sucrose and by a drop in the 8-10 internodes.

Girard—A noticeable slowing down of the accumulation of the sucrose in February accompanied by a small increase in the soluble-nitrogen and a 4-5 internode moisture content of 90 per cent was followed by an increase in the accumulation of sucrose followed by a further stoppage in April.

Digue—The 8-10 internode sucrose content dropped constantly after the rains at the beginning of February and the soluble-nitrogen in the stalk increased. After a slight slowing down during February, the accumulation of sugar continued until harvest.

Fonds Boyer—A constant drop in sucrose followed the rains at the beginning of February and soluble-nitrogen increased in the 8-10 internodes. The accumulation of

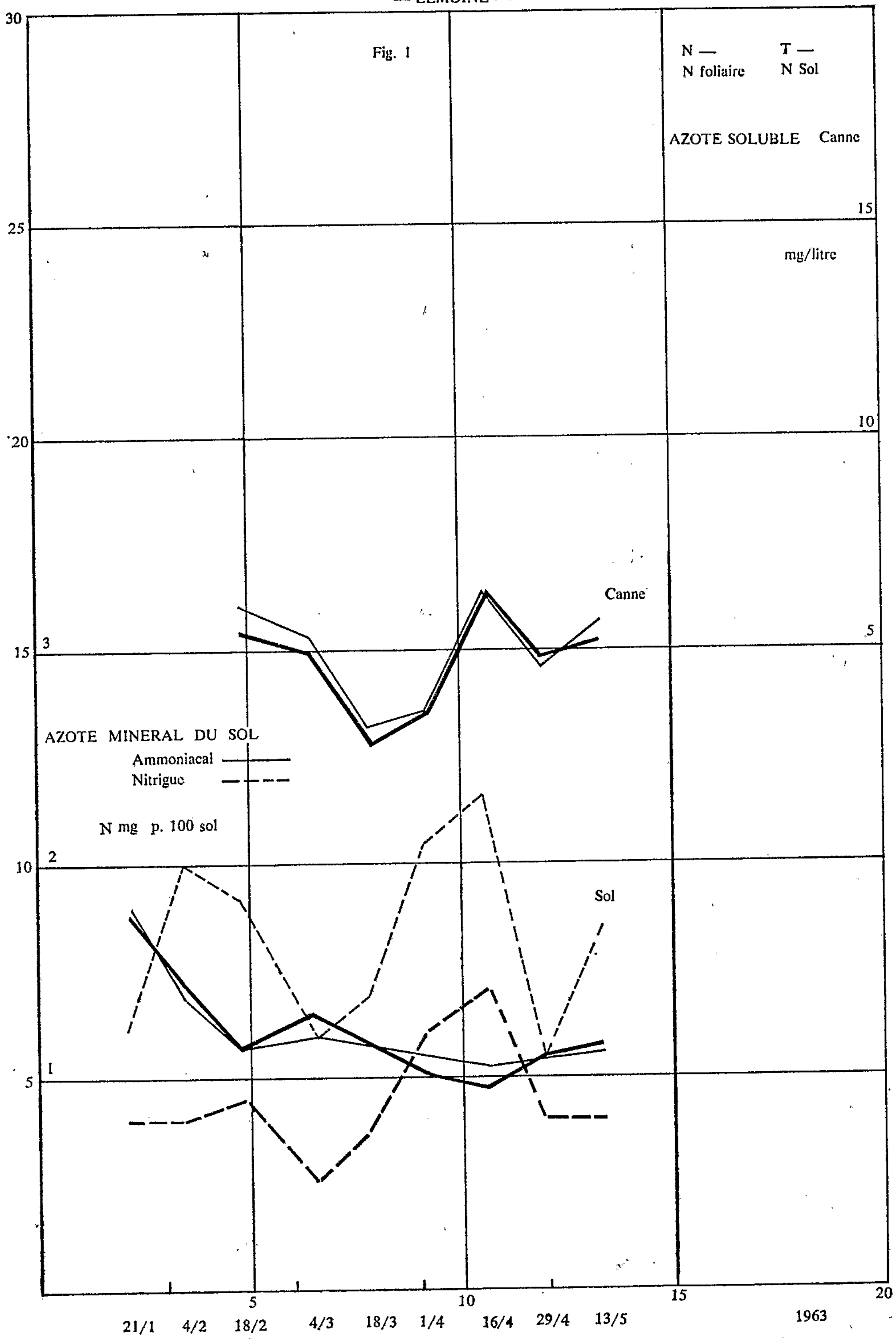
Fig. 1
N — N foliaire
T — N Sol
AZOTE SOLUBLE Canne
mg/litre
Canne
AZOTE MINERAL DU SOL
Ammoniacal
Nitrigue
N mg p. 100 sol
Sol
30
25
20
15
10
5
15
10
5
3
2
1
5
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21/1
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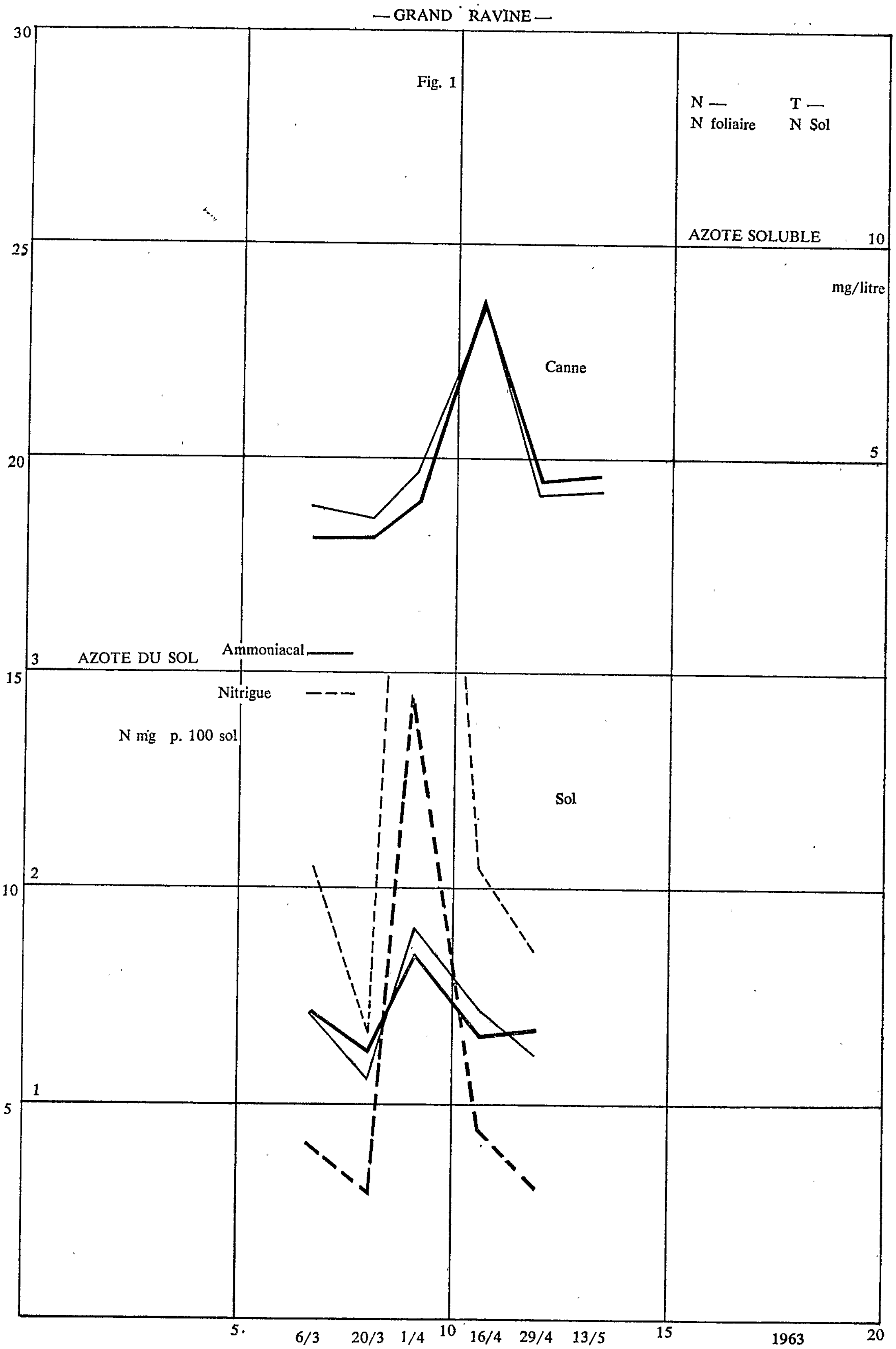
— GRAND RAVINE —
Fig. 1
N — N foliaire
T — N Sol
AZOTE SOLUBLE
mg/litre
Canne
AZOTE DU SOL
Ammoniacal
Nitrigue
N mg p. 100 sol
Sol
30
25
20
15
10
5
10
5
3
2
1
5
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6/3
20/3
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16/4
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13/5
1963

sucrose slowed down during February and increased again very slowly afterwards. The 4-5 internode moisture remained in the region of 90 to 91 per cent.

Dattier—A cessation of the accumulation of sucrose and an increase in soluble-nitrogen followed the first rains in February. During March soluble-nitrogen dropped and sucrose increased again; subsequently, further rains caused an increase in soluble-nitrogen, a drop in sucrose in the 8-10 internodes and a retardation of sucrose accumulation in the lower part of the stalk.

Pallabaty—A very high increase of soluble nitrogen followed the rains of February causing a cessation in the accumulation of sucrose in the lower and middle parts of the stalk. This was followed by a slight increase. There was a continuous drop in the sucrose content of the higher part of the stalk associated with a high level of reducing sugars.

Riz—There was a constant drop in the sucrose content of the 8-10 internodes and a cessation of ripening in the lower and middle parts of the stalk.

Basse Pointe—An increase of mineral nitrogen during February and March caused two decreases or slowing down of the accumulation of sucrose with a little increase in the middle.

Riviere Sales-Fromager—An increase in soluble-nitrogen caused a drop in the sucrose content of the stalk followed firstly by more rapid ripening and later by a further drop during April.

Parc à Boeufs—A slowing down of the ripening process during February-March, followed by a distinct drop in the 8-10 internodes.

Champs (1964); **Grand Ravine** (1964); **Lemoine** (1964) and **Ravine Negresse** (1964)—In 1964, a high increase in soluble-nitrogen in the lower part of the stalk and in the 8-10 internodes, and an associated fall in sucrose content was observed.

(iii) Yields in tons of cane and of sugar

(*a*) *Control of the foliar applications*

The control of the efficiency of foliar applications has been made by foliar diagnosis on the third leaf when the 4-5 internode moisture content was over 90 per cent.

A slightly lower level of nitrogen is often noted in the plots which have only received 30 kgs. per Ha. of nitrogen on the soil and no foliar applications. Immediately after the first foliar application the levels tend to become identical in the two treatments. The high values in most cases are very close to or somewhat above the usually regarded optimum.

One may often observe, though this is not invariably the case, that foliar applications of nitrogen seem also to increase the foliar level of K and P.

Foliar diagnosis is often inadequate to establish the tremendous importance of foliar applications.

Because of having relied too much on foliar diagnosis, in numerous fields in Martinique in 1965, yields have been considerably lower than those possible because of insufficient nitrogen foliar applications. An alternative method remains to be developed.

(*b*) In the following table the yields in tons cane per hectare, the extractable sugar per cent cane, and the total yield of sugar per hectare for 1965 and 1966 are presented. One notes very frequently that an important increase in the tons of cane/Ha. without an associated decrease in the sugar content occurs in the plots which have received foliar application.

Guadeloupe 1965	T.C./Ha.		S.E. % C		T.S./Ha.		Varieties		Type of soil
	N	T	N	T	N	T			
Plateau	55	54	10.85	10.18	5.98	5.53	B.51129	CP	Allophanes à gibbsite
Grand Ravine	82	71	12.87	12.14	10.54	8.68	B.51129	2R	Ferralitique friable
Fonds Boyer	90	87	11.12	11.05	10.0	9.55	B.51129	CP	Alluvions
Lemoine	70	57	13.99	13.07	9.77	7.51	B.51129	2R	Ferralitique friable
Bois Neuf	81	77	12.5	12.6	10.15	9.71	B.46364	CP	Grumosol calcaire
Grand Cesar	79	86	11.22	11.07	8.75	9.54	B.49119	2R	Grumosol calcaire
Loison	49	52	13.76	13.87	6.7	7.17	B.51129	CP	Ferrisol
Ravine Negresse	78	74	13.96	13.9	10.91	10.27	B.51129	2R	Ferralitique friable
Guadeloupe 1966									
Plateau	73	79	13.55	13.72	9.93	10.98	B.51129	1R	Allophane à gibbsite
Fonds Boyer	89	88	11.25	11.24	10.06	9.88	B.46364	1R	Grumosol calcaire
Loison	72	71	13.56	13.49	9.81	9.64	B.51129	1R	Ferrisol
Pallabaty	105	98	8.83	9.31	9.33	9.14	B.51129	1R	Ferralitique friable
Dattier	70	74	11.09	11.26	7.76	8.33	B.46364	1R	Grumosol calcaire
Digue	76	79	12.33	11.72	9.38	9.29	B.51129	1R	Ferralitique friable
Ride	76	76	10.50	10.55	7.81	8.06	B.51129	1R	Ferralitique friable
Grand Cesar	80	90	11.33	11.1	9.1	99.97	B.49119	3R	Grumosol calcaire
Martinique									
Parc à Boeufs	109	112	9.56	9.83	11.88	11.02	B.46364	CP	Alluvions lourdes
Fromager	138	118	8.38	8.52	11.51	10.08	B.46364	1R	Alluvions lourdes vertisol
Basse Pointe	132	161	10.32	9.61	13.70	15.6	B.51129	3R	Jeune sur cendres et ponces
Riz	202	181	7.93	9.2	16.24	16.57	B.37172	3R	Alluvions lourdes
Eloise	124	125	9.26	9.19	11.53	11.53	B.46364	1R	Alluvions
Vinaigrerie	115	118	11.7	11.54	13.47	13.61	B.46364	3R	Alluvions
Fanfan	175	166	9.25	9.14	16.15	15.24	B.37172	3R	Allophane à gibbsite
Paquemar	115	118	11.69	11.54	13.47	13.61	B.46364	3R	Vertisol magnésien
Ramier	131	116	6.64	6.09	8.66	7.04	B.46364	3R	Vertisol

One may say that in 1965 foliar applications of nitrogen caused a noticeable increase of cane and sugar yields (probably because of a better utilisation of nitrogen, during the boom period of growth) as compared to equal quantities applied on the soil, even though this dosage was a little higher than the usual dose.

In 1966, a year of exceptionally heavy rains during the harvest, yields have remained substantially the same, whether the nitrogen was applied on the soil or on the leaves.

It is rather premature to suggest the exact reason for these differences.

CONCLUSIONS

A relationship seems to exist between increases in soluble-nitrogen levels in the stalk and the retardation or actual cessation of sucrose accumulation.

These increases in soluble-nitrogen in the stalk occur during the ripening period when rain falls after a dry spell.

Are these increases of soluble-nitrogen in the stalk responsible for the slowing down of sucrose accumulation in the stalk? Sugar can in fact be utilised for the elaboration of amino acids and protein and utilised in respiration to produce the necessary energy.

Within the scope of these experiments, Mr. Yot of IFAC, has undertaken the detailed study of the amino acids, organic acids and sugars, to determine whether the biological mechanisms found confirm our preliminary hypothesis.

Should these increases in the soluble-nitrogen content of the stalk be attributed to absorption of nitrogen from the soil or to a conversion of the canes' protein reserves?

If the first supposition were correct, one should endeavour to reduce the soils ability to supply nitrogen to the plant during the ripening period as much as possible, as we have tried to do by avoiding appreciable applications of nitrogen to the soil, or by other methods yet to be developed.

It should be pointed out, however, that whereas the increase of soluble nitrogen in the cane seems almost invariably to coincide with rainy periods, such increases in the mineral nitrogen level of the soil are only associated with rainy periods in certain cases. Determinations of the mineral nitrogen content of the soil only indicate the level in the soil at a particular amount however, and give no indication of the soils ability to supply nitrogen to the plant over an extended period. We hope to improve this technique.

In the event of the second hypothesis (according to which the increase in the soluble-nitrogen level in the stalk would originate from the nitrogen reserves of the plant) being correct one should ensure that foliar applications made to induce optimum growth during the boom stage should not be so large as to cause excessive accumulation of nitrogen which would remain, eventually hampering the ripening process. Would it be possible to determine a critical period after which no foliar applications should be made in order not to inhibit the beginning of ripening?

Dr. Nickell of the H.S.P.A. had considered the use of the content in the stalk of soluble amino acids, or of some of them, to differentiate varieties with good and poor juice quality, the excess of amino acids being an indication of the failure of the active leaves completely to mobilise them, and thus resulting in their being found as amino acids in the stalk. The study of the various forms of nitrogen at the end of the growth period may help to find a control method.

In the meantime, it is already of considerable interest and importance to have established that similar high yields can be obtained either by foliar sprays of urea or by soil applications. It will therefore, be possible to put the results into practice immediately since the aerial application method is already being largely utilised in the French Islands for herbicide and fungicide applications to bananas.

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DISCUSSION

Mr. Le Grand said, from the limited knowledge he had about the French islands in the Caribbean, he was not surprised that juice quality was affected by aerial application of urea.

Harvest started in about January in both places, and an application of 20 kg. urea per hectare, about equivalent to 20 lb. of urea per acre, in November when the cane was about 10 months old, might affect proper maturation of the cane.

He knew that several field practices in the French West Indies resulted from experience gathered in Puerto Rico, where pioneering work with aerial application in that territory was started by Central Mercedita, on the south coast. Application of urea in this case was made as soon as the cane was "closed in", when the cane was about 3 to 4 months old. He felt, that a similar application and timing might greatly reduce maturing difficulties in the French West Indies. One application of 30 kg. per hectare to 4-5-months-old cane might be more effective than the three split applications now applied. No damage to the leaf surface should be feared with this rate of urea to the foliage, since much higher rates of applications had been reported without causing damage to the foliage.

Dr. Evans commented that in Martinique and Guadeloupe the problem was that during the harvesting season they had frequent heavy showers similar to those being experienced in Guyana this year. These resulted in significant drops in quality. In order to find out the reason for this, these experiments using aerial application at various times, were being carried out.

Mr. Le Grand observed that there were two rather distinct zones in both islands. The first area could be called wet, while the other zone could be regarded as receiving a moderate to heavy rainfall. The latter zone was mainly used for bananas, while the drier areas were often employed for growing sugarcane.

Mr. Strang noted, according to the authors, that a large part of the sugarcane growing area received frequent and heavy downpours throughout the harvesting period.

Mr. L. S. Birkett recalled that several years ago, he, along with his co-workers, carried out soil investigations and found that it was possible during boom periods of growth to get large variations in the nitrate and ammonia-nitrogen levels in the soil within relatively short periods.