Paddy Notes (2).

(a) The Preliminary Testing of Pure-line Selections of Rice. (b) An Account of Two Cultural Experiments.

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(a) Preliminary Testing of Pure-Line Selections of Rice.

THE first investigations carried out on this subject were described in the *Tropical Agriculturist*, Vol. LXVII., 5, 1926. The investigations have been continued for the past two seasons and the results have been embodied in a paper which is considered too technical for this Journal, and which will, therefore, be published, in due course, in the *Annals of the Royal Botanic Gardens, Peradeniya.*

The first investigations showed that the so-called rod-row plot (there, three rows of 30 plants each, 6 in. between rows and plants) was distinctly useful in testing new selections of rice at an early stage in their history when seed was available in small quantities only. The outer rows of plots were not discarded and yields were calculated on the basis of yields per hundred plants. Attention was drawn to the fact that the border effect on outside rows may affect the comparative yields of selections and that if the yields of the inner three rows of five-row plots were used (which would eliminate border effect) the legitimacy of using yields per hundred plants would have to be re-examined. The further investigations have shown that border effect may be appreciable and that it is necessary, therefore, to use yields of the inner three rows of five-row rod-row plots. The accuracy of using yields per hundred plants was accordingly examined and it has been concluded that (a) when the mean number of plants

per plot of any selection is much below 80 (the maximum number being 90) the use of both yields per hundred plants and of total yields per inner three rows is inaccurate, and (b) with means of over 80 plants per plot total yields and yields per hundred plants are approximately of equal accuracy. Where rod-row plots are used it is essential that almost all of the seedlings transplanted should reach maturity. This may be attained by filling up vacancies in the plots in the early weeks following transplanting and by lessening ravages by land crabs. Possible preventative measures against crabs are:

(1) thoroughly draining fields immediately after transplanting for a period of a week or so.
(2) planting a 2 ft.-3 ft. border of plants of any variety of paddy round the fields close to the bunds to attract crabs and keep them away from the plots.
(3) trapping crabs in pots according to the method described in the September, 1927, issue of this Journal, and
(4) catching crabs during the day time. Boys become expert at this and at Peradeniya a catch of 200 per day per boy is common.

It has been found that the seed of one ear-head when sown in a small nursery and the seedlings transplanted at distances of 6-12 in. between plants will, under good conditions, frequently produce a yield of 2 lb. of seed. This amount of seed is sufficient for from six to eight transplanted 1/200 ac. plots allowing for a 12 in. border of plants to be discarded prior to harvest. It is possible, therefore, under such conditions, to conduct the preliminary tests in 1/200 ac. plots instead of in rod-row plots. The advantage of doing this lies in the saving of time and in the probable reduction of experimental errors. Disadvantages are the larger area of ground required and the fewer replications necessary. At the commencement of pure-line selection work in a new district when large differences of yield may be expected from the selected strains the writer advocates using 1/200 ac. plots for preliminary tests, as a matter of expediency, whenever from fifteen to twenty of the initial selections produce 2 lb. of seed from the ear-to-row multiplication plots. In laying down the 1/200 ac. plots transplanting is preferable to broadcasting, but it is realised that in many districts where paddy-fields are entirely rain-fed broadcasting only is possible.

Experimental errors of varietal tests with rice in small plots have been found to be high and replications should be as many as possible. Sixteen replications of rod-row plots and ten replications of 1/200 ac. plots with careful cultural methods should detect 10% differences of yield. Two alterations in technique were made during the course of the further investigations; one

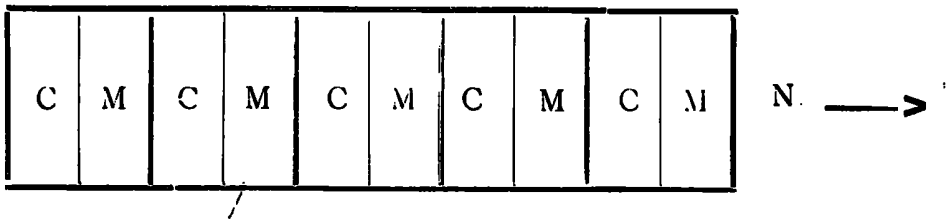
was in the method of arranging the different plots in each replication and the other, in the statistical examination of results. Plots are now laid down in what is known as "randomized blocks," a system advocated by R. A. Fisher and described by him in the *Journal of the Ministry of Agriculture*, 1926, pp. 503-513. This article which explains the necessity for this random arrangement was reprinted in this Journal for December, 1926.

The calculation of experimental errors is now made by what is known as the method of analysis of variance described by Fisher in his book *Statistical Methods for Research Workers*. These methods of plot arrangement and of statistical examination of results are the same as those now used in the new field experiments at Rothamsted.

The writer wishes to take this opportunity of thanking Dr. Fisher for his very kind advice and assistance.

(b.) An Account of Two Cultural Experiments.

Green Manuring Experiment.—An experiment was put down at Anuradhapura in 1926 to determine the effect of ploughing in a growing crop of a leguminous green manure on the yield of the succeeding paddy crop. Sunn Hemp (*Crotalaria juncea*) was the green manure used. Five rectangular 1/5 ac. fields were divided longitudinally into two equal parts by means of temporary bunds. On one-half of each field *Crotalaria juncea* was sown at the rate of 25 lb. per acre. The diagrammatic plan of the experiment is as follows:—



Irrigation channel

C = the unmanured and M = the manured plots. Each plot was approximately 1/10 ac. It will be noticed that the manured plots are always to the north of the control plots. This systematic arrangement of the plots affects to some extent the accuracy of the experiment and the validity of the calculated experimental error. The soil of paddy-fields is so thoroughly mixed, however, during the process of puddling that any differences of fertility in a field are due mainly to proximity to bunds and to water inlets and outlets. Each of the plots of the experiment had equal lengths of bund and each had its own inlet and outlet. It is not thought, therefore, that the systematic, instead of a random plot arrangement, has seriously affected the results. The green manure was sown early in December, 1926. This

sowing failed owing to heavy rains. The second sowing, on 28-12-26, was moderately successful. A 12-18 in. high crop was ploughed in dry on 10-2-27. The strong weed growth on the control plots was ploughed in on 21-4-27. All the plots were puddled on 27-4-27 ($2\frac{1}{2}$ months after the green manure was ploughed in) and sown with a pure line *Yala* paddy on the same date. The results of the experiment are as follows:—

Treatment	Mean yields of grain			Mean difference per plot lbs.	Standard Error of difference
	Actual yields per plot lbs.	Per Acre lbs.	Per-centage		
Manured	213·10	2,131·0	135	55·75	15·09
Control	157·35	1,573·5	100		

The odds that this difference is due to the treatment and not due to chance are nearly 50 to 1.

It is unfortunate that this experiment does not *prove* that the large difference of 35% is directly due to the effects of the green manure as the two sets of plots did not receive the same cultural treatment. The green manure was ploughed in about 10 weeks before sowing whereas the strong weed growth on the control plots was ploughed in just less than a week before. The green manure was ploughed in at that time as growth had ceased. The control plots were ploughed at the normal time of ploughing for the *Yala* crop. The question now arises, did the manured plots give an increased yield because of the extra nitrogen (obtained from the air) added to the soil? Or was the increase due to the fact that in the manured plots the nitrogen in the manure had sufficient time to "become an integral component of the soil before the irrigation season commences ?" (Harrison and Aiyar, *loc.cit.*) or again, did the control plots yield less than they might have done under different cultural methods because of the dissipation of most of the nitrogen of the weed growth as nitrogen gas under the puddled and hence anaerobic conditions?

The results of the experiment are a reminder of the fact that the problem of green manuring of paddy is a complicated one. Harrison and Aiyar* (p. 31) state that "When the green crop is puddled into the soil decomposition occurs and most of the nitrogen contained in it is dissipated as nitrogen gas and becomes valueless from the manurial point of view," and (p. 27) "If, therefore, this nitrogen (the nitrogen on the green manure) is to be utilized, two alternatives are open, either to greatly

* Harrison, W. H. and Aiyar, P. A. S. The Gases of Swamp Rice Soils, Pt. IV. *Mem Dept. Agric. India*, Vol. V., No. 1, 1916.

modify, or eliminate, the methods of swamp cultivation, or to apply the manure at such a time and under such conditions that the nitrogen can become an integral component of the soil before the irrigation season commences." The conditions under which the green manure was ploughed in, in this experiment, were such as to allow at least part of the nitrogen of the manure to become an 'integral component' of the soil.

But the puddling in of green manure immediately prior to sowing or transplanting seems general in India, and is probably the cheapest and most convenient method. Its efficacy has been shown by Parnell * in an experiment where green manure (not, however, grown *in situ*) was both ploughed in dry about six months before planting and puddled in just prior to planting. In discussing the results of the experiment, Parnell says: "It is, of course, impossible to rely on an isolated experiment of this kind, but the odds are distinctly in favour of puddling the green manure before planting, and the figures are simply given as a record of this fact in this particular case." There is reliable evidence (Kelly †), however, that organic substances under puddled, anaerobic conditions develop ammonia, the form in which it is believed nitrogen is mainly assimilated by the rice plant. It would appear, therefore, that the puddling in of green manures must be effective in spite of any loss of gaseous nitrogen. After considering the available evidence it is thought that the increased yield given by the manured plots in the Anuradhapura experiment is due to the added nitrogen supplied by the leaves and roots of the green manure and that, in all probability, puddling in the green manure would also have given similar beneficial results.

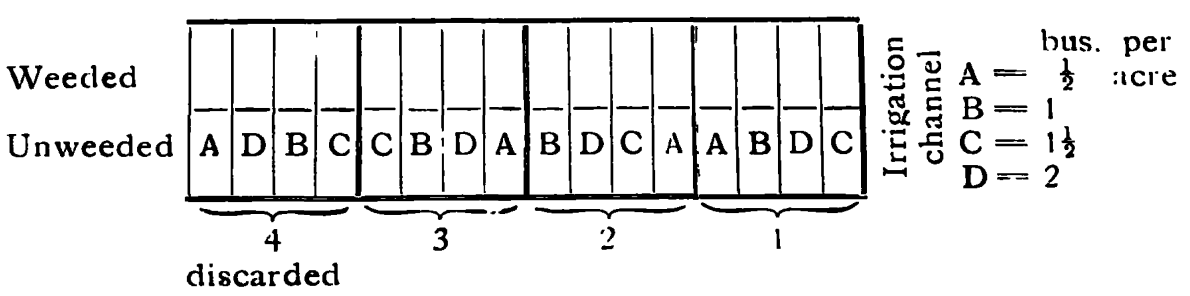
It is evident that the problem of the green manuring of paddy requires further investigation. In co-operation with the Agricultural Chemist, it is intended to lay down an experiment to determine (i) the optimum time and conditions for ploughing in green manures and (ii) the magnitude of the increase in yield which may be expected.

Seed Rate Experiment.—The average seed-rate for broadcasted paddy in Ceylon is two bushels per acre or more. The object of this heavy seed-rate is, apparently, to keep down the strong weed growth which is found in most districts. A seed-rate experiment was laid down at Anuradhapura during the *Yala* season of 1927 to determine the effect of different seed-rates un-

*. Parnell, F. R., Green Leaf Manuring of Dry Paddy Land. *Year Book of the Madras Agric. Dept.*, 1919.

† Kelly, W. P. The Assimilation of Nitrogen by Rice. *Hawaii Agric. Expt. Stn*, Bull. No. 24. 1911.

der weeded and unweeded conditions. A pure-line *Hinati* paddy was used in all plots and the plots were 1/100 ac. Four different seed-rates ½, 1, 1½ and 2 bushels per acre were used and each replicated four times. Owing to the use of different seed in one replication three replications only can be used. One-half of each plot was thoroughly weeded about five weeks after sowing. The yields recorded are therefore from 1/200 ac. plots. The diagrammatic plan of the experiment is as follows:



The four different seed-rates were put down in what is known as 'randomized blocks,' that is, the position of each seed-rate was at random in each of the four compact blocks. A block holds one complete replication. To simplify weeding the 1/100 ac. plots were divided into two halves by a coir rope and those halves to the north were weeded. The two halves were harvested and threshed separately. The distribution of the weeded plots was not at random and the calculated experimental error is therefore not absolutely valid. As mentioned in the account of the previous experiment, the preliminary puddling of paddy-fields results in such a thorough mixing of the soil over the whole field that differences of fertility are due mainly to proximity to the irrigation channel. In this experiment both weeded and unweeded plots are affected equally by this fact. The different seed-rates, which are not affected equally were laid down at random. The mean yields in lb. per 1/200 ac. plot and per acre of the different series are as follows:—

Seed-rate	Weeded		Unweeded	
	per plot lbs.	per acre lbs.	per plot lbs.	per acre lbs.
½ bushel	14·33	2,866	6·83	1,366
1 ,,	15·83	3,166	11·25	2,250
1½ ,,	17·41	3,482	12·50	2,500
2 ,,	16·25	3,250	12·75	2,550

(The standard error of the difference between any two plots is

0·93, Z = 0·6354.). Within the limits of the error of the experiment it is possible to state that the ½ bushel seed-rate is definitely the worst but there is no statistical evidence which of the remaining three is definitely the best. With good seed, a seed-rate of 1½ bushels per acre is ample. The results of this experiment show the very large increase of yield which may be expected to follow weeding. A comparison of the best weeded plot with the best unweeded shows an increase of 36%. If the 1, 1½ and 2 bushels seed-rates are compared collectively, weeding has resulted in a 35% increase. A conservative estimate of the increase to be gained through weeding would not be less than 20-25%. It is obvious that if the practice of weeding is universally adopted there will be a large increase in the amount of paddy produced in Ceylon. It is difficult to estimate the cost of weeding to the cultivator who may utilise his own labour, family labour or co-operative labour (a type of labour found to exist near Peradeniya during the time of transplanting). When all labour is paid for in money the costs will vary but should nowhere exceed Rs. 12·00 per acre whereas the least increase in yield should be six bushels of paddy.