Farming will never be a success unless the farmer had more voice in the disposal of his produce—P. Morrel.

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Some Experiments on the Manurial Requirements of Paddy

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Paddy occupies the largest area of cultivated crops in Madras and is grown in deltas, along river banks and under tanks. References to the grain in old Indian literature and the ancient irrigation systems bear testimony to its antiquity as the most important staple food crop of the country. Water is the first and deciding limiting factor for the growth of the crop and, barring some localities receiving silt from higher levels, a large proportion of the paddy soils in Madras with which alone the writer is quite familiar, may be said to have reached their minimum cropping value; and this statement is substantiated by Dr. Butler who, in an account of his deputation to the International Rice Congress in Spain in 1914, published in Volume IV of the Agricultural Journal of India, 1914, gives the following figures as the average yields of grain per acre in different countries:—

	lbs.
Spain (Province of Valencia) ...	5700
Italy	3300
Egypt	3300
Japan	2100
India	890

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2. Why is the yield so low in India? The straight forward answer is that, nature providing an adequate water supply, paddy which, for a lazy cultivator, is the easiest crop to grow has been cultivated for centuries without adequate return to the land, and the soils are therefore generally in an exhausted condition except for the fresh silt of rivers. 5 Soil Surveys of deltaic tracts have been done in Madras with reference to the manurial content in these soils, and the general inference is somewhat as follows.—

Derived directly or indirectly from gneissic rocks containing orthoclase felspar, the soils are generally well supplied with total and available potash. The amount of organic matter is low and the nitrogen content is in proportion also low. This is largely rectified by the general practice prevailing in Madras of ploughing in green manures, formerly cut from forests and waste lands and now largely grown as leguminous crops in the fields themselves. Let alone the question whether green manures directly supply nitrogen to the plants under swampy conditions of cultivation, there has been a general improvement in crop production as a result of green manuring. Ryots do understand the efficacy of farmyard manure, sheep penning and organic manures like poonacs, but only a small proportion of the lands under cultivation receive anything like manure. Next, the lime-magnesia ratio, as advised by Japanese scientists, seems to be about properly maintained in these soils and there does not seem to be any immediate need for the supply of lime as a manure. With regard to phosphoric acid, the outlook seems despondent; the content of both total and available phosphoric acid is very low, and the continuous depletion of phosphoric acid goes on, as the grain in which most of the phosphoric acid is lodged is sold off the land. The only sources of phosphatic manures available in Madras are bones and Trichinopoly phosphate. The manufacture of super on an extensive scale is apparently a remote and even impossible task, and there is probably no need to use the more costly super in paddy lands, while the cheaper bonemeal and powdered phosphatic nodules seem to be equally good for paddy under the conditions of cultivation carried on in the country. The writer's work on the availability of flour phosphate has confirmed the result that flour phosphate is rendered available to paddy when green manure is ploughed in, especially if a readily available nitrogenous manure is also applied. Field experiments in Madras have given similar results.

3. As a sequence of the work on the availability of flour phosphate, the question of evolving suitable manure mixtures for the paddy lands of Madras was taken up, especially of the premier rice growing district of Tanjore which forms the Cauvery delta.

Phosphoric acid and nitrogen being the two manurial ingredients required for these soils, the investigation required the elucidation of the two following points:—

(i) the comparative merits of the chief organic nitrogenous fertilizers at present available in Madras; and

(ii) the comparative merits of bone meal and flour phosphate as suppliers of phosphoric acid.

Experiment I.

20 plots, 5 cents each, were laid out in four different villages in Tanjore District, and 4 organic manures, fish guano, groundnut cake, horn-and-hoof meal and castor cake were applied, some mixed with flour phosphate and some with bone meal the total amount of nitrogen and phosphoric acid being 10 lbs. and 30 lbs., respectively, per acre. The duplicates received 2 lbs. of ammoniacal nitrogen and 4 lbs. of water soluble phosphoric acid, to find out whether these small quantities stimulated the growth of the crop in early stages. The soils varied, in nitrogen content from ·049 to ·074 per cent, in total phosphoric acid from ·053 to ·087, and in available phosphoric acid from 0·0035 to ·009. Seedlings of long duration varieties of paddy were planted about the end of September 1923 and harvested in the 1st week of February 1924. The harvest was done under departmental supervision and, while the yields of grain may be taken as accurate, the yields of straw were only approximate owing to the differences in its dry or green state.

The same experiment was carried out in pots in the pot culture house at Coimbatore, with a soil which contained ·067 per cent of nitrogen, ·038 of phosphoric acid and ·005 of available phosphoric acid. Each manured field-plot and each manured pot received same quantities of nitrogen and phosphoric acid per acre, the nitrogen of bone meal and the phosphoric acid content of the organic manures being taken into account. The general opinion that bone meal is superior to flour phosphate is not borne out by these experiments, the flour phosphate series, on the other hand, being slightly superior to the bone meal series. The following summary from the tabulated figures brings out the force of the above statement :—

Nature of Experiment.	Yield in lbs per acre. Grain.	Straw.
Check (average of 8)	2013	4379
Flour phosphate series (average of 32) ...	2310	5315
Increase due to phosphate	297	936
Check (average of 8)	2105	4766
Bone meal series (average of 32)	2249	5029
Increase due to phosphate	144	263

As suppliers of phosphoric acid, therefore, both bonemeal and flour phosphate may be said to be of equal value and the present experiments show, if any, that flour phosphate is superior to bonemeal. In other words, divested of its nitrogen, the phosphoric acid in bones has equal value with the phosphoric acid of flour phosphate, as it is present in both cases as the insoluble tricalcic phosphate. This is a very important consideration considering the present market price of the two manures. Owing to the demand from Ceylon and other countries, bonemeal is now selling at Rs. 120 per ton, while a manure Firm in Madras to whom a portion of the phosphatic nodule area has been leased out, has stipulated with the Government to supply properly ground mineral phosphate at Rs. 40/- per ton.

As regards the organic manures, all the four manures seem to be of equal value as suppliers of nitrogen. The following summary makes this point clear:—

Number of experiments.	Nature of Experiment.	Yield in lbs. per acre. Grain	Straw	Excess yield over check in lbs. Grain	Straw
Average of 8.	Check	2107	4573	...	...
,, 8.	Fish guano series	2266	5072	159	499
,, 8.	Groundnut cake series	2247	5044	140	471
,, 8.	Horn & hoof meal series	2201	5358	194	785
,, 8.	Castor cake series	2308	5214	201	641

The results do not warrant a statement regarding the superiority of any of the four manures as suppliers of nitrogen, although castor cake and horn meal seem to be better. The choice for a manure mixture will, therefore, depend on the quantities which can be procured in a particular locality and the price at which it is available. The current prices are as follows:—

Nitrogen in	fish guano	Rs. 12 to 13 per unit.
,,	groundnut cake	15 to 16 ,,
,,	horn meal	11 to 12 ,,
,,	castor cake	20 to 21 ,,

From the above remarks, it will be seen that fish guano and horn and hoof meal amongst organic nitrogenous fertilisers and flour phosphate amongst the phosphatic manures, may be the bases for manure mixtures. Sulphate of ammonia is available in Madras at Rs. 14 per unit and should also form an ingredient of manure mixtures, especially as ammonium salts are easily fixed in soils and as paddy feeds directly on ammonium salts.

Experiment II.

Based on some experiments carried out by the writer in 1918 on the availability of flour phosphate, as a result of composting it with different organic fertilisers in puddle, a manure mixture was evolved by the Deputy Director of Agriculture, and has been in use with fairly satisfactory results for the last 5 years in the Tanjore delta; and, on account of the present higher prices of some of the ingredients of that mixture and on account of the increased grain-yield not covering the cost of the manure in some cases, it was considered desirable to examine the question of manure mixtures more thoroughly.

An experiment was tried with an improvised manure mixture, containing 5.25 per cent of nitrogen and 12.5 per cent of phosphoric acid, in 20 villages in the Tanjore district. Selected plots in these villages were divided into an even number of strips, alternate plots receiving the manure at 2 cwts. per acre. In two cases, the manurial plots yielded less grain than the unmanured. Of the remaining 18 plots, 12 plots gave an increased amount of grain covering the cost of manure which was Rs. 10 per acre.

4. The experiments of 1923-24 having, to a certain extent, elucidated the comparative merits of the organic fertilisers and the phosphatic manures, proposals were ready for the continuation of the experiments in the year 1924-25, both in the field and pot culture house. The dislocation of Railway traffic owing to floods interfered with the transport and application of manures, and the field experiments had to be dropped ,for the present.

The pot experiments were, however, improved upon in the following manner. As it is very difficult to maintain in pots, the actual paddy soil conditions, throughout the season of growth, Cuddapah slab frames, each one yard square, were sunk in the paddy lands of the Central Farm Coimbatore after the usual preparatory cultivation was over ; and different proportions of manure mixtures were applied to each frame. the field being carefully laid out for letting in and letting out water, without contaminating other plots. These experiments were modelled after Kellner in Japan.

5. The next point for consideration is the quantity of manure which should be applied. The general principles governing the application of manures are so many and so varied, that it is difficult to give a definite answer. Manure Firms which sell fertilisers for different crops appear to have compounded their mixtures chiefly on the basis

of the quantities of nitrogen, phosphoric acid and potash which will be removed by an average crop annually. In Spain, 800 lbs. of a manure mixture containg 64 lbs. of ammoniacal nitrogen, 70 lbs. of water soluble phosphoric acid and 24 lbs. of potash are applied per acre and this will cost at the present market rate about Rs. 60 in Madras. Kellner recommends an application of 75 kilograms of ammonium sulphate and 125 kilograms of water-soluble phosphoric acid per hectare, which amounts to 65 lbs. of nitrogen and 110 lbs. of phosphoric acid per acre, and this will cost again about Rs. 60. In his calculations, Kellner has taken into consideration not only the quantities of nitrogen, phosphoric acid and potash removed by crops but also the assimilation factor for each manurial ingredient, which worked out to 56 to 62 per cent of *nitrogen* in ammonium sulphate, 50 per cent of *potash* in sulphate of potash and 21 per cent of *phosphoric* acid in superphosphate. Kellner's experiments were carried out over 30 years ago in Japan and the results of his experiments are buried in old Japanese bulletins, but one certainly gets a certain amount of inspiraton from these old records. His final results regarding the manurial requirements of paddy may be summarised in the statement:—

For every 100 kilograms grain, apply 2.53 kilograms of ammoniacal nitrogen and 1·42 kilogram of water-soluble phosphoric acid and, if there is a deficiency of potash, 1.31 kilogram of potash as a soluble salt.

The soils of Japan contain from .489 to .799 per cent of nitrogen and .49 per cent of total phosphoric acid, ten times the nitrogen and phosphoric acid content of South Indian soils and, when Kellner recommends an application of a heavy manurial treatment as described above, there is a feeling of despondency about the possibility of our improving Indian soils with such small homoeopathic doses as 10 lbs. of nitrogen and 30 lbs. of insoluble phosphoric acid. Scientific determination of the requirements of paddy for maximum crops is one question, and the recommendation to a cultivator to apply a certain quantity of manure is another ; the lattcr depends upon his ability to find the cost of the manure, and at present the cultivators of Tanjore are unwilling, rather unable, to spend more than Rs. 10 to Rs. 15 per acre for manures. The scientific aspect, however, is the more important and requires several years, sustained work on a definite policy and, if possible, concerted action between workers in different Provinces.

[The Tabular Statements giving detailed results of experiments have been left over for a future issue—Editor.]