

Manuring of Rice in Malabar

By

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Introduction: In Malabar, rice is cultivated on three classes of lands, those that lie irregularly along the ridges and slopes of low hills where dry paddy is raised; the terraced level type of lands that skirt the lower slopes where a single crop of swamp paddy is grown and the flat valleys that form the typical wetland paddy areas where two or three crops are raised in a year.

The majority of the soils in Malabar are red loams of lateritic origin with varying proportions of clay and coarse sand. They are generally poor and are subject to constant depletion of finer fractions of the soil and soluble plant foods in the torrential rains during the South-West monsoon period, when 60—80 inches of rain are received within two months, June and July.

According to Ramiah (1936) typical rice soils should contain 40—60 percent of clay and silt. The results of mechanical analysis of the three classes of soils at the Agricultural Research Station, Pattambi, which are representative of the predominant types of soil in the tract, are given in table I.

TABLE I.—Mechanical analysis of soil (percentages).

	Double-Crop lands	Single-Crop lands	Dry Paddy soils
Clay	26.49	32.78	26.61
Silt	14.17	11.79	8.77
Fine Silt	18.55	12.90	16.22
Coarse Sand	40.79	42.53	48.40

It will be seen that the single and double crop swamp paddy soils contain 40—45 percent of clay and silt while it is only 35 percent in the case of dry paddy soils. All the three types contain a high proportion of sand. Soils of the double crop lands show 41 percent and the other two classes 43—48 percent, which is higher than the highest limit set by Jacks (1923) for second class rice soils. Chemical analysis indicates that the soils are adequately supplied with the major plant foods except phosphoric acid and lime.

Intensive manuring of rice is not done in Malabar. The ryots do realise the value of manures like green leaf and cattle manure for rice but apply them in doses that seldom exceed 2,000 lb. per acre. No manuring is given for broadcast crops of paddy, except a sprinkling of wood ash at about 500 to 1,000 lb./acre.

This paper is a brief review of the more important results and conclusions drawn from a number of manurial experiments conducted at the Pattambi Agricultural Research Station. In all cases the layout was in Latin Square or in randomised blocks, each subplot measuring not less than half a cent. Results of statistical analyses are given only for typical experiments conducted for two seasons and more.

Experimental: I. Application of lime: In view of the deficiency of the soils as regards lime and phosphoric acid the first set of experiments was designed to find out the effects of lime and phosphoric acid on the yield of paddy.

Lime was applied as finely ground calcium carbonate at the time of planting in doses varying from 500 to 1,000 lb. per acre. The results for three years given in table II indicate very little improvement from lime, the 'Z' test not being satisfied in any of the three years.

TABLE II.—Lime Experiment.

Treatments:— 1. No manure. 2. Lime at 500 lb. per acre, 3. Lime at 1000 lb. per acre. 4. Lime at 2000 lb. per acre.

Mean yield as percentage on general mean.

	1	2	3	4	'Z' test satisfied or not	S. E.	C. D.
I Crop:							
1933—34	96.7	98.1	99.8	105.5	No	3.25	8.00
1934—35	88.7	96.2	99.9	115.3	No	10.46	25.60
1935—36	94.7	103.5	100.6	101.1	No	5.66	13.85
II Crop:							
1933—34	93.5	102.5	100.4	103.3	No	4.95	12.11
1934—35	96.2	100.5	100.7	102.5	No	4.52	11.07
1935—36	96.1	100.9	98.9	104.1	No	2.83	6.93

II. Phosphatic manures: (a) In one of the experiments in this series, bonemeal and superphosphate was compared with Ammophos (13/45 grade containing both nitrogen and phosphoric acid), with and without a basal dressing of green leaf. The leaves were applied two weeks before planting, phosphates at the time of planting and Ammophos a month after planting. The results are set out in table III. Out of the three years of trial, the 'Z' test was satisfied in two years. Green leaf at 4,000 lb. per acre gave 16.2 percent higher yield than control. The effect of bone-meal and superphosphate was not consistent but that of ammonium sulphate was evident throughout.

TABLE III.—Phosphatic manures experiment.

Treatments:—

1. No manure.
 2. Leaf at 4000 lb. per acre.
 3. As treatment 2, plus Bonemeal to supply 30 to P_2O_5
 4. do. Super phosphate 30 to P_2O_5
 5. do. Ammophos 30 to P_2O_5
 6. As treatment 4, plus ammonium sulphate to supply nitrogen equivalent in 3.
 7. As treatment 4, plus ammonium sulphate to supply nitrogen equivalent in 5.
 8. As treatment 3, plus ammonium sulphate to supply nitrogen equivalent in 5.
- Mean yields as percentage on general mean.

	1	2	3	4	5	6	7	8	'Z' test	S. E.	C. D.
1933—34	91.4	100.5	100.3	102.9	104.4	101.1	103.5	95.9	Not satisfied	7.35	15.18
1934—35	79.8	95.9	104.6	104.7	103.0	96.5	108.8	106.7	..	3.68	7.59
1935—36	83.3	99.5	103.1	98.6	103.9	98.6	107.0	106.7	..	2.69	5.60

(b) Kossier phosphate, which is a finely ground phosphate containing 32 percent phosphoric acid was also tried without any appreciable effect. The same was the case with basic silicophosphate, a product considered to be good for tracts deficient in lime. The manures were applied to supply 40 lb. phosphoric acid per acre.

Further trials on the effect of phosphatic manures were therefore continued with superphosphate to supply from 20 to 50 lb. phosphoric acid per acre, in combination with green leaf at 2,000 lb. per acre and ammonium sulphate to supply 10 lb. nitrogen per acre. The leaves were applied two weeks before planting, superphosphate just before planting and ammonium sulphate a month after planting. It will be seen from the results given in table IV, that in no year was the 'Z' test satisfied.

TABLE IV.—Kossier phosphate trial.

Treatments:—

1. Green leaf 2000 lb. per acre plus 10 lb. nitrogen as ammonium sulphate.
2. As 1 plus superphosphate to supply 20 lb. P_2O_5 per acre.
3. As 1 plus do. 30 lb. do.
4. As 1 plus do. 40 lb. do.
5. As 1 plus do. 50 lb. do.

Mean yield as percentage on general mean.

	1	2	3	4	5	'Z' test satisfied or not	S. E.	C. D.
1933—34	99.4	101.0	100.3	100.5	98.7	No	1.70	3.70
1934—35	97.5	99.9	101.8	99.4	101.3	No	2.55	5.55
1935—36	99.2	97.6	101.2	101.8	101.1	No	2.26	4.92

III: **Organic manures:** Since very consistent results were obtained with green leaf and ammonium sulphate, the next line of work was directed to different organic manures.

(a) One of the experiments in this series comprised application of green leaf, groundnut cake and cattle manure alone and in combinations to supply 15 lb. and 20 lb. nitrogen per acre. Cattle manure and leaf were applied a week before planting and groundnut cake at the time of planting. The results for three years are presented in table V. The best yields are given by groundnut cake alone or in combination with green leaf or cattle manure, the cake on the basis of 30 lb. nitrogen per acre recording 25 percent increased yield. However green leaf or a combination of leaf and cattle manure was more economical.

TABLE V.—The effect of cattle manure, green leaf and groundnut cake.

Treatments:—

1. Groundnut cake to supply 30 lb. Nitrogen per acre.
2. Green leaf do. 30 lb. do.
3. Cattle manure do. 30 lb. do.
4. Green leaf to supply 15 lb. nitrogen plus groundnut cake to supply 15 lb. nitrogen.
5. Cattle manure to supply 15 lb. nitrogen plus groundnut cake to supply 15 lb. nitrogen.
6. Green leaf to supply 15 lb. nitrogen & cattle manure to supply 15 lb. nitrogen.
7. Cattle manure alone to supply 15 lb. nitrogen.
8. Groundnut cake alone to supply 15 lb. nitrogen.
9. No manure (control).

Mean yield as percentage on general mean.

	1	2	3	4	5	6	7	8	9	G.M.	S. E.	'Z' test satisfied or not	C. D.
I Crop :													
1937-38	132.3	121.4	109.9	126.6	111.6	116.8	112.1	119.2	109.0	100	6.50	Yes	12.74
1938-39	99.7	90.1	83.5	90.5	92.3	83.0	75.0	85.2	76.7				
1939-40	116.3	102.1	88.8	102.5	106.3	100.4	74.0	92.6	83.1				
II Crop :													
1937-38	101.5	93.7	75.1	95.3	99.4	83.6	62.3	83.9	81.7	100	5.12	Yes	10.04
1938-39	104.4	95.1	80.4	91.3	96.9	84.8	66.4	87.3	73.9				
1939-40	143.9	133.8	119.9	137.0	132.4	129.1	106.8	121.8	118.4				
Conclusion :													
1937-38	1.5.4.2.8.6.9.3.7												
1938-39	1.5.2.4.8.6.3.9.7												
1939-40	1.4.2.5.6.8.3.9.7												

(b) *Organic and artificial manures:* In this experiment organic manures like cattle manure and green leaf were compared with ammonium sulphate & Nicifos containing 22 percent nitrogen and 18 percent phosphoric acid. The results, set out in table VI, show that green leaf at the rate of 5,000 lb. per acre or ammonium sulphate to supply 30 lb. nitrogen per acre recorded the best yields, on an average 32 percent over 'no manure' plots, while in the second crop season, green leaf recorded up to 41 percent, followed by ammonium sulphate, with 29 percent increased yield.

TABLE VI.—Organic and artificial manures.

Treatments:— 1. No manure. 2. Cattlemanure at 5000 lb. per acre. 3. Green leaf at 5000 lb. per acre. 4. Nicifos 22/18 to supply 30 lb. nitrogen per acre. 5. Ammonium sulphate to supply 30 lb. nitrogen per acre.

Mean yield as percentage on general mean.

	1	2	3	4	5	G.M.	S. E.	'Z' test satisfied or not	C. D.
I Crop :									
1937-38	65.1	76.5	93.6	77.6	95.2	100	2.86	Yes	5.61
1938-39	90.1	99.9	116.2	105.4	123.2				
1939-40	85.7	105.5	128.4	118.2	119.6				
II Crop :									
1937-38	88.2	103.1	129.9	108.5	120.5	100	2.12	Yes	4.16
1938-39	93.2	106.6	137.8	113.6	127.8				
1939-40	94.0	101.2	129.8	106.3	112.8				
Conclusion :									
I Crop	1937-38 — 3.5.4.2.1								
II Crop	1938-39 — 3.5.4.2.1								
	1939-40 — 3.5.4.2.1								

(c) *Leaf versus processed leaf:* The effect of green leaf was so marked that the method of processing the green leaf by using it as a manure later, was followed and the product compared with fresh leaves and cattle manure in doses varying from 2,000 lb. to 8,000 lb. per acre. The results presented in table VII indicate that there is very little to choose between green leaves and processed leaves.

TABLE VII.—Processed leaf experiment.

Treatment:	1. Green leaf at 2000 lb. per acre.	2. Green leaf at 4000 lb. per acre.
	3. " " 6000 "	4. " " 8000 "
	5. Processed leaf at 2000 "	5. Processed " 4000 "
	7. " " 6000 "	8. " " 8000 "
	9. Cattle manure 2000 "	10. Cattle manure 4000 "
	11. " " 6000 "	12. " " 8000 "

Mean yields as percentage on general mean
Kinds of organic manures.

	Green leaf G. L.	Processed leaf P. L.	Cattle manure C. M.	'Z' test satisfied or not	C. D.	Conclusion
1942-43	106.0	101.3	92.7	Yes	3.6	<u>GL. PL. CM.</u>
1943-44	106.6	97.8	95.4	No	3.2	
1944-45	99.7	101.0	99.4	No	5.0	

	Quantities.				'Z' test satisfied or not	C. D.	Conclusion
	2000 lb.	4000 lb.	6000 lb.	8000 lb.			
1942-43	94.5	100.3	101.1	103.8	No	4.4	
1943-44	97.2	100.0	99.8	103.2	No	3.8	
1945-46	91.5	100.2	103.2	105.1	Yes	5.9	<u>8000, 6000, 4000, 2000</u>

(d) *Different oil cakes at different levels of nitrogen*: From the results presented in table V it will be seen that groundnut cake is very helpful in improving the yield of swamp paddy. Its application at a rate to supply 30 lb. nitrogen per acre gave up to an increased yield of 30 percent over 'No manure'. It was therefore proposed to compare cakes of groundnut, neem and castor on equal nitrogen basis. The details of the treatments and results are given in table VIII. All cakes were found to be equally effective on equivalent doses of nitrogen; progressive increases in yield were recorded with increasing doses of nitrogen upto 60 lb. per acre.

TABLE VIII.—Oil cakes at different levels of nitrogen.

Treatments: Groundnut cake, Neem cake and Castor cake at 0, 20, 40 and 60 lb. Nitrogen per acre

Cakes only

	Groundnut cake G.	Castor C.	Neem N.	'Z' test satisfied or not	C. D.	Conclusions
I Crop: 1943-44	101.7	98.7	99.6	No		
1944-45	100.5	92.5	107.0	Yes	3.5	<u>N. G. C.</u>
1945-46	102.8	101.9	95.2	Yes	5.5	<u>G. C. N.</u>
II Crop: 1943-44	99.0	102.6	98.5	Yes	4.2	<u>C. G. N.</u>
1944-45	98.5	97.8	103.8	No		
1945-46	100.9	100.6	99.5	No		

Levels of Nitrogen.

	0	20	40	60	'Z' test satisfied or not	C.D.	Conclusions
I Crop : 1943-44	88.9	99.2	102.2	109.7	Yes	4.0	60, 40, 20, 0
1944-45	89.0	92.6	104.6	113.7	Yes	6.9	60, 40, 20, 0
1945-46	92.4	97.0	101.4	109.1	Yes	5.6	60, 40, 20, 0
II Crop : 1943-44	79.6	96.0	107.7	117.0	Yes	4.4	60, 40, 20, 0
1944-45	79.0	96.7	109.2	115.2	Yes	10.8	60, 40, 20, 0
1945-46	82.0	96.0	103.0	109.0	Yes	4.2	60, 40, 20, 0

Interactions.

	Ground nut cake				Castor cake				Neem cake				'Z' test satisfied or not	C.D.
	0	20	40	60	9	20	40	60	0	20	40	60		
I Crop :														
1943-44	89.5	102.1	101.8	113.4	87.7	100.6	101.1	105.1	89.3	94.5	103.5	110.4	No	6.9
1944-45	91.8	91.8	98.6	119.3	84.6	89.0	97.6	98.7	91.8	96.2	118.3	122.4	Yes	11.2
1945-46	95.5	97.2	105.6	112.8	93.7	101.5	99.6	112.9	88.0	92.3	99.1	101.5	No	9.4
II Crop :														
1943-44	78.1	98.2	102.5	117.7	78.6	97.2	108.7	110.0	82.6	92.7	112.6	123.5	Yes	7.6
1944-45	79.9	93.4	104.8	116.3	76.9	98.0	107.0	108.4	80.1	98.2	116.0	120.7	No	15.5
1945-46	93.8	98.6	104.8	106.5	92.9	98.0	102.6	109.8	90.9	91.9	102.8	112.6	Yes	7.2

(e) *Leaf, oil cakes and ammonium sulphate*: From the results of previous trials it was found that nitrogen had the greatest influence on the growth and yield of swamp paddy. Oil cakes, green leaf and ammonium sulphate were individually found to be effective. Since the bulk of nitrogen has to go in the form of organic manure, an experiment was conducted with different organic manures to supply 30 lb. nitrogen per acre, alone and in combination with ammonium sulphate to supply 15 lb. nitrogen per acre. It is seen from the results given in table IX that the green leaf and groundnut cake gave the maximum increased yield. Green leaf combined with ammonium sulphate was the most economical.

TABLE IX—Leaf, Oil Cakes and Ammonium sulphate.

Treatments:—

1. Castor cake to supply 30 lb. nitrogen, plus ammonium sulphate to supply 15 lb. nitrogen.
2. Castor cake alone to supply 30 lb. nitrogen.
3. Groundnut cake to supply 30 lb. nitrogen, plus ammonium sulphate to supply 15 lb. nitrogen.
4. Groundnut cake to supply 30 lbs. nitrogen.
5. Neem cake to supply 30 lb. nitrogen, plus ammonium sulphate to supply 15 lb. nitrogen.
6. Neem cake alone, to supply 30 lb. nitrogen.
7. Green leaf to supply 30 lb nitrogen plus ammonium sulphate to supply 15 lb. nitrogen.
8. Green leaf alone, to supply 15 lb nitrogen.
9. Ammonium sulphate alone, to supply 15 lb. nitrogen.
10. No manure.

Summary of results for organic manures

	Castor cake (1)	Ground nut (2)	Neem (3)	Green leaf (4)	No Manure (5)	G.M.	S.E.	'Z' test satisfied or not	C.D.
1937—38	103.4	106.2	96.3	110.1	84.1	100	2.08	Yes	5.97
1938—39	104.1	109.5	104.2	101.1	81.3	100	2.39	Yes	4.68

Conclusion :— 1937—38. 4, 2, 1, 3, 5
1938—39. 3, 2, 1, 4, 5

Summary of results for ammonium sulphate and no ammonium sulphate

	Ammonium sulphate (1)	No amm. sulphate (2)	G.M.	S. E.	'Z' test satisfied or not	G.D.	Conclusion
1937—38	110.8	89.1	100	3.43	Yes	10.00	1.2
1938—39	116.0	84.0	100	2.49	Yes	4.40	1.2
1939—40	110.5	89.5	100	3.93	Yes	10.10	1.2

IV. **Time of application of manures:** Experiments were laid out in two series. The optimum quantities of ammonium sulphate and the best time of its application with reference to time of planting were the objects in one of the series. In the other the best time of application with reference to flowering time was determined.

(a) *With reference to planting time:* The experiment was laid out in the second crop season (winter) with a medium duration strain of rice. The results indicate that the application of ammonium sulphate fully or in part doses to supply 30 lb. nitrogen per acre a month or two after planting is more efficacious; an increased yield of 23 percent was recorded.

TABLE X.—Time of applying ammonium sulphate with reference to planting.

Treatments:—

1. Green leaf at 2000 lb. per acre.
2. As 1, plus superphosphate at 1 cwt. per acre.
3. As 2, plus ammonium sulphate to supply 30 lb. nitrogen at planting.
4. As 2, plus do. do. one month later.
5. As 2, plus do. do. two months later.
6. As 2, plus ammonium sulphate to supply 15 lb. nitrogen at planting plus 15 lb. nitrogen 1 month after.
7. As 2, plus ammonium sulphate to supply 15 lb. nitrogen at planting plus 15 lb. nitrogen two months after.
8. As 2, plus ammonium sulphate to supply 10 lb. nitrogen at planting plus 10 lb. nitrogen one month late plus 10 lb. nitrogen two months later.

	1	2	3	4	5	6	7	8	S.E.	'Z' test satisfied or not	C.D.
1933—34	90.9	92.6	95.2	110.4	100.6	102.7	101.6	106.0	4.86	No	10.18
1934—35	85.3	89.8	96.7	111.3	93.7	102.8	109.1	111.4	3.68	Yes	7.65
1935—36	86.5	91.4	100.6	105.3	99.9	99.3	108.6	108.4	4.27	Yes	8.88

(b) *With reference to flowering:* In this series ammonium sulphate to supply 30 lb. nitrogen per acre was applied six weeks, five weeks, four weeks, two weeks, one week before and at the time of flowering. The three years' results are given in Table XI. It will be seen from these results that the application four weeks before flowering secured the best yield, followed by 5 or 6 weeks before flowering.

TABLE XI.—Time of applying ammonium sulphate with reference to flowering.

Treatments:—

1.	Green leaf at 2,000 lb. per acre.
2.	As 1 plus ammonium sulphate to supply 30 lb. nitrogen 6 weeks before following.
3.	As 1, plus do. 5 weeks before flowering.
4.	As 1, plus do. 4 do.
5.	As 1, plus do. 3 do.
6.	As 1, plus do. 2 do.
7.	As 1, plus do. 1 do.
8.	As 1, plus do. at flowering time.

	1	2	3	4	5	6	7	8	G.M. S.E.	% satis- fied or not	C.D.	Conclusions	
Mean yields as percentage on general mean.													
1937—38	99.2	109.6	110.9	111.9	107.9	107.2	107.9	104.4	100	3.90	Yes	7.64	4,3,2 5,7,6 8,1
1938—39	91.2	99.9	98.6	101.5	88.7	90.9	86.4	88.8					4,2,3 1,6,8 5,7
1939—40	97.1	100.5	103.0	101.5	96.9	105.0	93.5	98.4					6,3,4 2,8,1 5,7

(c) The best time of applying a concentrated organic manure like groundnut cake was also determined. The cake was applied at 20 lb. and 40 lb. nitrogen per acre in full and in part doses at the time of planting and 2 and 4 weeks later. In no year were the treatment differences significant with reference to time of application, showing thereby that it could be applied at planting time or later.

V. **Other manures and combinations of manures:** (a) *Wood ashes:* It is a common practice in Malabar to apply wood ash to nurseries and broadcast crops of paddy at the time of sowing. No effect was however noticed on the yield of transplant crops when wood ash was applied to nurseries at the rate of 4,000 lb. per acre. An experiment was therefore laid out, to see if the wood ash improves the yield when applied to transplant crops. It was applied at the rate of 4,000 lb. per acre over a basal dressing of green leaf at 4,000 lb. or groundnut cake at 400 lb. per acre. The ash was applied first before transplanting. The experiment was laid out in both the seasons, autumn and winter. The results for 3 years set out in tables XII a, b and c, show that ash alone contributed to an increased yield of 5–11 percent and that its combination with groundnut cake rather than green leaf secured the maximum yield.

TABLE XII.—Wood ash Experiment.

Treatments:— 1. No manure.
 2. Wood ash at 4,000 lb. per acre.
 3. As 2, plus green leaf at 4,000 lb. per acre.
 4. Green leaf at 4,000 lb. per acre.
 5. As 2, plus groundnut cake at 400 lb. per acre.
 6. Groundnut cake at 400 lb. per acre.
 Mean yields as percentage on control.

		'Z' test								
Ash application		No ash	Ash	satisfied	C. D.	Conclusions				
				or not						
I Crop:	1942—43	100	108.0	Yes	7.3	Ash	>	No ash		
	1943—44	100	105.3	No	7.5					
	1944—45	100	109.5	Yes	5.8	Ash	>	No ash		
II Crop:	1942—43	100	102.3	No	4.6					
	1943—44	100	122.2	Yes	6.2	Ash	>	No ash		
	1944—45	100	111.8	Yes	7.1	Ash	>	No ash		
Basal Dressings										
		No basal dressings N. B.	Leaf G. L.	Ground- nut cake G. N. C.	'Z' test satisfied	C. D.	Conclusions			
					or not					
I Crop:	1942—43	100	113.7	113.6	Yes	9.9	<u>GL, GNC, NB.</u>			
	1943—44	100	107.2	112.0	Yes	8.5	<u>GNC, GL, NB.</u>			
	1944—45	100	110.7	109.3	Yes	7.1	<u>GL, GNC, NB.</u>			
II Crop:	1942—43	100	111.1	106.7	Yes	5.7	<u>GL, GNC, NB.</u>			
	1943—44	100	113.8	119.8	Yes	7.4	<u>GNC, GL, NB.</u>			
	1944—45	100	111.1	112.4	Yes	10.0	<u>GNC, GL, NB.</u>			
Interactions										
		1	2	3	4	5	6	'Z' test satisfied	C. D.	Conclusions
								or not		
I Crop:	1942—43	100	108.7	120.5	116.7	125.9	110.1	Yes	13.9	<u>5, 3, 4, 6, 2, 1</u>
	1943—44	100	113.0	117.4	110.2	122.7	115.1	Yes	12.0	<u>5, 3, 6, 2, 4, 1</u>
	1944—45	100	110.6	118.1	115.0	123.5	108.4	Yes	9.9	<u>5, 3, 4, 2, 6, 1</u>
II Crop:	1942—43	100	104.2	117.2	119.7	111.3	106.6	Yes	8.0	<u>3, 4, 5, 6, 2, 1</u>
	1943—44	100	115.8	136.3	109.0	143.5	115.0	Yes	10.6	<u>5, 3, 2, 6, 4, 1</u>
	1944—45	100	116.1	120.0	120.0	128.5	114.0	No	12.2	

(b) *Fish guano*: Fish and fish products are always available in some quantities on the West Coast. It is considered to be a good manure for paddy but its effect in incremental doses remained to be investigated. Fish guano was applied at the rate of 200 lb. to 400 lb. per acre with and without green leaf at 2,000 lb. and 4,000 lb. per acre. From the trend of the results in table XIII it would appear that a higher dosage than 400 lb. per acre is necessary to equal the effect of leaf at 4,000 lb. per acre. Fish guano at 400 lb. per acre is as good as leaf at 2,000 lb. giving on an average 14 per cent increased yield over 'no manure'.

TABLE XIII.—Fish Guano Experiment

- Treatments:—
1. No manure. (control)
 2. Green leaf at 2000 lb. per acre.
 3. Green leaf at 4000 lb. per acre.
 4. Fish guano at 400 lb. per acre.
 5. Fish guano at 200 lb. per acre.
 6. Fish guano at 200 lb. per acre plus green leaf 2000 lb. per acre.
 7. Do. 200 plus d. do.

Mean yields as percentage on control

	1	2	3	4	5	6	7	'Z' test satisfied or not	O. D.	Conclusions
I Crop :										
1944—45	100	111.6	124.4	118.6	110.0	128.0	118.6	Yes	6.5	<u>6,3,4,7,2,5,1.</u>
1945—46	91.4	98.6	111.8	97.5	91.4	108.2	101.1	Yes	11.7	<u>3,6,7,2,4,5,1.</u>
II Crop :										
1944—45	100	113.6	120.9	127.5	109.6	125.2	113.9	Yes	10.2	<u>4,6,3,7,2,5,1.</u>

(c) Phosphatic manures did not give consistent results when applied either alone or in combination with green leaf or ammonium sulphate. It was therefore proposed to try superphosphate alone and in combination with manures like groundnut cake and wood ash. The details of the experiment and the results for two seasons are brought out in table XIV. It will be seen that the results, so far as the effect of superphosphate is concerned are inconclusive.

TABLE XIV.—Groundnut cake, Wood ash and Superphosphate.

- Treatments:—
1. Green leaf at 2000 lb. per acre.
 2. As 1, plus cake at 500 lb. per acre.
 3. As 1, plus superphosphate 200 lb. per acre.
 4. As 1, plus wood ash at 4000 lb. per acre.
 5. As 1, plus cake 500 lb. plus superphosphate 200 lb.
 6. As 1, plus cake 500 lb. plus ash 4000 lb.
 7. As 1, plus superphosphate 200 lb. plus ash 4000 lb.
 8. As 1, plus superphosphate 200 lb. plus cake 500 to plus ash 4000 lb.

Mean yields as percentage on General Mean.

	1	2	3	4	5	6	7	8	G.M.	S.E.	'Z' test satisfied or not	C.D.
I	68.6	104.3	97.1	97.6	104.8	113.3	103.3	107.5	100	3.04	Yes	6.32
II	93.2	105.1	95.6	95.6	109.7	101.5	97.9	101.5	100	3.80	Yes	7.90

Conclusion:— I.—6, 8, 5, 2, 7, 4, 3, 1.

II.—5, 2, 6, 8, 7, 4, 3, 1.

(d) *Compost manure*: In order to put all the farm wastes into use, they were made into compost and their value as a manure was determined in comparison with farmyard manure on equivalent nitrogen basis. The experiment was laid out in dry paddy and the results are encouraging. The figures for the past two seasons indicate that compost is equivalent to farmyard manure and an increase of 13.8 per cent over 'no manure' was recorded. The experiment is being continued.

VI. Discussion of Results: The results would show that the laterite soils of Malabar do not uniformly respond to phosphatic fertilisers like bonemeal, basic silicophosphate, Kossier phosphate and superphosphate when applied even at the rate of 50 lb. phosphoric acid per acre. The effects in combination with nitrogenous and potassic manures also have been inconclusive. Other commercial products like Ultraphos, containing 22 per cent phosphoric acid and Reno hyper phosphate having 25-30 per cent P_2O_5 were also tried without any appreciable effect. It is known that the soils contain large percentages of iron and alumina in the presence of which the phosphates are converted into a form unavailable to the plants. The whole problem of phosphate deficiency and its effective application have therefore to be studied in a more intensive manner.

Though the soils on the West Coast are deficient in lime, its application as calcium carbonate at the rate of 2,000 lb. per acre showed very little effect. Experiments are under way to assess its influence at higher doses with and without a combination of green leaves and ammonium sulphate, lime being applied at three doses 1,000, 2,000 and 3,000 lb. per acre. The trend of the results so far indicate that an increased yield up to 24 per cent is recorded by applying lime at 3,000 lb. per acre. Such a large dose is hardly economical, but a study of this type with concurrent analyses of soil would throw light on the reaction and requirement of the soil and the best way of its exploitation for increased crop production.

Of the potassic manures, wood ash has some effect in enhancing the yield of rice. Its application has its limitations, as about 4,000 lb. per acre have to be applied for any appreciable increase in yield. It has the best effect in combination with groundnut cake which has secured 15% increased yield. Potash in the form of potassium sulphate also, it may be mentioned, had very little effect when applied at 60 lb. K_2O per acre. Wood ash is generally applied to the nurseries, presumably for reasons other than improving the yield. Experiments have shown however, that its application at the high rate of 4,000 lb. per acre to the nursery did not influence the yield of transplant crop.

The most important point that is observed in all the manurial experiments is the consistent response of rice to nitrogen, organic or inorganic. It will be seen from the results that each of the three manures namely green leaf, groundnut cake and ammonium sulphate to supply 30 lb. nitrogen which works out to 4,000 to 5,000 lb. of leaf, 400 lb. of groundnut cake and 150 lb. of ammonium sulphate per acre, brings about an increased yield of 30 per cent or 400 lb. of paddy (rice in husk) per acre. There is progressive increase in yields up to 60 lb. nitrogen acre but 40 lb. nitrogen per acre would appear to be the optimum. The best combination would be a dose of 4,000 lb. of green leaf or 400 lb. of groundnut cake as a basal dressing and 75 lb. of ammonium sulphate per acre as a top dressing. Consistent with economy the dosage could be proportionately increased to a limit of 60 lb. nitrogen per acre.

It has also been possible to fix the best time at which the manures are to be applied for maximum production. Groundnut cake can be applied at the time of planting or sometime after. A month before

flowering is the best time for ammonium sulphate. For short duration varieties of 100 to 130 days the time would coincide with a month after planting and in the case of long duration varieties about 2 months after planting.

Fish guano could be applied with advantage along with green leaf. An increase of 14% is obtained by its application at the rate of 400 lb. per acre at which rate it is as efficacious as green leaf at 2,000 lb. per acre.

While the cost and availability should decide the choice of manures like groundnut cake, wood ash and fish guano, it is necessary that every farmstead should aim at self-sufficiency as regards green leaf and cattle manure. Trials have shown that green leaf could be applied up to 8,000 lb. per acre with advantage. It can be supplemented by cattle manure on equal nitrogen basis. The green leaf could be brought from outside or sown and ploughed 'in situ.' As a result of large-scale trials, it has been found that wild indigo, *Daincha*, *Crotalaria striata* and *Sesbania speciosa* are the best-suited green manures for Malabar.

Grown as a mixed crop with horse gram after paddy in single crop lands, wild indigo would give on an average 2,000 lb. of green matter per acre for the following paddy crop. *Daincha* and *Crotalaria striata* grown in double crop lands after harvest of winter paddy have yielded on an average 8,000 lb. each to an acre and *Sesbania speciosa* over 9,000 lb. per acre. Planted along field bunds, 2 lb. of seeds of *Sesbania speciosa* or 150 lb. of green matter could be obtained from every 100 feet of bund.

VII. Present and future lines of work: Since the soils are found to be deficient in lime and phosphoric acid, the reason for the lack of response to lime and phosphatic manures needs more intensive investigation. Experiments are under way to find out their influence in heavy dosages in combination with organic manures. Incremental doses upto 60 lb. P_2O_5 per acre over incremental doses of green manure are included in one experiment. The study of laterite soils with reference to their iron and alumina content is also envisaged.

Application of phosphatic manures to leguminous green manure crops (after the TVA plan) would appear to be promising. The investigation is to be continued with *daincha* in double-crop lands and wild indigo in single-crop lands.

Manuring of the broadcast crop of autumn rice is a problem that has not been tackled adequately on the West Coast. Trials have indicated that green leaf could be brought and applied to such crops or green manures could be sown as a mixture at the time of sowing paddy and incorporated later. Another line of work is to manure the winter crop intensively and see if this would obviate the necessity of a basal dressing for the following autumn crop without impairing the fertility of the soil.

VIII. Summary: 1. Experiments conducted with nitrogenous, phosphatic and potassic manures conducted at the Agricultural Research Station, Pattambi for two decades have been reviewed.

2. The results with phosphatic and potassic fertilisers were in the inconclusive. Wood ash at the rate of 4,000 lb. per acre gave 15 percent increased yield. Its best combination is with groundnut cake. Fish guano at 400 lb. per acre was found to be as efficient as green leaf at 2000 lb.; an increased yield of 14 percent was recorded.

3. There is consistent response to nitrogen, increased yield being obtained with increasing doses up to 60 lb. nitrogen per acre.

Green leaf at 5,000 lb.; groundnut cake at 400 lb. and ammonium sulphate at 150 lb. per acre to supply 30 lb. nitrogen secured on an average 30% increased yield. The best combination would be a basal dressing of leaf at 4,000 lb. per acre and ammonium sulphate at 75 lb. per acre as top dressing. The dose of nitrogen could be proportionately increased up to 60 lb. per acre.

4. It has been found that groundnut cake can be applied either at planting time or two to four weeks after planting. The best time for ammonium sulphate is a month before flowering.

5. The possibility of growing ones' own green manures and production of seeds are outlined.

6. Dry paddy was found to respond as much to compost manure as farmyard manure, recording an increased yield of 13.1%.

7. Future lines of work are indicated with reference to lime and phosphatic manures and green manure crops.

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