

RESULTS OF MOSAIC TOLERANCE TRIALS

By N. C. KING.

Introduction.

The history of mosaic in Natal dates back to the year 1922 when Dr. H. H. Storey was appointed to the Durban Herbarium. At that time Uba was being grown commercially on a large scale, but the thick tropical canes, mainly varieties of *Saccharum officinarum*, e.g. Port Mackay, Rose Bamboo, Green Natal, etc., were also being grown to a limited extent, mainly by the Indians who were growing them for eating purposes. It was in the highly susceptible *S. officinarum* varieties that Dr. Storey first found mosaic in Natal. Uba in Natal is immune to mosaic but in the U.S.A. it has been found to be susceptible; this is not due to a change in the susceptibility of the plant itself but to the fact that different strains of the mosaic virus are present in different countries.

In 1922, then, Dr. Storey was confronted with an industry which was growing a large number of varieties varying in susceptibility to mosaic from very susceptible to immune. The obvious solution of this problem of mosaic was to grow only immune Uba which at that time was practically the only variety grown. By allowing only Uba to be grown it was hoped that mosaic would be eradicated from Natal. It was known that mosaic was present in a number of the grasses but it was thought that this would not play an important part in the spread of mosaic. However, in 1927 a law was passed prohibiting the growth of any varieties of cane other than Uba.

Introduction of Mosaic.

Sugar cane mosaic is not endemic to South Africa and it is thought that the disease was introduced from the Argentine in 1914, in a consignment of Java canes. At that time, there was a quarantine station in Durban, but the leaf symptoms of mosaic on some of these varieties, notably P.O.J.213, are very indistinct and it is probable that the disease slipped through the quarantine station. This is borne out by the fact that all the canes grown from this original consignment were infected with mosaic and the original seed probably came from diseased stock.

Period 1927-43.

The period 1927-43 was one of comparative freedom from mosaic in commercial plantations and the only disease of note was streak in Uba. Mosaic was still present but it was under control and looked as if it might almost be a disease of the past. However, the yields of Uba were considerably reduced

by the high incidence of streak and a number of varieties were imported to possibly replace Uba. Co.281 was one of these varieties and its release for commercial planting was withheld for some time because it was found that it could be infected with mosaic. It was, however, eventually released and proved an extremely good cane and was cultivated for some ten years before any mosaic was found. In 1943 mosaic was first noticed in Co.281 at the Experiment Station.

Period 1943-52.

After the discovery of mosaic in Co.281 a survey of the Sugar Industry was made. Mosaic was found to be most prevalent in the Umzinto area and some fields were 60-70 per cent. infected, mainly in Co.281. The North Coast was not so heavily infected and only isolated cases of mosaic were found. This outbreak of mosaic was probably brought about by the presence of mosaic in some of the grasses and it was accentuated by the interplanting of maize with cane, which action considerably increased the number of vectors of the disease. (The vector of sugar cane mosaic, *Aphis maidis*, colonises on the maize plant.)

The position today is that mosaic is still being found on both the North and South Coasts, but generally the high incidence of mosaic in the Umzinto area is no longer present. Along the North Coast mosaic is still being found but in the majority of cases it is confined to a few isolated stools.

The writer has recently seen a couple of outbreaks of mosaic where the incidence of the disease has been exceptionally high. An investigation showed that the cane had been planted adjacent to a maize patch. The maize plants were infected with mosaic and had been covered with aphids. There were a number of species of grass present, mainly a species of *Panicum*, which was heavily infected with mosaic. The conditions here were ideal for the rapid spread of mosaic, and resulted in the plot of cane becoming heavily infected with mosaic. Another plot of the same variety, growing about a mile away and in an area where no mealies were growing, was found to be free of mosaic. Some years ago a paper was presented to a meeting of this Association on the influence of maize on the spread of mosaic in sugar cane. It was definitely shown that the presence of maize in the proximity of growing cane considerably increased the spread of mosaic. Apart from any agricultural consideration the practice of interplanting maize and cane is to be condemned.

Experimental Work.

Recently, two mosaic experiments have been planted with the object of obtaining some information on the loss in yield due to mosaic. At the same time the secondary spread was investigated but it soon became apparent that the secondary spread (i.e. by Aphids) was so rapid that the original idea of comparing yields from healthy and mosaic canes had to be abandoned and yields from primary and secondary infections were compared.

Influence on Yield on Mosaic.

Experiment I was planted in January, 1949 and since then has been harvested three times. Table I gives the yields for the experiment.

TABLE I.
YIELDS, IN TONS PER ACRE, HARVESTED
FROM EXPERIMENT I.

		Setts Planted Diseased.				Setts Planted Healthy.			
		Plant Cane.	First Ratoon.	Second Ratoon.	Total for 3 Crops.	Plant Cane.	First Ratoon.	Second Ratoon.	Total for 3 Crops.
Co.281	Diseased	24.7	21.2	22.1	68.0	21.3	18.6	19.4	59.3
	Healthy	0.1	0.0	0.0	0.1	2.5	2.2	2.3	7.0
	Total ...	24.8	21.2	22.1	68.1	23.8	20.8	21.7	66.3
Co.301	Diseased	44.6	20.7	24.1	89.4	46.9	24.4	12.9	84.2
	Healthy	2.5	6.4	10.7	19.6	11.5	9.5	26.2	47.2
	Total ...	47.1	27.1	34.8	109.0	58.4	33.9	39.1	131.4
N:Co.291	Diseased	49.5	30.8	33.1	113.4	45.8	28.9	31.1	105.8
	Healthy	2.3	0.0	0.0	2.3	5.7	2.1	3.0	10.8
	Total ...	51.8	30.8	33.1	115.7	51.5	31.0	34.1	116.6
N:Co.310	Diseased	17.3	12.2	8.2	37.7	7.4	1.2	0.5	9.1
	Healthy	2.9	4.5	14.0	21.4	45.9	33.9	41.7	121.5
	Total ...	20.2	16.7	22.2	59.1	53.3	35.1	42.2	130.6

An analysis of the yields in Table I showed that there was no difference in yield in the varieties Co.281, Co.301 and N:Co.291, between cane which had been planted diseased and cane which had been planted healthy. In N:Co.310 there was a significantly lower yield from cane which had been planted diseased as compared with cane which had been planted healthy.

TABLE II.
AVERAGE WEIGHT OF STICKS.

			Lbs. per Stick.	Difference. lbs.
Co.281	...	Diseased ...	1.08	
		Healthy ...	1.11	+ 0.03
Co.301	...	Diseased ...	1.45	
		Healthy ...	1.47	+ 0.02
N:Co.291	...	Diseased ...	1.82	
		Healthy ...	2.04	+ 0.22
N:Co.310	...	Diseased ...	1.12	
		Healthy ...	1.81	+ 0.69

From Table II we find that the diseased sticks of N:Co.310 are significantly lighter than those which remained healthy throughout the experiment. From Table I it can be seen that the varieties Co.281, Co.301 and N:Co.291 were almost entirely infected

with mosaic but from Table II it is seen that there is no difference in weight between the diseased and healthy sticks. These results show that N:Co.310 is susceptible but not tolerant to mosaic, while the varieties N:Co.291, Co.301 and Co.281 although the plots were almost entirely infected with mosaic the average weight of the sticks from healthy and diseased material was almost the same. These varieties then can be classified as being susceptible but tolerant. From observations it is apparent that the low yield given by Co.281 is not due to mosaic but to some other cause which at present is being investigated.

Experiment II was planted in January, 1950 and has been harvested twice. Table I (a) gives the yields for this experiment.



PHOTOGRAPH I.
This Shows the Effect of Mosaic on the Sticks of N: Co.349.

TABLE I (a).
YIELDS, IN TONS CANE PER ACRE,
HARVESTED FROM EXPERIMENT II.

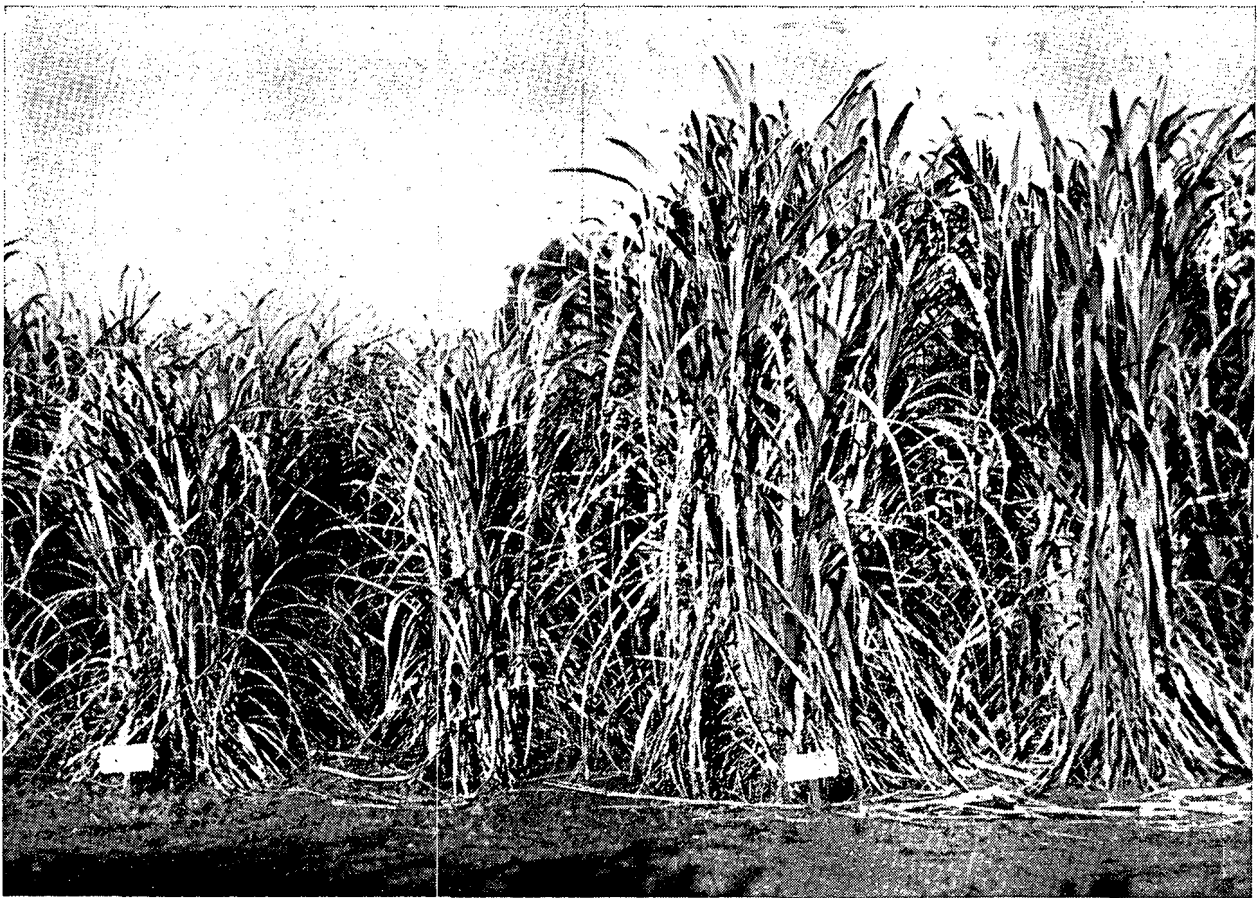
		Setts Planted Diseased.			Setts Planted Healthy.		
		Plant Cane.	First Ratoon.	Total for 2 Crops.	Plant Cane.	First Ratoon.	Total for 2 Cro; s.
Co. 331	Diseased ...	39.1	26.1	65.2	17.4	11.2	28.6
	Healthy ...	0.7	5.4	6.1	29.1	33.0	62.1
	Total ...	39.8	31.5	71.3	46.5	44.2	90.7
N:Co.349	Diseased ...	18.0	12.4	30.4	15.5	10.4	25.9
	Healthy ...	0.1	0.4	0.5	8.4	10.4	18.8
	Total ...	18.1	12.8	30.9	23.9	20.8	44.7
N:Co.339	Diseased ...	38.9	35.9	74.8	38.0	39.7	77.7
	Healthy ...	2.5	1.7	4.2	4.4	2.1	6.5
	Total ...	41.4	37.6	79.0	42.4	41.8	84.2
N:Co.310	Diseased ...	26.2	15.1	41.3	4.8	1.3	6.1
	Healthy ...	1.7	6.5	8.2	40.3	29.6	69.9
	Total ...	27.9	21.6	49.5	45.1	30.9	76.0

From Table I (a) the statistical analysis reveals that in the variety N:Co.339 there is no difference in yield between cane which was planted diseased and cane which was planted healthy. The varieties Co.331, N:Co.349 and N:Co.310 showed a significantly lower yield from cane planted from diseased setts when compared with yields obtained from healthy setts.

TABLE II (a).

	Diseased.	Healthy. lbs.	Difference.
Co.331 ...	1.63	1.82	+ 0.19
N:Co.349 ...	1.00	2.00	+ 1.00
N:Co.310 ...	1.34	2.01	+ 0.67
N:Co.339 ...	1.61	1.48	- 0.13

From Table II (a) we find that in the varieties Co.331 and N:Co.339 there is no difference in weight between diseased and healthy canes. The diseased sticks of N:Co.310 and N:Co.349 were significantly lighter than the healthy canes. These figures from Tables I (a) and II (a) indicate that N:Co.339 is susceptible but tolerant while N:Co.349, N:Co.310 and Co. 331 are susceptible but not tolerant to mosaic. The loss in yield in N:Co.310 and N:Co.349 was due to thinner and lighter sticks while in Co.331 the loss was due to there being fewer sticks in the diseased plots.



PHOTOGRAPH II.

N: Co.310 19-months-old Plant Cane showing two lines on left Mosaic infected, two lines on right healthy.

Photograph 1 shows what effect mosaic has on the cane itself. The mosaic infected sticks are much thinner, internodes shorter and more concave than the healthy cane. There were also mosaic stem markings on the rind which can be seen on the right hand mosaic stick.

Photographs 2 and 3 illustrate what effect mosaic has on the growth of cane in the varieties N:Co.310 and N:Co.349 respectively. Note the severe stunting in both cases, due to mosaic.

Infection and Recovery.

The series of graphs of Experiment I illustrate to what extent each variety has been infected with mosaic. In the series "planted diseased" it will

be noticed that very little healthy cane was produced, with the exception of Co.301 (graph 8), which shows a certain amount of recovery from the disease but later these shoots were infected and eventually the whole plot was totally diseased. In the "planted healthy" series all the setts germinated healthy but in the varieties N:Co.291, Co.281 and Co.301 the shoots were rapidly infected and as shown in the graphs 3, 5 and 7 the plots were easily infected and even after seven months only about half of the plot was infected with mosaic. The spread of mosaic, although the chances of acquiring the disease were the same, was much slower than in the other varieties and can be considered to be only moderately susceptible to the disease.



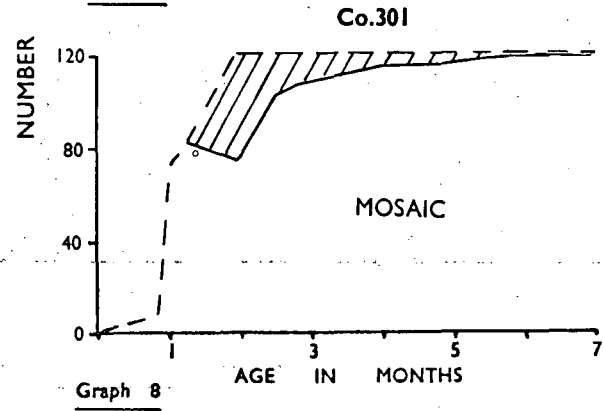
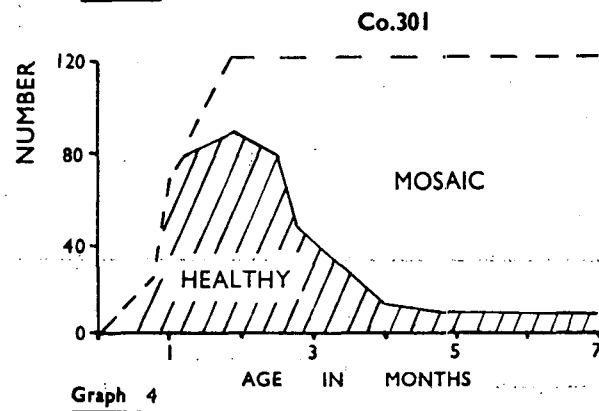
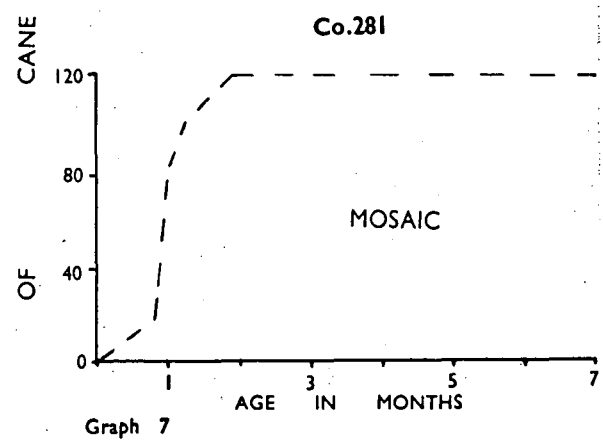
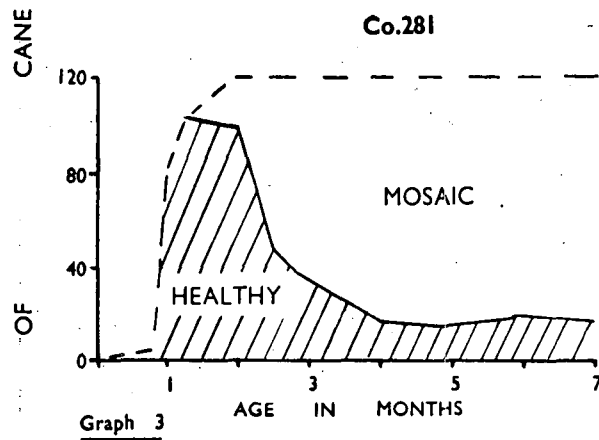
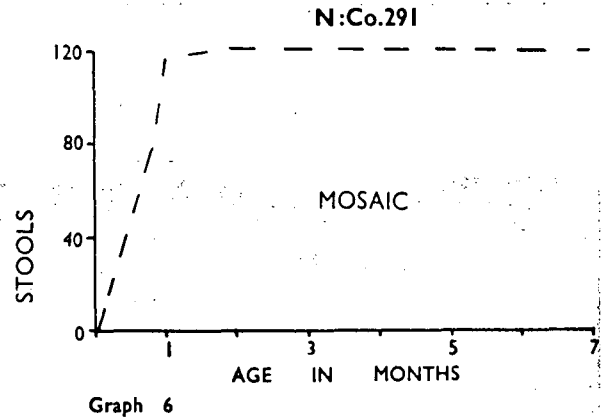
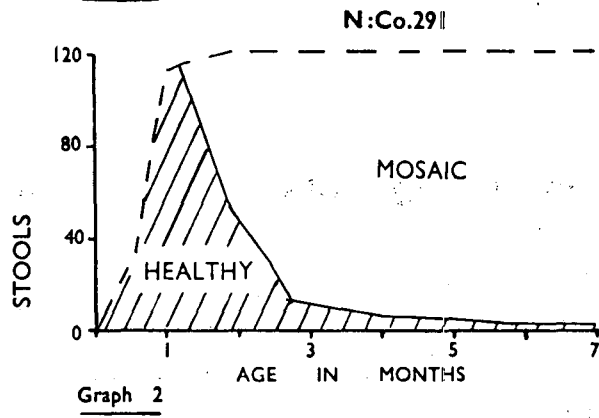
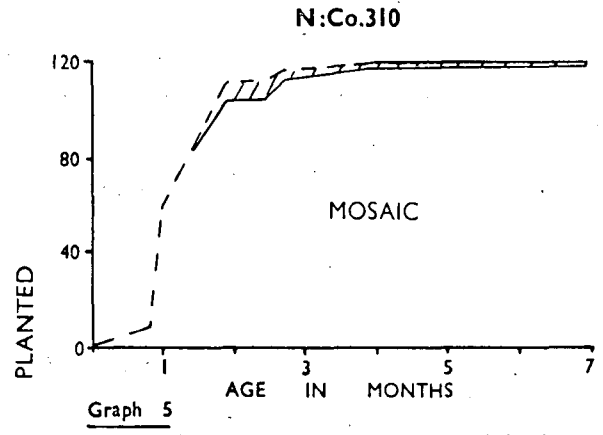
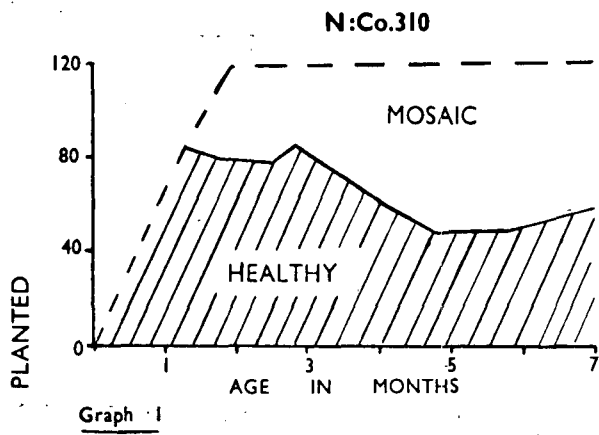
PHOTOGRAPH III.

N: Co.349 19-months-old Plant Cane showing two stools on left Mosaic infected, two stools on right healthy.

These graphs show the number of cane stools infected with mosaic during the first seven months of Experiment I.
 (The broken line indicates the rate of and total germination)

PLANTED HEALTHY

PLANTED DISEASED



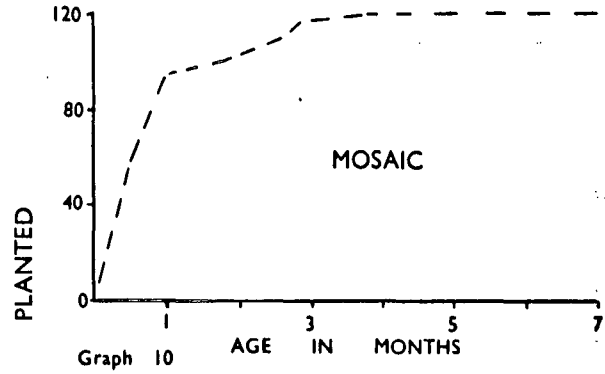
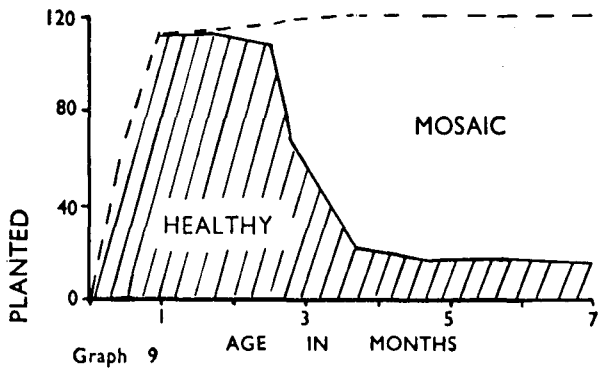
These graphs show the number of cane stools infected with mosaic during the first seven months of Experiment II.
 (The broken line indicates the rate of and total germination)

PLANTED HEALTHY

PLANTED DISEASED

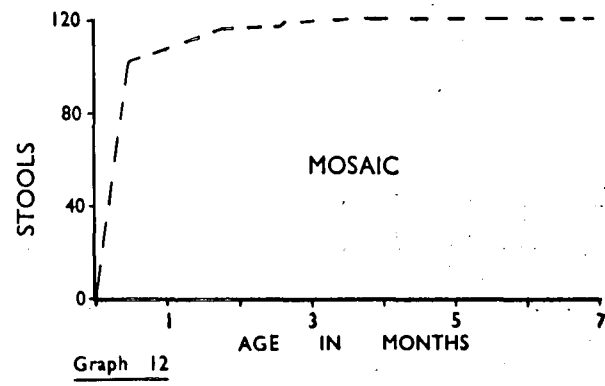
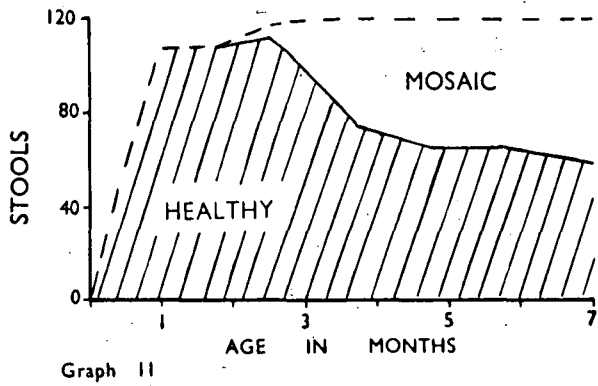
N:Co.349

N:Co.349



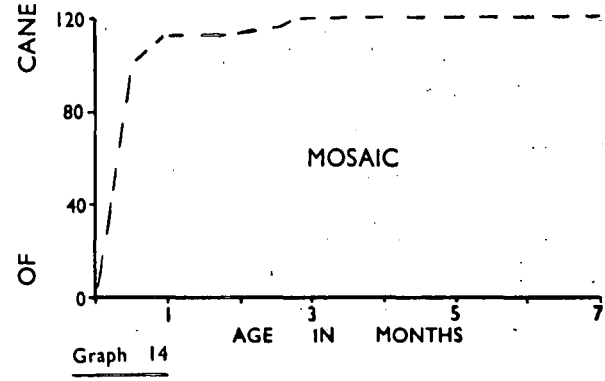
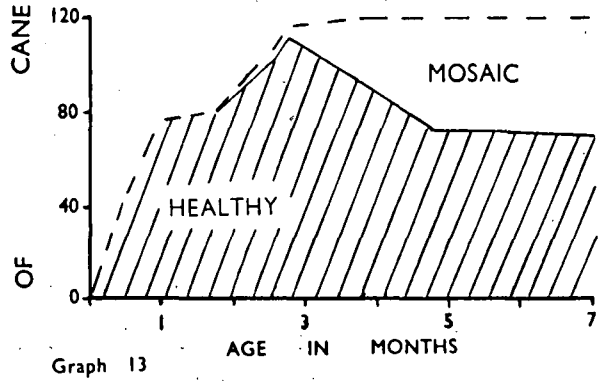
Co.331

Co.331



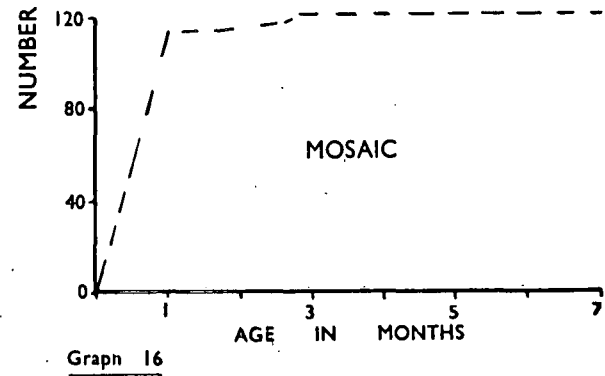
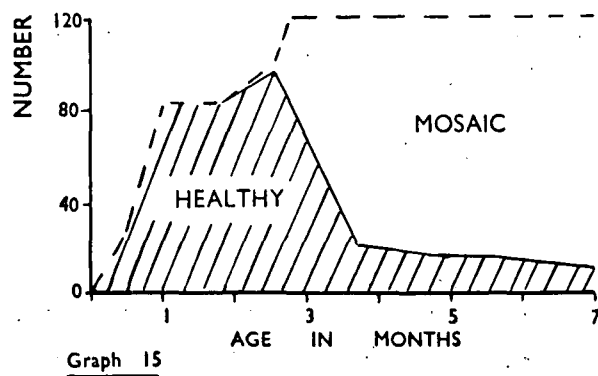
N:Co.310

N:Co.310

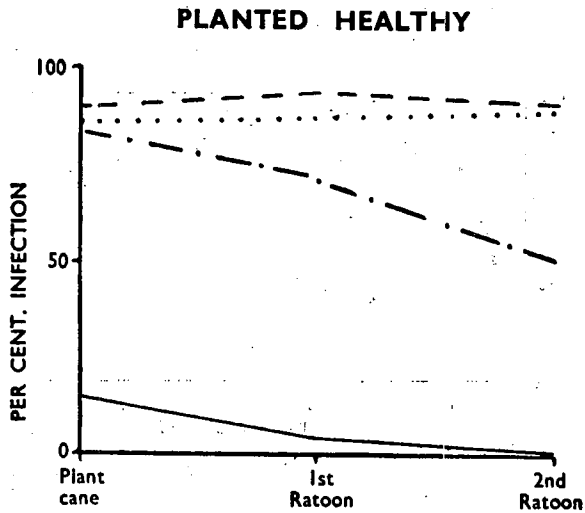


N:Co.339

N:Co.339

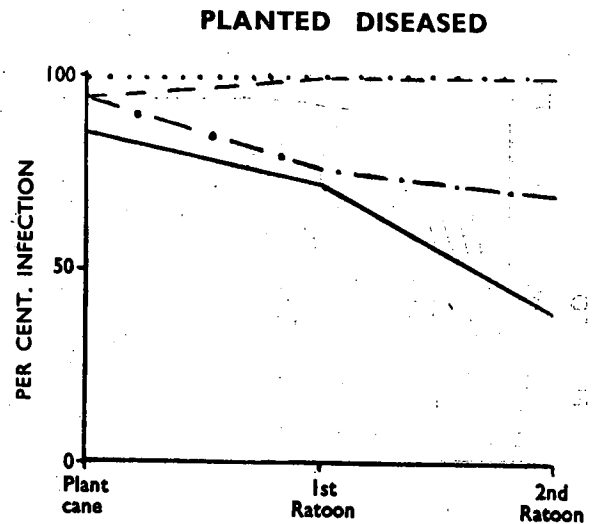


Graphs showing relationship between recovery and age of cane.



Graph 17

N:Co.310 ————— Co.281
 N:Co.291 - - - - - Co.301 - - - - -



Graph 18

The series of graphs of Experiment II follow the same pattern as those of Experiment I. In the "planted diseased" series all the setts germinated diseased and virtually no healthy shoots were produced, i.e. there was no recovery. The "planted healthy" series shows the extreme susceptibility of N:Co.349 and N:Co.339. N:Co.310 is very similar to the one in Experiment I (graph 1). Co.331 (graph 13), shows the variety to be moderately resistant to mosaic and is very similar to N:Co.310, when secondary infection is compared.

So far it has been seen that there is very little recovery from mosaic in the plant cane crop. Graphs 17 and 18 show that in the varieties N:Co.310 and Co.301 there is considerable recovery in the first and second ratoon crops. The plant cane crop of N:Co.310, planted diseased, gave an infection of 85 per cent but in the second ratoon crop this percentage was reduced to 37 per cent. Corresponding figures for Co.301 are 80 per cent. and 49 per cent. In the plots which were originally planted healthy, N:Co.310 which in the plant cane crop was 13 per cent. infected was in the second ratoon nearly all healthy. The varieties Co.281 and N:Co.291 showed no tendencies to throw off the disease. This recovery in the ratoon crop is important in that there is less chance of secondary spread taking place as the source of infection is constantly being removed.

Conclusions.

We in Natal are fortunate in that although mosaic is potentially a serious disease it has been kept under control and at present is doing very little

damage to the annual crop. This satisfactory condition can only be maintained by the growing of suitable varieties which are tolerant to mosaic. The ideal position would be to grow only immune varieties but it must be realised that if this was done there would be very few varieties suitable for cultivation. One of the pathologist's problems is to test out new varieties against the more important diseases. One variety may be immune to mosaic but on the other hand extremely susceptible to some other disease. A variety such as this, although excellent from a mosaic point of view, would probably have to be discarded because of the other disease. It is seen, therefore, that a balance has to be found between the various diseases.

It we cannot find immune varieties what then is the solution? As shown earlier in this paper a number of varieties are susceptible but tolerant to mosaic, others are susceptible but not tolerant. In other parts of the world it has been found that the growing of susceptible but tolerant varieties is satisfactory, and there is no reason why the same system should not be adopted here. At present in Natal we are growing both tolerant and non-tolerant varieties together and it is the writer's view that if tolerant varieties are to be grown then they must exhibit a certain degree of resistance. It is obvious that it is unwise to grow both tolerant and non-tolerant varieties at the same time.

Summary.

A brief review is given of the introduction of mosaic to Natal and the identification of the disease by Dr. H. H. Storey.

The mosaic position in Natal during the period 1927-53 is discussed. The finding of mosaic in Co.281 in 1943 marks the turning point, from a period of freedom from mosaic to a period when the disease is once more present in the cane fields.

Results of tolerance trials are given. The varieties Co.281, Co.301, N:Co.339 and N:Co.291 are very susceptible but tolerant while N:Co.310, N:Co.349 and Co.331 are susceptible but not tolerant. Three photographs illustrate the effect of mosaic on sugar cane.

Graphs have been drawn showing the recovery and infection of the various varieties under trial. In some varieties more recovery took place in the ratoon crops than in the plant cane crop and there are indications that N:Co.310 may completely recover from the disease if allowed to ratoon long enough.

REFERENCES.

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²A. McMartin and N. C. King: Some factors influencing the spread of Sugarcane Mosaic in Natal. S.A. Sugar Technologists, 1948.

³E. M. Summers, E.W. Brandes and R. D. Rands: Mosaic of Sugarcane in the U.S.A. with special reference to strains of the virus U.S. Dept. of Agri. Tech. Bull., 955, 1948.

Mr. Adams said he had recently read "Humus, and the Farmer" by Sykes. He suggested that if the fertility of the soil was correct, then everything else was correct. He thought Mr. Dymond had written an article on mosaic in relation to compost. He asked Mr. King whether, in his experiments, he had tried any of the theories propounded by Sykes. In other words, had he planted diseased cane in soil which was 100 per cent healthy and sound.

Mr. Dymond said the subject had been brought up year after year and while he did not agree entirely with Sykes, he felt there was some foundation for the theory he had propounded of healthy soils producing healthy plants. He was still experimenting with the theories which Mr. Adams had referred to. His experiment was concerned mainly with streak. He had used Uba cane which was 60 per cent streak infected and in three years had brought the incidence of streak down to nothing. He had not had such good results with a variety of Uba cane that was stunted and diseased but he hoped that it would cure itself in time.

Mr. Barnes observed that mosaic had been a serious problem in most sugar cane countries, and still was important in many. Its menace had been countered by breeding resistant varieties. In the West Indies, only Jamaica of the British territories

experienced difficulty. The principal variety grown there, B34 104, was susceptible but tolerant, and though visible signs of mosaic disappeared with this variety after the early stages of growth, it was regarded as 100 per cent affected. In such circumstances it was impossible to grow a susceptible variety on a commercial scale, whatever its merits in other ways might be.

There was no evidence in Jamaica that the use of farmyard manure and other organic matter had any effect on the incidence of mosaic disease. In actual fact the epidemic of the 1920's and later was most severe in lands which had been manured with these materials for generations, and where the use of "artificial" was little practised until recent times.

He said that Mr. King had very properly been guarded in his final statement, but the word "dangerous" should replace "unwise."

Mr. King said the reference to the application of manure increasing the spread of mosaic was very interesting, but that in Natal there was not the opportunity of observing this fact as very little farmyard manure was used. The question of curing mosaic with compost had been tried out at the Experiment Station, but with no success.

Mr. Barnes said the question of the recovery of cane from mosaic was one that had confronted him for many years during his work. One very popular variety of cane in the West Indies was B. 34.104 which was accepted as tolerant. It seemed to throw off the symptoms of mosaic and these could not be detected after it had grown for some time. Yet that cane was regarded pathologically as one hundred per cent infected. The disease appeared only in the very early stages and then disappeared with growth, which suggested that the variety could throw off the disease. He did not know whether this applied to other varieties.

Dr. McMartin said there were many instances of different varieties throwing off the effects of mosaic, and that the recovery was real, i.e. not merely a masking of symptoms. Some varieties including Uba were able to throw off streak quite readily, irrespective of the treatment accorded to it. The Experiment Station had been able to find no foundation for the theory that it was possible to treat cane by raising the soil fertility and so enable them to throw off disease. He asked whether the chairman could define what was a healthy soil.

Dr. Dick asked whether once a cane had thrown off mosaic it was afterwards nearer immunity than the original cane.

Mr. King said that he knew of no actual case where mosaic had been thrown off and the plant remained completely immune afterwards. There were indications, however, that some sort of in-

creased resistance developed, but this could be due either to a change in the host or the virus itself. For example, P.O.J. 213, when it was grown commercially, was nearly completely infected with mosaic, but when healthy sticks were selected and planted in the collection of varieties very little mosaic was found.

Dr. Dodds said that although there had been no major losses from mosaic in this country, other countries had not been so fortunate. He had seen mosaic in many countries and in many different types of soil, but he could not say that he had heard or seen that any attention to the fertility of the soil had any effect on the incidence of mosaic. In Louisiana, mosaic had almost wiped out the sugar industry, but fortunately it had been able to recover and pull through. The relative amount of injury done by mosaic in different countries depended largely on the strains of the disease that happened to be prevalent; different strains of mosaic disease often varied greatly in virulence.

Dr. Dodds asked whether there were any strains newly developed in South Africa which more severely attacked sugar cane.

Mr. King said that about two weeks previously he had found, at the Experiment Station, two distinct patterns of mosaic leaf markings on the same variety. These leaf markings appeared to be the first indications of different strains of mosaic existing in Natal.

Dr. McMartin said that it had been found in Louisiana that if a cane recovered from mosaic no immunity was conferred. It could develop mosaic again. A mild strain might, however, give immunity from a severe strain.

Mr. Dymond said that he would have liked Mr. King's and Dr. Dick's papers to be presented at the Experiment Station, but this was not possible owing to the large number of papers. He felt, however, that the amount of discussion that had taken place clearly showed the interest taken and he asked that a vote of thanks be accorded to Mr. King.