STUDIES ON PADDY CULTIVATION—VI

THE COMPOSITION OF THE PADDY CROP AND SOIL IN RELATION TO FORM OF FERTILISER AND TIME OF APPLICATION

A. W. R. JOACHIM, Ph. D.,
AGRICULTURAL CHEMIST
AND
S. KANDIAH (Dip. Agric., Poona) and
D. G. PANDITTESEKERE (Dip. Agric., Poona),
ASSISTANTS IN AGRICUTURAL CHEMISTRY

IN *The Tropical Agriculturist* of November 1935 (1) an account was given of experiments designed to determine the effects on paddy yields (*a*) of applying the same quantities of ammonium phosphate in one, two and three doses; and (*b*) of different forms of phosphatic fertiliser. In the present paper the chemical data to which reference was made in the earlier publication are discussed in greater detail. Owing to the comprehensive nature of the two investigations and their continuance over two seasons, the number and size of tables have been reduced to the minimum possible.

The chemical investigations were on the same lines as those previously carried out, but the analytical determinations varied to some extent. Analyses were made of the crop of each treatment at the three main stages of growth, with particular reference to dry matter, nitrogen and phosphoric acid. In regard to the soil data, as the main problem investigated was the response to and availability of added phosphoric acid, attention was directed solely to available phosphoric acid. This was determined in a number of soils by the methods of Truog (2), Chapman (3), Lohse and Ruhuke (4), but as only the first of these gave results that might have been expected under the experimental conditions, the others were omitted in subsequent determinations. The results of the two experiments will be considered separately.

THE EFFECT OF TIME OF APPLICATION OF FERTILISER

In table I the composition of the crops from differently treated plots, at different stages of their growth, during the *Mäha* 1933 and *Yala* 1934 seasons is shown. The results are expressed as percentages of dry matter at 100°C. The rates of absorption of fertilisers at flowering are set out in table II and in table III the total constituents removed in the crop and parts of the crop in lb. per acre are indicated.

TABLE I

PERCENTAGE CONSTITUENTS IN PLANT
MAHA 1933 AND YALA 1934

TREATMENT		SEEDLING				FLOWERING				HARVEST			
		Dry Matter	Ash	Nitrogen	Phos. Acid	Dry Matter	Ash	Nitrogen	Phos. Acid	Dry Matter	Ash	Nitrogen	Phos. Acid
1. One application of	M ..					24·3	14·5	·94	·44	47·6	13·3	·76	·34
N. R. Nicifos	Y ..					26·4	12·0	·85	·31	41·0	12·4	·80	·28
2. Two applications of	M ..					23·2	14·5	·97	·33	48·9	12·7	·84	·37
N. R. Nicifos	Y ..					26·3	12·4	·90	·33	40·3	12·6	·79	·30
3. Three applications of	M ..					23·7	14·2	·91	·35	48·8	12·3	·84	·36
N. R. Nicifos	Y ..					27·0	12·8	·94	·38	40·0	13·1	·81	·33
4. One application of	M ..	17·5	18·4	2·30	·62	23·2	14·1	·80	·44	46·7	12·6	·76	·39
B. R. Nicifos	Y ..	19·7	17·0	2·09	·29	27·4	12·4	·97	·33	40·9	12·8	·75	·32
5. Two applications of	M ..					23·0	14·6	·81	·46	48·8	12·8	·83	·43
B. R. Nicifos	Y ..					26·7	11·3	·64	·37	41·6	13·3	·82	·32
6. Three applications of	M ..					23·0	14·1	·81	·46	48·1	13·0	·81	·37
B. R. Nicifos	Y ..					27·3	12·2	·73	·38	39·4	14·2	·69	·34
Average	M ..					23·4	14·3	·87	·41	48·1	12·8	·81	·38
Average	Y ..					26·8	12·2	·84	·35	40·5	13·1	·77	.31

M = Maha N. R. = Narrow ratio
Y = Yala B. R. = Broad ratio

A comparison of the above figures with those obtained in previous investigations (5, 6) will reveal that they are in general higher, especially in regard to phosphoric acid at harvest. The composition of the variously-treated crops at harvest shows no marked or consistent variation from each other. The average nitrogen content of the narrow ratio Nicifos fertilised crop is however higher than that of the corresponding wide ratio crop at the time of flowering during the *Maha* season. The reverse holds with regard to phosphoric acid. The data in regard to percentage composition of parts of crop (not published) and to the change in composition with age are generally very similar to those obtained previously.

TABLE II

PERCENTAGE RATES OF ABSORPTION AT FLOWERING MAHA 1933 AND YALA 1934

TREATMENT		FLOWERING			
		Dry Matter	Ash	Nitrogen	Phos. Acid
1. One application of N. R. Nicifos	M	40·2	43·6	50·0	52·5
	Y	42·8	41·3	45·3	48·0
2. Two applications of N. R. Nicifos	M	48·1	54·5	55·2	42·6
	Y	39·8	39·2	45·1	44·1
3. Three applications of N. R. Nicifos	M	52·2	60·3	56·1	50·6
	Y	43·8	42·9	50·6	50·1
4. One application of B. R. Nicifos	M	41·1	46·5	43·1	46·0
	Y	53·0	50·9	69·0	54·1
5. Two applications of B. R. Nicifos	M	40·8	46·4	39·5	43·0
	Y	63·4	52·6	49·0	72·6
6. Three applications of B. R. Nicifos	M	36·8	40·1	36·7	46·2
	Y	63·1	54·2	58·6	69·8
Average	M	43·2	48·5	46·7	46·8
Average	Y	51·0	46·8	52·9	56·4

M.=Maha N. R.=Narrow ratio
Y.=Yala B. R.=Broad ratio

An examination of the above table and its comparison with previous similar tables will indicate that:

(1) The average rates of absorption of nitrogen and phosphoric acid at flowering during *Maha* 1933 are similar to those obtained in previous experiments with transplanted crops. The corresponding figures for *Yala* are however much higher than those found previously. The reason for this variation is not obvious.

(2) At flowering, the average rate of absorption of the nitrogen of the narrow ratio Nicifos is higher during the *Maha* and lower during the *Yala* than that of the wide ratio Nicifos. Thus the former gives averages of 53·8 and 47·0 per cent. for *Maha* and *Yala* respectively, while the broad ratio Nicifos gives 39·8 and 58·9 respectively. The same holds, though to a lesser degree, with phosphoric acid. Whatever the reason for these phenomena may be, they appear to have had no effects on yields.

(3) The absorption figures for nitrogen and phosphoric acid vary fairly appreciably with the different treatments, but not with any consistency, nor do they appear to bear any relation to yield. The variation may partly be attributed to differences in the times of flowering.

(4) Previous observations are generally confirmed in regard to the relative absorption of fertilising constituents by different parts of the crop (data not reproduced).

TABLE III

TOTAL CONSTITUENTS IN CROP IN LB. PER ACRE

TREATMENT	MAHA 1933								YALA 1934								TOTAL	
	STRAW		GRAIN		CHAFF		TOTAL		STRAW		GRAIN		CHAFF		TOTAL			
	Nitrogen	Phos. Acid	Nitrogen	Phos. Acid	Nitrogen	Phos. Acid	Nitrogen	Phos. Acid	Nitrogen	Phos. Acid	Nitrogen	Phos. Acid	Nitrogen	Phos. Acid	Nitrogen	Phos. Acid	Nitrogen	Phos. Acid
1. One application of N. R. Nicifos	14·5	3·4	35·1	18·3	1·4	·6	51·0	22·3	5·9	1·1	15·6	6·1	1·1	·4	22·6	7·6	73·6	29·9
2. Two applications of N. R. Nicifos	12·7	2·6	34·5	18·5	1·3	·6	48·5	21·7	6·6	1·4	19·4	8·1	·9	·3	26·9	9·8	75·4	31·5
3. Three applications of N. R. Nicifos	11·6	4·2	34·5	15·6	1·4	·6	47·5	20·4	7·4	1·5	17·2	7·6	·9	·3	25·5	9·4	73·0	29·8
4. One application of B. R. Nicifos	13·7	4·4	32·7	19·8	1·7	·7	48·1	24·9	6·6	1·3	15·0	7·5	·8	·3	22·4	9·1	70·5	34·0
5. Two applications of B. R. Nicifos	12·7	4·3	35·5	21·4	1·6	·7	49·8	26·4	7·3	1·2	15·4	7·5	·9	·3	23·6	9·0	73·4	35·4
6. Three applications of B. R. Nicifos	13·7	3·4	37·3	20·8	1·3	·6	52·3	24·8	6·1	1·3	16·6	8·6	·9	·3	23·6	10·2	75·9	35·0
Average	13·1	3·7	34·9	19·1	1·4	·6	49·5	23·4	6·6	1·3	16·5	7·5	·9	·3	24·1	9·2	73·6	32·6

N. R.=Narrow ratio
B. R.=Broad ratio

Table III will show that:

(1) The average amounts of fertilising constituents removed in the crops in lb. per acre are as follows:

	Nitrogen	Phos. acid
Maha 1933	49·5	23·4
Yala 1934	24·1	9·2
	73·6	32·6

These figures are much higher than those obtained in previous experiments and are due to: (1) the higher yields obtained in this series of experiments, (2) the higher percentages of nitrogen and phosphoric acid in the crops, and (3) the absence of controls to lower the average.

(2) There are no appreciable or consistent differences between the amounts of constituents removed in the crops from plots receiving one, two or three doses of fertiliser.

(3) The average amounts of nitrogen removed in the narrow and wide ratio Nicifos fertilised crops are approximately the same, *viz.*, 74 and 73·2 lb. respectively. As the amounts of nitrogen added were the same in both series of plots and previous investigations had shown that nitrogen as ammonium phosphate is absorbed almost wholly by the crop during both seasons, this result is only to be expected. The average figure for absorption of nitrogen during the *Maha* crop (70 per cent.) confirms previous records in this respect.

The corresponding figures for phosphoric acid are 30·4 lb. and 34·8 lb. Thus only about 4·5 lb. per acre more of phosphoric acid are absorbed by the wide ratio Nicifos treated crops, though 27·9 lb. more were originally applied to the soil. The increased percentage absorption works out to about 16·5 per cent. of the added phosphoric acid, a figure similar to those previously determined. The *Maha* crop again contains 70 per cent. of the absorbed phosphoric acid. That neither the frequency of application nor the quantity of phosphatic fertiliser applied has effected a significant difference in yield, would indicate that added phosphoric acid is readily fixed in the soil under the experimental conditions and only a small proportion of it is available to the crop at any one time. The soil data to be discussed later will throw further light on this point. The above data would also point to the advantage of using, at any rate under Peradeniya conditions, the cheaper narrow ratio ammonium phosphate in paddy manuring.

(4) The data in regard to the relative distribution of constituents among the various parts of the crop are similar to those recorded previously.

In table IV below the " readily available phosphoric acid " contents of the soils as determined by Truog's method are shown.

TABLE IV

SOIL ANALYSIS

READILY AVAILABLE PHOSPHORIC ACID (p.p.m.)

MAHA 1933

	Initial	After first application of manure	Increase	At flowering	At harvest
1. One application of N. R. Nicifos ..	6·7	12·6	5·9	9·1	8·2
2. Two applications of N. R. Nicifos ..	6·6	10·3	3·7	6·2	9·6
3. Three applications of N. R. Nicifos ..	6·7	11·4	4·7	6·2	10·3
4. One application of B. R. Nicifos ..	6·6	11·4	4·8	8·2	8·9
5. Two applications of B. R. Nicifos ..	10·3	14·1	3·8	6·6	10·1
6. Three applications of B. R. Nicifos ..	10·3	14·8	4·5	7·3	9·9

It will be noted that the application of phosphatic fertiliser whether in one, two or three doses, has resulted in an increase of available phosphoric acid in the soil in every instance. The increase is not however proportional to the amounts applied. Reckoning that a 6 in. acre depth of soil weighs 2,000,000 lb. the increase of available phosphoric acid varies from 7·4 to 11·8 lb. per acre, while the amounts applied varied from 15·7 to 48·1 lb. per acre. The fact that the amounts of available phosphoric acid in the soil at flowering are generally lower than those at harvesting, would clearly indicate that the reserve of fixed phosphoric acid is being made slowly available to the crop as its needs demand.

THE FORM OF PHOSPHATIC FERTILISER

In this experiment, phosphoric acid was applied in four forms—as superphosphate, steamed bone meal, ammonium phosphate and mineral phosphate at the rate of 87·2 lb. per acre, the amounts of nitrogen being kept constant. The yield data showed no significant differences in response to treatments.

The analytical data relative to this experiment are presented in tables V, VI, VII and VIII.

TABLE V
PERCENTAGE CONSTITUENTS IN PLANT
MAHA 1933 AND YALA 1934

TREATMENT		SEEDLING				FLOWERING				HARVEST			
		Dry Matter	Ash	Nitrogen	Phos. Acid	Dry Matter	Ash	Nitrogen	Phos. Acid	Dry Matter	Ash	Nitrogen	Phos. Acid
1. Nicifos	M					24·3	16·8	·79	·40	53·8	12·0	·80	·41
	Y					26·7	12·5	·91	·32	42·8	13·1	·84	·28
2. Steamed bone meal	M					25·2	15·4	·84	·35	54·3	11·9	·82	·37
+ Sulphate of ammonia	Y					26·8	14·4	1·08	·33	44·2	12·5	·90	·29
3. Superphosphate	M	17·5	18·4	2·30	·62	24·3	20·3	·74	·41	52·8	12·2	·74	·37
+ Sulphate of ammonia	Y	19·	17·0	2·09	·29	27·9	12·2	·84	·28	43·2	12·7	·87	·29
4. Saposphosphate	M					25·4	16·9	·86	·36	52·4	12·6	·77	·34
+ Sulphate of ammonia	Y					27·5	12·9	·79	·28	44·7	12·7	·86	·28
Average	M	17·5	18·4	2·30	·62	24·8	17·3	·81	·38	53·3	12·2	·78	·37
Average	Y	19·	17·0	2·09	·29	27·2	13·0	·90	·30	43·7	12·7	·87	·29

M = Maha Y = Yala

PERCENTAGE COMPOSITION OF CROP

This table calls for little comment, the data merely confirming what has been observed in regard to the other experiments of the series. The Nicifos plots have highest phosphoric acid contents in the crop at harvest during *Maha.*

TABLE VI
PERCENTAGE RATES OF ABSORPTION
MAHA 1933 AND YALA 1934

TREATMENT		FLOWERING				HARVEST			
		Dry Matter	Ash	Nitrogen	Phos. Acid	Dry Matter	Ash	Nitrogen	Phos. Acid
1. Nicifos	M	44·1	61·4	43·4	42·8				
	Y	47·9	45·7	51·1	54·3				
2. Steamed bone meal	M	49·9	64·6	51·1	47·0				
+ Sulphate of ammonia	Y	45·6	52·8	54·6	51·6				
3. Superphosphate	M	55·1	81·8	55·0	59·4	—	100		—
+ Sulphate of ammonia	Y	52·2	50·3	50·5	50·1				
4. Saposphosphate	M	51·8	69·5	58·5	56·3				
+ Sulphate of ammonia	Y	53·3	54·5	49·1	52·2				
Average	M	50·2	69·3	52·0	51·4	—	100		—
Average	Y	49·7	50·8	51·3	52·0				

M = Maha Y = Yala

The percentage rates of absorption at flowering shown in the above table confirm generally what has been noted in the frequency of application experiment and other previous investigations. The sulphate of ammonia plots have however recorded higher nitrogen absorption figures than the Nicifos plots, and the superphosphate plots higher phosphoric acid absorption rates than the bone meal or mineral phosphate plots during the *Maha* season. No such differences are observed during *Yala.* The detailed data (unpublished) show that the fertilising constituents are distributed throughout the crop in the same proportions as have been found previously.

TABLE VII

TOTAL CONSTITUENTS IN CROP IN LB. PER ACRE

TREATMENT	MAHA 1933								YALA 1934								TOTAL OF BOTH	
	STRAW		GRAIN		CHAFF		TOTAL		STRAW		GRAIN		CHAFF		TOTAL			
	Nitrogen	Phos. Acid	Nitrogen	Phos. Acid	Nitrogen	Phos. Acid	Nitrogen	Phos. Acid	Nitrogen	Phos. Acid	Nitrogen	Phos. Acid	Nitrogen	Phos. Acid	Nitrogen	Phos. Acid	Nitrogen	Phos. Acid
1. Nicifos	11·0	3·5	35·2	20·0	·9	·4	47·1	23·9	4·3	·7	12·8	5·0	·8	·3	17·9	6·0	65·0	29·9
2. Steamed bone meal + Sulphate of ammonia	11·0	2·2	34·5	18·1	·9	·4	46·4	20·7	4·2	·7	13·0	4·7	·9	·3	18·1	5·7	64·5	26·4
3. Superphosphate .. + Sulphate of ammonia	10·9	3·3	30·8	18·2	·8	·3	42·5	21·8	4·8	·7	12·5	4·9	·8	·3	18·1	5·9	60·6	27·7
4. Saposphosphate .. + Sulphate of ammonia	8·9	1·8	31·5	16·5	·8	·3	41·2	18·6	4·1	·7	14·6	5·5	·9	·3	19·6	6·5	60·8	25·1
(Average) ..	10·4	2·7	33·0	18·2	·9	·4	44·3	21·2	4·3	·7	13·2	5·0	·9	·3	18·4	6·0	62·7	27·3

The table showing the total constituents removed by the crops under the various treatments indicate that the amounts of such constituents in lb. per acre are as follows :

		Nitrogen		*Phosphoric acid*
Maha 1933	..	44·3	..	21·2
Yala 1934	..	18·4	..	6·0
		62·7		27·2

These are somewhat lower than the corresponding figures in the frequency of application experiment and are largely due to the lower yields obtained in this experiment during the *Yala*. The differences between the amounts of fertilising constituents in crops from differently-treated plots are not very marked, especially in regard to the *Yala* crop. Where these are of fair magnitude they are mainly governed by the yield data. The Nicifos plots show highest and the mineral phosphate plots lowest amounts of nitrogen and phosphoric acid in the crop.

CONCLUSION

The chemical data obtained from the study of the crop composition and the available phosphoric acid of the soil in the experiments designed to determine the effects of (1) frequency of application (2) form of phosphatic fertiliser, generally bear out the non-significance of the differences in yields between the varied treatments under the experimental conditions at Peradeniya. That phosphoric acid fixation does take place to a marked degree and that neither frequency of application nor amount of phosphoric applied appreciably affects the available amounts of this constituent, appears to be indicated by the soil data.

REFERENCES

1. Haigh, J. C. and Joachim, A. W. R.—Studies on Paddy Cultivation—The Effect of Time of Application of Fertilizer and Form of Phosphoric Acid Applied. *The Tropical Agriculturist*, Vol. LXXXV, 1935.
2. Truog, E.—Determination of Readily Available Phosphorus of Soil. *Jour. Amer. Soc. Agron.* Vol. XXII, 1930.

3. Chapman, H. D.—Studies on the Blue Colorimetric Method for the Determination of Phosphorus. *Soil Science*, Vol. XXXIII, 1932.

4. Lohse, H. W. and Ruhnke, G. N.—Studies on Readily Soluble Phosphates in Soils : Extraction of Readily Soluble Phosphates from Soils by Means of Dilute Acid Potassium Sulphate. *Soil Science*, Vol. XXXV, 1933.

5. Joachim, A. W. R., Kandiah, S. and Pandittesekere, D. G.—Studies on Paddy Cultivation—The Effect of Manures on the Composition of the Paddy Crop and Soil. *The Tropical Agriculturist*, Vol. LXXXI, 1933.

6. Joachim, A. W. R., Kandiah, S. and Pandittesekere, D. G.—Studies on Paddy Cultivation—The Effect of System of Cultivation on the Composition of the Paddy Crop and Soil. *The Tropical Agriculturist*, Vol. LXXXIII, 1934.