NOTES ON FERTILIZER EXPERIMENTS HARVESTED AT TONGAAT DURING 1936 AND 1937.

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Since a programme of field trials was inaugurated, at the beginning of 1936, a number of replicated plot experiments have been harvested. The information disclosed is so far rather meagre and disappointing; but certain trends emerge which are of general interest. The intention of this paper is to review the position in an attempt to ascertain in what direction the clues lead, both from the point of view of adjusting current field practice, and also in connection with subsequent phases of fertility investigations.

The form of experiment that was decided upon was a very simple arrangement of balanced blocks. In actual fact the decision to adopt such an arrangement was scarcely a matter of choice in the absence of anyone with a knowledge of factorial design to superintend laying out complex experiments. Apart from this side of the question there are some advantages appertaining to the running of simple experiments:—

(1) A field trial is at all times subject to accidents, which may render it completely valueless. In a complex experiment a large number of inquiries are entrusted to one experiment; if all goes well the results may be immediately valuable. But the chances are rather high that an accident may occur—fire, stray livestock, or locust swarm—in which case the whole project comes to grief. If, on the other hand, the same number of inquiries are spread to an equal number of simple experiments, one may confidently expect that a fair proportion of them will escape damage and be productive of reliable figures at harvesting time.

(2) The success of a programme of field experiments depends very largely on the interest, co-operation, and enthusiasm of the field official in charge of the plantation. His interest in a simple experiment in which comparative effects can be observed from time to time during the growing period is liable to be more sustained than in the case of a complex experiment in which visible effects are masked by super-imposed treatments.

(3) The ultimate object of an experiment is to change routine practice, for which the authority of owners or directorates is required. Here the value of argument drawn from the results of simple experiments which are often themselves "demonstrations"—is quite apparent.

T. S. Co., Ltd. — Lay out of Experiments.

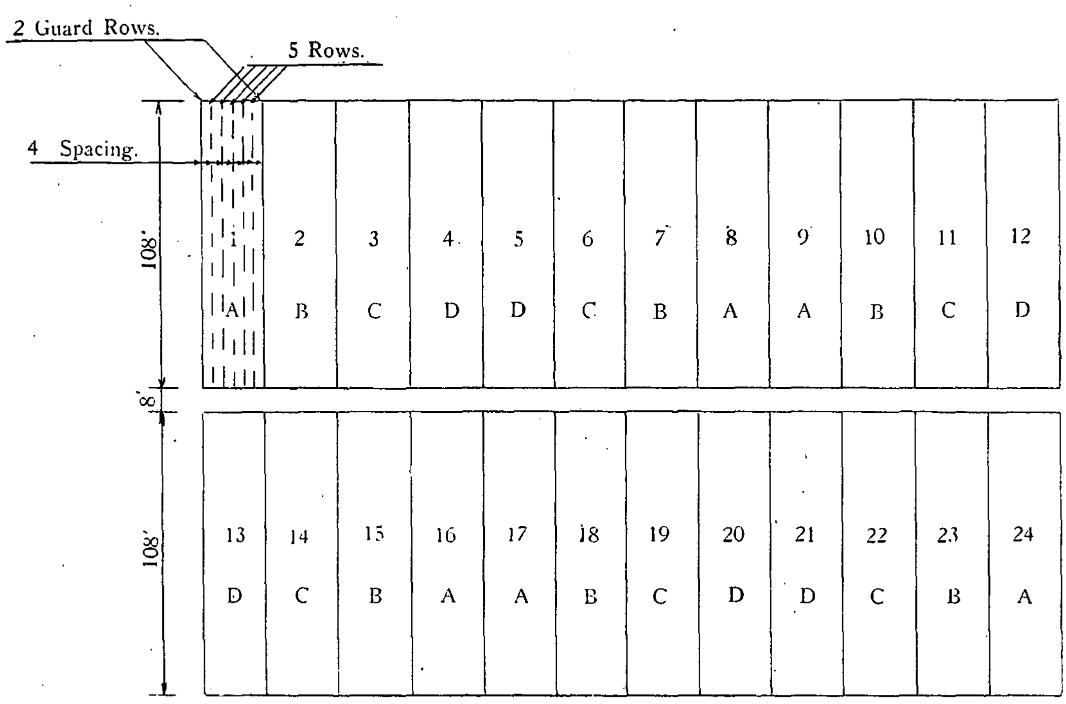


Fig. 1

The technique of these simple experiments presents very little difficulty. The lay-out, shown in Figure 1, consists of six blocks, each containing four 1-20th acre plots. The plot, doubtless on the small side from a statistical point of view, offers advantages in economy of material, ease of location, and less trouble when harvesting. The plots contain five cane-rows apiece, 4 ft. apart and 108 ft. long; thus each cane-row is equal to 1-100th of an acre, which is an added convenience when weighing out plot treatments. A border or guard-row is on either side of each plot, to minimize border effect, the canes in which are cut out and discarded prior to harvesting the experiment. Short lengths of old tram-track are used for staking at each end of every guard-row, permanently marking plot corners. Metal caption-boards, on which the details of the treatment, plot number, etc., are stencilled, are provided for each plot. Besides facilitating the application of treatments the caption-boards offer an easily readable explanation of the experiment, and promote interest by enabling all concerned in the welfare of the trial to observe its progress without the inconvenience of referring to note-books and diagrams. If the nature of the site permits the preferred arrangement is two "banks" each consisting of three blocks of plots. Frequently it is necessary to modify the arrangement in order to fit into the chosen area, and it may be one bank of six blocks of plots, three banks of two blocks each, or one may even be compelled, in the search for a uniform site, to put down the experiment in two or more portions, separated by small areas of crop cane (1).

Plots are not randomized, but arranged with a view to minimizing border effect. This non-conformity with the requirements of statistical design is open to much criticism. When further refinements come to be investigated it may be necessary to introduce randomization. Meantime it is thought that in view of the type of experiment being undertaken and the wide divergence between tratments that may be expected, the validity of results will not be greatly impaired by failure to conform to the requirements of the theory of random placements of plots. It may also be observed that there is little chance of favouring any given treatment when a pre-arranged standard plot layout is applied without any modification in respect of individual plots to areas in which the soil is well known to be extremely diversified in almost every conceivable way.

Fertiliser treatments are separately weighed and applied in respect of each cane row, thus, insuring uniform application. Guard rows receive the treatment of the plot in which they are located. Calico bags, holding about 20 lbs. are an aid to accurate and rapid applications. Generally speaking the phosphates are applied at the start of the crop, and nitrogen and potash are side-dressed in two or more applications (2).

The first group of experiments, the results of which are given in Table 1, was inaugurated with the object of ascertaining under various soil conditions, and with plant cane as well as ratoons, whether the routine fertiliser aplication, as in vogue at Tongaat during the 1935 season, consisting of 1,000 lbs. of predominantly phosphatic material, provided an adequate supply of plant food, or whether a treatment containing rather large amounts of each of the three principal plant food ingredients would cause marked increases in yield. The group was laid down in a hurry, and neither the sites nor the layouts were very satisfactory. Notwithstanding these disadvantages the crops harvested showed significant, and in most cases economic responses, to augmentations of plant food a long way in excess of the hitherto routine applications.

TABLE 1.

Results of Experiments showing response to high NPK treatments compared to 1935 routine practice.

Field	Cauvins House	Studd	Tongaat River	Jeehan	Jeehan
Experiment No.	2	8	3	12a	12b
Variety	Co.290	Uba	P.O.J.2878	Co.290	Co.290
Crop	Plant	1 Rat.	1 Rat.	Plant	1 Rat.
Year	1936	1937	1937	1936	1937
Age—months	15.5	24.5	23.5	19.0	14.0
TCPA Harvested:					
High NPK	43.97	51.69	49.33	27.86	34.16
1935 Routine	35.29	41.72	41.75	20.51	15.66
Significant Gains:					
Tons cane per acre ..	8.68	9.97	7.58	7.35	18.5
Tons sucrose per acre	0.87	0.97	1.12	0.89	2.68
Rainfall—inches	61.67	83.89	85.85	61.15	39.51
Soil — available P_2O_5	0.010	0.022	0.030	—	—
,, K_2O	0.009	0.017	0.010	—	—

Exps. 2, 8 and 3—grey-brown sandy loam, fairly fertile area. Exp. 12—T.M.S. drained swamp, growth failure area.

Fig. 2.

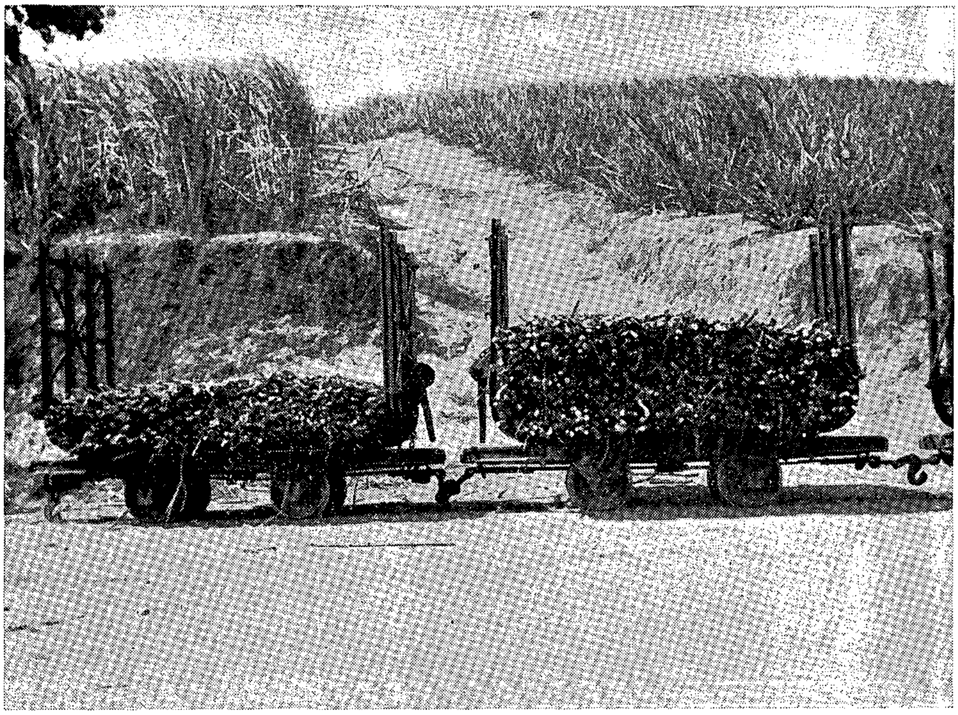


Fig. 3.

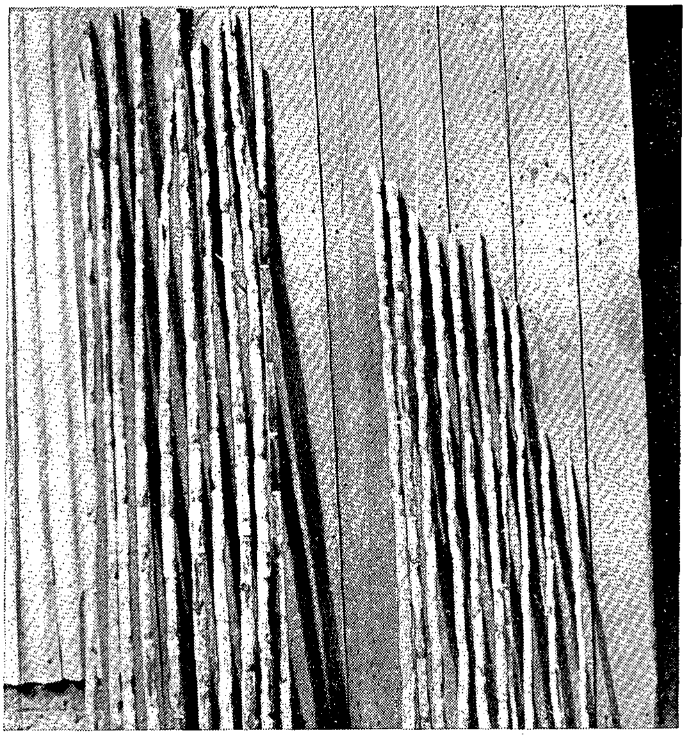
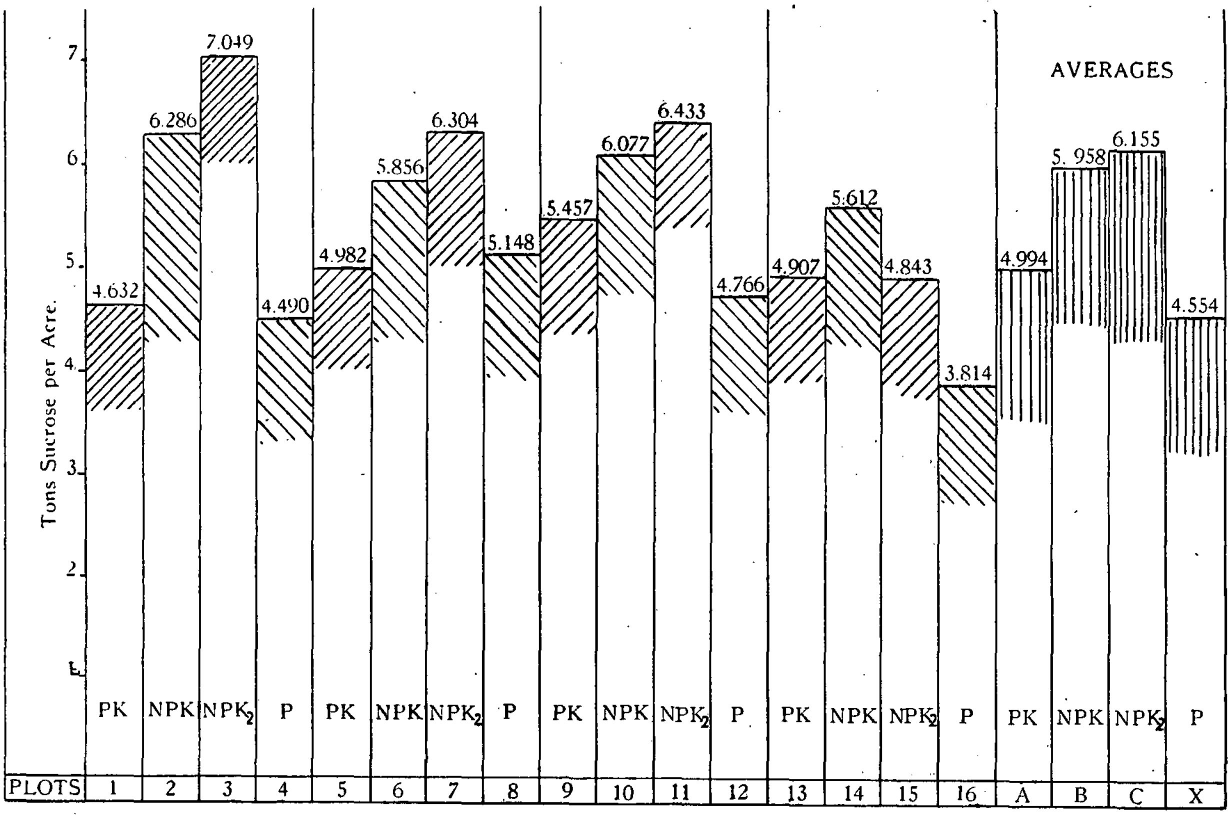


Fig. 4.



T. S. Co., Ltd. Exp. 13, Series 1. Field 163 Beach Road, Tongaat Sect.

Co.290, Planted April 30th, 1936, harvested October 11th, 1937, 17 Mos. old.

P = 900 lbs. Super = 180 lbs. P_2O_5.

N = 1,000 lbs. Amm. Sulph. = 200 lbs. N

K = 333 lbs. Mur. Potas. = 200 lbs. K_2O

Fig. 5.

The 1935 season standard treatment for plant cane was as follows:—

	N	P_2O_5	K_2O
325lbs. No. 2 whale guano	19.5	48.75	
600lbs. super 20 per cent ..		120.0	
75lbs. muriate of potash ..			45
	19.5	168.75	45

Ratoons received 300lbs. of super only.

The high NPK treatments varied slightly but generally were as follows:—

	N	P_2O_5	K_2O
1,000lbs. ammonium sulphate	200		
1,000lbs. super 20 per cent ..		200	
333lbs. muriate of potash ..			200

Supers were applied in one dose at the start of the crop; potash and nitrogen were given later, in two and four equal doses respectively.

Figures 2, 3 and 4 illustrate the difference between treatments in the first ratoon crop of Experiment 12, where an increase of 2·68 tons of sucrose gave a good margin of profit over the cost of the fertiliser application, which amounted to £6/1/8 per acre

The second group of experiments, the results of which are shown in Table 2, was arranged with the object of ascertaining the response to the addition of potash, nitrogen plus potash, and nitrogen plus double potash, to an initial application of phosphate. In Experiment 13, Fig. 5 located in a low-lying drained swamp of sandy soil, similar to the wind-blown sand series. with a certain amount of clay underlying it, there was a marked reaction to the addition of 1,000 lbs. of ammonium sulphate in the presence of potash. The PK plots gave no significant increase over P, nor was there a singnificant response when the potash application was doubled (NPK_2), but owing to the absence of an NP series of plots, it is not possible to comment at this time on the potash requirements of this part of the plantation. In fact the available potash in the soil is at a level at which favourable reaction to augmentations of potash might well be expected. (See Table 2).

In striking contrast, Experiments 23 and 24, located in two similar areas of reddish wind-blown sand, showed no response whatever to additions of 800 lbs. of ammonium sulphate and up to 400 lbs. of muriate of potash to the initial application of phosphate. In Experiment 24 the dressing of phosphate, common to all plots, was applied in the form of filter cake. Containing 3.15 per cent P_2O_5 the 20 ton per acre application supplied 1,260 lbs. P_2O_5 to the soil. In Experiment 23 phosphate was given in the form of super, 20 per cent, at the rate of 1,500 lbs. per acre, equivalent to 300 lbs. P_2O_5 per acre. In the latter experiment an extra treatment was included consisting of filter cake only, the application being at the same rate as the initial (phosphate) dressing in Experiment 24. The results show that filter cake applied alone gave yields which were superior to all other treatments.

TABLE 2.

Response to Applications of Nitrogen and Potash with Phosphate remaining constant.

Field	Beach Road	Carisbrook	Paget
Experiment No.	13	24	23
Variety	Co.290	Co.290	Co.290
Crop	Plant	Plant	Plant
Year	1937	1937	1937
Age—months	16.3	14.8	14.5
Tons cane per acre harvested:			
P	31.99	29.76	24.42
PK	34.18	28.93	25.27
NPK	41.65	29.51	27.61
NPK_2	42.18	27.61	26.51
Filter cake only ..	—	—	30.19
Significant Gains:			
Tons cane per acre ..	9.66 (1)	—	5.77 (2)
Tons sucrose per acre	1.404	—	0.655
Rainfall —inches	55.13	49.57	45.94
In Soil:			
Total Nitrogen ..	0.07	0.031	0.034
Available P_2O_5	0.032	0.005	0.006
" K_2O	0.005	0.006	0.002
pH	6.7	6.6	6.7

(1) NPK over P
NPK over PK is also significant.

(2) Filter Cake over Super.

Table 3 gives the results of an experiment put down on poor grey clay loam to determine the response to augmentations of potash in the presence of adequate nitrogen and phosphate. The slight, statistically insignificant response to the first addition of potash (195 lbs. K_2O) and the highly significant reaction to the larger application (345 lbs. K_2O) encourage further study of the potash requirements of this type of soil. It is interesting to note, in connection with this experiment, that the total rainfall during the growth of the crop in question was 65 inches, and, bearing in mind the difficult and droughty nature of the soil, it may be said that the performance set up by the plots fertilised on the higher level is rather outstanding.

TABLE 3.
Response to Potash.

Field	Wattles 20 acre	TCPA Harvested:	
Experiment	1		
Variety	Co.281	NP	35.23
Crop	Plant	NPK	39.01
Year	1937	NPK_2	42.44
Age—months	21	Significant Gains:	
Rainfall—inches	65.0	(NPK over NP)	
In Soil:			
Available P_2O_5	0.012	TCPA	7.21
„ K_2O	0.016	TSPA	0.9637

When the programme of field work, a part of which forms the subject of this paper, was first thought over, the question was asked: Is the plant food which we are now supplying to our crops, generally speaking, adequate for the production of the highest possible economic yield? Or may such applications generally speaking be increased with corresponding gains in yield of sucrose per acre? The results of the first group of trials go a little way towards answering these questions. In effect they demonstrate that in respect of the particular areas represented, the soil conditions existing therin. and the variety of cane grown, crop growth may be increased with profit by applications of fertilisers supplying considerably more plant food per acre than the hitherto routine dressings. The analysis of the 1935 routine is 2—17—4.5. Mixtures corresponding quite closely to the above analysis are on the market, and are no doubt quite widely used, and there are many who employ a lower analysis. The application of 800—1,000 lbs. of such mixtures may therefore be said to be inadequate for the crop requirements over quite a large range of growing conditions, as represented by the four experiment sites figuring in the group.

In the two plant cane experiments (Nos. 2 and 12a) it seems that the increased yields should be attributed to nitrogen and potash, and not to the slightly increased ration of phosphate. Since the controls in the ratoon experiments (Nos. 8, 3 and 12b) only received 60 lbs. P_2O_5 one cannot put aside the probable influence of the increased ration of phosphate. But if it is so that there is a response to nitrogen and potash in plant cane, then it is even more likely that there will be a response in ratoons. A sound deduction would therefore appear to be that in the ratoons the response was probably due to nitrogen and potash and also possibly partly due to the increased application of phosphate.

In Experiment 13 of the second group, it is fairly definitely established that nitrogen, in the presence of potash, increases the yield resulting from phosphate only. The addition of potash gave only a very slight increase in the average yields, as did the double potash dressing. Information of this kind where the odds that the difference was due to treatment and not to chance were very high, is sufficiently definite to justify, and indeed to demand, a modification of field routine, which would take the form of increasing the nitrogen application to similar areas throughout the plantation. But without further data on the point it would be a mistake —and perhaps a costly one—to with-hold potash, notwithstanding that in this trial it did not appear to influence crop growth directly. It must be pointed out that there is nothing to indicate that nitrogen is the sole cause of the higher yields of the NPK series. Lintner (3), discussing the results of an experiment conducted at Umbogintwini on somewhat similar soil, says: "The trend of effects on the different fertiliser dressings on the individual yields is of some interest because there appears to be some indication of a necessary NK ratio."

The results of Experiment 13 can be put to practical use without much difficulty by increasing the amount of nitrogen supplied in certain well defined areas. The task of modifying plantation practice in accordance with the trends disclosed by the first group of experiments is not so easy. The increased cash outlay prohibits a bold change-over to the higher levels; moreover such a policy would without doubt involve its exponent in wasteful applications. Pending the collection of further

N	120
P_2O_5	O
K_2O	240

N	120
P_2O_5	300
K_2O	240

N	O
P_2O_5	200
K_2O	240

N	80
P_2O_5	200
K_2O	240

Fig. 6.

data one is inclined to suggest that the following alterations to field routine are justified:—

(1) Avoid or abandon the use of pre-mixed so-called "complete" fertilisers;

(2) in plant cane leave the phosphate application at its present level, but apply it in the form of 20 per cent super at the start of the crop;

(3) in ratoons increase the phosphate application more or less to the level of the plant cane application, and apply it in the same way:

(4) in plant cane and ratoons apply at the very least a "significant" amount of nitrogen and potash as a side dressing soon after the crop is established. (19·5 lbs. N and 45 lbs. K_2O are insignificant compared to the amounts which may be absorbed by the plant; the suggestion is to increase these amounts to 60 lbs. and 120 lbs. respectively; that is: 300 lbs. ammonium sulphate and 200 lbs. muriate).

The above are generalities and therefore to be condemned at once as such, for there can be nothing so misleading and harmful as generalized formulae concerning the treatment of such a heterogeneous commodity as the soil. But, in default of any more practical recommendation at the time, they may serve as a compromise until further and more specific information makes it possible to supply with less inaccuracy the food requirements of plant and soil. Meantime a further extensive range of experiments is in progress with the object of determining optimum applications of the three principal ingredients of plant food in respect of the main soil types. The illustrations (figure 6) show the effect, at 4 months, of 300 lbs. O_5P_2 (1.500 lbs. of super) on the growth of Co.290 on reddish wind-blown sandy soil, and also the effect of 80 lbs. N compared with no nitrogen, on Table Mountain sandstone.

Summary.

A form of technique for simple field experiments is outlined. A series of experiments is described comparing high NPK treatments with customary field dressings. A second series is reported in which the effects of additions of nitrogen and potash on reddish sandy soil are studied. The results of the experiments are discussed and certain amendments to field routine, indicated by the trends disclosed, are suggested.

References.

(1) Borden, R. J., Field Experiment Technique. Haw. Planters' Rec. July, 1931.

(2) Caudwell, E. S., Fertiliser Trials on Sugar Cane at Umbogintwini. Proc. S. Afr. Sug. Tech. Ass. p. 134, 1929.

(3) Lintner, J., Results of a Fertiliser Experiment on Sugar Cane. Proc. S. Afr. Sugar Tech. Ass. p. 163, 1936.

(4) Lintner, J., Some Fertiliser Trials on Sugar Cane. Proc. S. Afr. Sug. Tech. Ass. pp. 142-157, 1937.

The PRESIDENT: Complimented Mr. Watson on his paper and remarked that it contained much information.

Mr. B. CAMPBELL: In congratulating Mr. Watson pointed out that a fertiliser policy different to that generally accepted in Natal was given in this paper. He hoped the experiments would be repeated on a large scale. Mr. Campbell then went on to discuss simple and complex experiments. At Natal Estates they had gone in for complex experiments on a fairly large scale. Mr. Watson admitted that complex experiments contained more potential information, but that should the experiment be damaged in any way, all this information was lost. Mr. Watson therefore advocated devoting a simple experiment to each of the enquiries which could be embodied in a complex experiment, thus reducing the chances of losing all this information by one accident. Were it proposed to lay down one complex experiment, the case was different, but since there were no deterrants such as increased cost, amount of labour required (and one was just as easy to lay out as the other) why not lay out a series of factorial designs in place of the simple ones, thus increasing considerably the amount of information available per unit of work expended, placing it on a wider inductive basis, and revealing possible interactions between the various treatments. Referring to the second point on the first page of the paper he said he was in agreement with Mr. Watson. In regard to the demonstration effect of simple experiments he thought that a balance sheet would be more effective than a mere visual observation. Lastly he asked Mr. Watson if the high available phosphate figures were typical of Tongaat soils.

Mr. DODDS: Expressed his pleasure that the larger estates were carrying out field experiments. as it was impracticable for any Experiment Station to carry out all the experiments for the Industry.

Mr. DYMOND: Referred to the analysis of filter cake. He had found that the phosphoric acid in filter cake became more available on standing. He thought also that when experiments with filter cake were laid down it should be specified whether the sulphitation or carbonation filter cake had been used.

Dr. McMARTIN: Drew attention to the significant gains in Table 1 for the high NPK treatments over the 1935 routine. Did these figures represent gains over and above the experimental error, or did they include error? He regretted that tables of costs showing the gain per acre in terms of money had not been given.

Mr. LINTNER: Expressed appreciation of the paper and seconded the remarks of Mr. B. Campbell and Dr. McMartin regarding complex experiments. He thought it a great pity that time should be wasted on simple experiments when complex experiments could tell us so very much more. He noted also, that with one exception, all these experiments were on very light soils. This had reference to Mr. Watson's suggestion that fertiliser dressings (nitrogen and potash) should be split up and applied in small dressings. He doubted the advisability of doing that on a heavy soil, owing to the possible fixation of the ingredients. On a heavy clay soil he had obtained response only when they were applied together.

Mr. WATSON: Replying to Mr. Campbell said he had not intended to raise an argument over simple versus complex experiments, but merely to point out certain features of them which were advantageous under certain conditions. He did not prefer simple experiments, but chose them because of lack of experience with the complex type. It was easier to sustain a lively interest in experimentation amongst field officials through the medium of simple experiments. Referring to Dr. McMartin's question concerning error, he said that the differences between treatments where such differences were larger than the calculated differnces necessary for significance. They included error.

The PRESIDENT: Concluded by thanking Mr. Watson for his paper. He hoped that complex experiments would be dealt with more fully at the next Congress.