The Selection of Pure-line Strains of Paddy, their Testing and Distribution.

L. LORD, M.A.,

Economic Botanist, Ceylon.

FROM articles which have appeared in the local press there would seem to be a certain degree of ignorance as to the work being carried out by the Department of Agriculture on the improvement of paddy cultivation in Ceylon. The annual reports of the Department show the progress that is taking place but as such reports receive little publicity this brief account has been prepared.

Classes of Improvement.

The improvement of paddy cultivation may conveniently be discussed under six classes:—

1. Seed and Seed Supply
2. Cultural Methods
3. Pests and Diseases
4. Credit Facilities
5. Marketing
6. Land Tenure

It is intended in this paper to deal only with the first two although it is possible that in a particular district any one of the above classes may provide the limiting factor. It may also be exceedingly difficult or perhaps impossible to effect certain improvements. The control of some of the pests and diseases of paddy offers a fertile if difficult problem. Ceylon paddies (compared with those in Burma at any rate) are particularly unfortunate in the extent and intensity of the damage they suffer from insects. Paddy Fly, Stem Borer and the Swarming Caterpillar all do a tremendous amount of harm.

Credit facilities will improve with the spread of the co-operative spirit; but improvement of marketing conditions is rendered difficult by the fact that the local milling industry is yet in an embryonic condition. Land tenure does not come within the scope of this paper.

Seed and Seed Supply.

One of the most profitable methods of increasing the yields of crops is by the use of improved seed. Improved seed which implies some method of selection or of hybridising, has been used for many years. Selection may be of four kinds—casual, mass, pedigree or pure line and continuous selection. Casual selection is the selection of some spontaneously occurring advantageous plant followed by multiplication of the seed. Mass selection consists either in choosing by observation the best heads from a crop and using the seeds of these the following season, or in picking out the largest seeds. If one is lucky casual selection may still be employed, and mass selection has its uses for the cultivator himself, but for all modern work pedigree or pure-line selection is invariably used either with or without repeated or continuous selection within the pure-lines evolved. Pedigree selection has often been described and it is not necessary here to do more than refer to it in the briefest possible way. Commercial varieties of any agricultural crop are composed of a mixture of different types, which may differ in their hereditary constitution even when similar in appearance, and which vary amongst other things in yielding power and disease resistance. In pure-line selection of self-fertilised crops a number of these different types is picked out by observation or weight per ear head. These selections are multiplied under conditions which prevent cross-pollination until (generally in the third year) there is sufficient seed for testing. After testing the most suitable selection is then retained and multiplied and the remaining selections discarded. So far as Ceylon paddies are concerned the main characters which determine the value of a selection are

1. Yielding power
2. Percentage husk to grain
3. Standing power (per cent. lodging)
4. Disease resistance
5. Absence of awns

The colour of the rice is of little importance although in some districts red rices are preferred.

Before dealing with the technique employed on pure-line selection and with the progress of the work in Ceylon there is still to be mentioned continuous selection and hybridisation. Hybridisation consists in artificially crossing desirable plants and segregating and stabilising certain of the resulting types before dealing with them as pure-lines. Hybridisation in rice is not yet practised by the Department as the immediate possibilities of pure-line selection are nowhere near exhausted. Continuous selection within a pure-line has lately been shown to be necessary. At the Imperial Botanical Conference in 1924 Percival

said " It is being taught that the single initial selection in self-fertilised plants is alone of value; once obtain your improved variety, it maintains its characters from generation to generation and further selection is superfluous. This, I think, is to be regretted, for hereditary variations, mutations, or whatever they may be called, do occur in such lines, and it is only by renewed selection that these can be discovered and isolated; even if we were quite certain that the causes which produce fluctuations do not affect the hereditary mechanism of the plant we should be justified in the practice of repeated selection on this account. .....repeated selection in all lines should be diligently pursued." J. A. Thomson writing in the *New Statesman* (Dec. 11, 1926) refers to "..... Baur's recent study of snapdragons in which it is shown, after many years of research, that the garden races are constantly exhibiting small mutations, transmissible in their entirety in Mendelian fashion, often going one better than their parents, and occurring copiously even in 'pure-lines' that is to say, in lineages all descended from one."

Quite apart from the large amount of initial selection still to be done amongst Ceylon paddies there will always be the necessary work of continuous selection waiting to be started. Up to the present it has been impossible to attempt this and it will be for some time to come.

The Progress of Pure-line Selection in Ceylon.

At the end of 1926 there were forty-one Maha selections and forty-seven Yala selections isolated and tested at Peradeniya and Anuradhapura of which sufficient seed was available for starting outside trials in 1925. For convenience these are called the main series selections and are the result of isolations begun in 1921. Distinct from the main series selections there were also in existence at the end of last year 652 new selections which have now reached the stage of preliminary testing. After two years' testing nineteen out of every twenty of these selections will be discarded. During 1926 over 300 ear head selections have been made which this year will be multiplied on the ear-to-row method prior to preliminary testing in 1928.

The Main Series.

These include selections from the most popular and largely grown paddies, e.g., *Mawi, Kohu Mawi, Kalukan Mawi, Sudu Mawi, Goda Mawi, Maha Mawi. Ratkunda, Podiwi, Molagusamba Polluksamba* (Maha paddies) and *Hinati, Kalu Hinati, Chinati, Karuppu Chinati, Danahala, Dahanala, Podi Hinati, Sinatti, Morungan, Ilankalayan.*

Work with these main series pure lines consists first in maintaining the purity of the lines (by bagging) at Anuradhapura and

Peradeniya and in providing sufficient seed for field tests at those Paddy Seed Stations where the lines are likely to be successful and secondly in supplying seed to the cultivator. The machinery which exists at the present time for the testing of pure-line paddies consists of the Economic Botanist's areas at Peradeniya and Anuradhapura and of nineteen small Paddy Seed Stations scattered over the Island. The writer has prepared for the 1927 Yearbook of the Department of Agriculture a short account of these stations. Apart from the pure-lines which have proved successful at these seed stations during Maha 1926-27 certain of the pure-lines have already been taken up by cultivators notably a-8 near Negombo, B-11 and Hk-13 at Katugastota, R-11 at Ratnapura (where the selection is known as Peradeniya Ratkunda), Mb-14 and Ho-33 at Mannar, G-1 and other selections in the North-Western Province.

Altogether over 350 bushels of pure-line paddies are recorded as having been sown by cultivators for Maha 1926-27. Tests at the Paddy Seed Stations and distribution of seed to cultivators are in the hands of the divisional staffs of the Department and more detailed information on the spread of pure-line seed will be given by them.

The New Selections.

The 652 new selections were made about three years ago from ear heads sent in by agricultural instructors. Generally they represent varieties of more local interest than the main series. The following varieties are included in the new selections: *Sulai*, *Hinkarael*, *Bala Suduwi*, *Karayel*, *Ekkawi*, *Muppangan*, *Oddavalan*, *Chellakadai*, *Hinsuduwi*, *Honderawala*, *Perilavel*, *Morungakkai*. As a rule twenty initial selections of each variety were made and the problem now is to pick out the best of each twenty. Most of these new selections have been tested this last Maha and this has involved laying down over 3,000 individual plots. The methods used in testing will be dealt with later.

Ear head Selections.

Over 300 ear head selections were made in 1926 from the following varieties: *Dewaredderi*, *Florida*, *Sinnanayam*, *Maha Suduwi*, *Ratkarayel*, *Muppangan*, Black *Illankalayan*, *Sawer Kuran*, *Kandimurungan*, *Hetadawi*, *Perillanel*, *Morungakai*. In some of the above selections (and this will be done in all future selection work) fifty ear heads of each variety worked on were taken in order to give a better chance of discovering a much higher yielding pure-line. The procedure in this initial stage is known as ear-to-row sowings. The seeds from each ear head are sown (at distances of 12 inches between seeds) in rows, the rows of each selection being six feet apart to lessen risk of cross-pollination. After harvest yields are worked out to yields per

hundred plants and at least 60 per cent. of the initial selections are discarded as the result of this information plus observations during growth. The following year, all being well, there will be sufficient seed available for testing in small (rod-row) plots.

The Testing of Pure-line Selections.

One of the reasons for the long time entailed in producing a pure-line paddy (or for producing an improved strain of any crop) is the difficulty of getting an accurate test of the comparative yielding powers of the selections of any variety. First sufficient seed must be grown to allow plots to be replicated frequently enough for statistical purposes; secondly a technique must be developed which reduces errors caused by uneven fertility of fields, etc., to workable limits; and thirdly the effect of varying seasons must be eliminated. The writer cannot emphasise too strongly the grave danger of introducing a new selection to the cultivator before rigorous tests have proved its undoubted superiority. And it is this rigorous testing which takes so much time. " It is nearly as difficult," say two of our leading authorities, " to make sure of the yielding capacities of two varieties as it is to get your ball through the hoop at a game of croquet, when the mallets are flamingos and the balls are hedgehogs."* The methods used in preliminary tests of selections, that is, at an early stage in their career, has been fully described in the *Tropical Agriculturist* † for November, 1926.

Some idea of the amount of care necessary and of the work entailed may be gained when it is realised that the figures given there refer to only twenty selections of one variety. Field tests of selections take place in the later stages of their history before they are ear-marked for distribution to cultivators. Each selection is tested against a control—that is, the most popular local paddy—and tests are held, as far as possible, in the neighbourhood for which the selection is intended. Selections are grown in 1/200 acre plots replicated from six to ten times. In addition each selection is grown in a plot of from a half to one acre for observation purposes. Such tests should be carried on for at least two years.

Paddy Seed Stations.

In the last paragraph it was stated that field tests were conducted as far as possible in the neighbourhood for which the selection is intended. It has been found that the behaviour of a selection at the main stations of Peradeniya and Anuradhapura is no criterion of its behaviour say at Galle or Batticaloa. Be-

* The Principles and Practice of Yield Trials: F. L. Engledow and G. Udny Yule, *Empire Cotton Growing Review* III. 2. 1926.

† The Preliminary Testing of Pure Line Selections of Rice: L. Lord, *Trop. Agric.* LXVII. 5. 1926.

haviour here refers particularly to the life period and yielding powers of a selection. In some districts a difference of seven days in the time of flowering brings on a fatal attack by Paddy Flies. Because of this difference of behaviour in new environments it was decided to open, in various parts of the Island, a number of Paddy Seed Stations whose object primarily was to serve as test stations. During 1926 nineteen such stations were opened and conducted tests during the Maha season. Paddy Seed Stations are also serving as centres for making selections *in situ* of the popular local paddies. They will also act as demonstration stations where improved cultural methods can be *shown* to the cultivator. Finally, their ultimate and main service will be the production and distribution to cultivators of improved seed.

The Organisation of Seed Supply.

The work entailed in the production and maintenance of a pure-line is useless unless some organisation exists for the distribution year after year of seed of the pure-line to cultivators. Continuous distribution of the maintained pure-line is essential owing to the cross-pollination, mixing and deterioration which will occur. In countries where agriculture has reached a high state of efficiency the work of seed supply is carried out by seedsmen and by individual farmers who grow strains specially for seed purposes. The trouble of the seedsman is paid for in the increased price a sound farmer will always pay for good seed. In the East generally the multiplication and distribution of improved seed commences and always, to some extent, continues as Government enterprise. To what extent the supply of improved seed becomes private enterprise depends upon the co-operation and public spiritedness of the rural communities. It may be laid down that it is the duty of an Agricultural Department in the East first to produce improved strains and then to ensure that yearly a fresh supply of the improved seed gets into the hands of the cultivator either direct or *via* a private seedsman or a co-operative seed society. In Ceylon where the supply of improved seed is yet in its initial stages the procedure at present is as follows: the purity of selections is maintained at the central stations (and if necessary will be maintained also at certain seed stations), yearly this pure seed is multiplied at the Paddy Seed Stations and distributed to cultivators. Cultivators will be encouraged to retain a portion of their crop for seed purposes but owing to crossing and mixing fresh supplies of seed will be necessary at frequent intervals. For example, a district round a seed station might be divided into four or five or even more blocks and one year one block could be given seed from the seed station, the next year another and so on, thus fresh seed will reach each block

every four or five years. The size of the seed station would then depend upon the size of the blocks to be supplied. Ten acres could supply roughly say 200 acres (at 1½ bushels per acre allowing a 30 bushel yield). If however the produce from a ten acre seed farm were again multiplied by private seedsmen the seed then available would suffice 4,000 acres.

The multiplication of improved seed, for distribution to cultivators, by land owners or by co-operative societies would seem to be a suitable way of solving the problem of seed supply in Ceylon.

Cultural Methods.

A regular and ample supply of pure-line seed is one of the most fertile means of improving paddy cultivation but at the same time the improvement of local cultural methods should not be neglected. At the present time work is being carried out on the possibility of reducing the average seed rate by using cleaner cultivation; on the effect of green manures on the yield of paddy; on the effect of bone meal on paddy; on the real value of transplanting as against broadcasting; on the suitability of different green manures. In addition an experiment in trapping land crabs was started at Peradeniya towards the end of last year and over 1,400 crabs were trapped during two months in less than an acre of land. Not only do land crabs cut down young paddy plants but they do a tremendous amount of damage to bunds which is serious where there is terraced cultivation.

One of the chief difficulties in paddy cultivation in Ceylon is the large number of weeds to be contended with. There are three ways of dealing with weeds in paddy fields: one is to carry out thorough preliminary cultivation of the fields with more efficient implements than are used at present. The Burmese Harrow has been introduced and used at Peradeniya and Anuradhapura and at the Paddy Seed Stations. At the two former places it has proved efficient and economical in preparing a clean and well puddled seed bed. The harrow is used after ploughing and can be pulled by a pair of buffaloes. The harrow costs about Rs. 4·50 when jungle wood can be cut free of cost.

Transplanting is of value when weeds are numerous in that it gives an extra month during which fields may be prepared. A second way of dealing with weeds is the obvious one of weeding the crop when it is from one to two months old. A third method is to practise, when this is possible, continuous submergence of the paddy fields from about four days after sowing the crop until the fields are dried off before harvest. This method, which can be practised only where water is abundant, is used in California. It was tried last season at Peradeniya and was apparently successful in completely controlling the common weed *Fimbristylis miliacea*.

The adoption of certain improved cultural methods depends upon the financial condition of the cultivator—a Burmese Harrow is no use unless a man possesses a pair of buffaloes. The final test of improved methods is the financial return they bring and this aspect must never be neglected in following an academic ideal.

Discussion.

MUDALIYAR J. P. OBEYESEKERE said that some of the selected seed had last year been tested in his district but the returns were not so good as they had expected. This year 3 or 4 acres had been sown and the results were far better than last year. The plants grew to a great height resembling sugar-cane and the seed had been distributed to the villagers. He could not remember what the number of the selected seed was.

MR. K. B. BEDDEWELA said that he had taken a lot of interest in the question of the selection of seed paddy. The selection of seed pady was one of the most difficult things to do. He suggested that the type of paddy in the poor districts of the Island should be improved. The condition of the Sinhalese cultivator in these districts was deplorable. It was not that they were lazy, but that the climatic and other conditions were extremely difficult for them to grow sufficient food for their needs. Most of them lived on only one meal a day and they suffered from malaria and parangi and other diseases which interrupted their agricultural activities. A doctor in these districts had informed him that parangi might be caused by the combination of bad water and kurakkan.

SIR SOLOMON DIAS BANDARANAIKE inquired whether any attention has been paid to the selection of seed of hill paddy.

MR. LORD replied that nothing had specifically been done in this direction as yet but that hill paddy was sown in Anuradhapura this season. He was going to test some hill paddy which came from Ratnapura with one of his own selections at the Anuradhapura Experiment Station in the next Maha.

J. C. RATWATTE, DISSAWA said that there was an impression in this country especially in the rural districts that there was nothing to be learnt from Peradeniya as far as paddy cultivation was concerned. He had heard it so often that he had almost come to believe it himself until he visited the Experiment Station where he was convinced that the villager had everything to gain by following the methods prescribed by Peradeniya. One of the difficulties connected with the introduction of a better type of paddy was that of seed stores. If the Agricultural Department could get its officers in the rural districts to get into touch with the more energetic of the paddy cultivators with a view to installing seed stores and the organization of Co-operative Societies for distribution of seed, he felt that paddy could be made a more profitable industry for the villager.

DR. RAJASINGHAM said he understood that transplanting of paddy was largely done in India. Perhaps Mr. Lord could give him some idea as to how many fold increase could be obtained from transplanting. He would also like to know the average yield of paddy per bushel sowing.

MR. LORD said that he had gone to Anuradhapura to try and get the figures of increase of yield to be laid before the Conference. Owing to adverse weather however, the threshing operations had been interrupted and the figures would not be available for some days. There were indications that transplanting did increase the yield, but he could not say to what extent.

THE HON. MR. FLETCHER, Colonial Secretary, said that he could hardly fail to be interested in the discussion seeing that he had lived for 25 years in South China which was the home of paddy cultivation. In

Canton for instance for hundreds of miles there was nothing except an enormous chessboard of paddy intersected here and there by very small pieces of high land which served as graveyards. The Chinese had their own methods of selecting seed. They grow their paddy to perfection as far as neatness of operation was concerned. It was all put out by hand in exact rows and there was never a weed to be seen from the day the seed is sown till the crop is reaped. Cultivation was very intensive in China. In many parts they grew three crops—paddy in March and August and in the winter peanuts or sweet potatos. He was afraid he had no scientific knowledge on the subject, but it was true that the Chinese had their own secrets of seed selection. In the hinterland of Hong-Kong, such good paddy was grown that it was not sold in the country but sent across to the Chinese colony in America. The Hong-Kong Government was studying the question of seed selection from the scientific point of view but felt that there was nothing that they could teach the Chinese on the subject. It seemed to him that it might be advantageous to this country if there could be some exchange in knowiedge with the Chinese on the subject as to the methods of seed selection.

THE DIRECTOR OF AGRICULTURE mentioned that the Department was now in the seventh year of its work in connection with paddy and had gained a good deal of experience. They knew for example that pure line seed paddy selected either at Peradeniya or Anuradhapura did not produce the same performance in other districts and for that reason they had to open seed stations in various districts. There were 19 at the present time where pure line seed paddy was being tested out. He felt most strongly that the Department of Agriculture should not distribute seed paddy to any area which it could not guarantee was suited to that area; because if it did and failure resulted the Department would lose the confidence of the grower. Progress in the distribution of seed depended entirely upon the confidence that the grower had in the seed and in the Department. Mr. Ratwatte, Dissawa had touched upon two points—visits to the Experiment Station and the establishment of seed stores. It was intended to arrange for regular visits by cultivators to Experiment Stations and furthermore it was intended to erect on these stations stores for the storing of seed as well as implements and other agricultural requirements, such as manures, etc., so that cultivators may know where to go for their supplies. The manure question was being gone into in addition to that of departmental stores. He also hoped it would be possible to arrange for certified shopkeepers to act as agents for the Department for the distribution of manures, tools, etc. The existing machinery would be employed as much as possible in order to avoid excessive departmental operations.

HIS EXCELLENCY THE GOVERNOR: I would like to say a few words before we pass on to the next paper. First of all I would like to express my regret that Mr. Lord's very interesting lecture this morning should be addressed to a sadly depleted audience compared to those which we have had during the last two days. I especially regret the absence of the European planters and still more the leading members of the Low Country Products Association who till to-day have been with us in so much force and have added so greatly to the interest of the discussions.

It seems to me that the lecture that we have listened to-day is on a subject of extraordinary importance to all of us, no matter whether our interests are directly connected with paddy cultivation but, as loyal children of Ceylon who are taking a very keen interest in the matter. With the exception of coconuts the area of which if I am correctly informed is about 900,000 acres, paddy which is in the neighbourhood of 850,000 acres occupies a larger area of cultivated land than any other crop in Ceylon, and its importance as the staple food of the people cannot be exaggerated. I personally, though it will be accounted in some quarters to

be heretical, very much doubt that a time will ever come when Ceylon will become self-supporting as a rice-producing country. The temptation to make use of the land available for more lucrative products is likely to be very strong for many years to come and as long as you can import large quantities of good rice into the country at reasonable prices the inducement for our local cultivators to take up rice cultivation instead of rubber and tea is likely to be very feeble. I have listened with very great interest to the discussion which has taken place to-day and I should like in the first instance to congratulate Mr. Lord upon the very interesting lecture he has given us.

Mr. Lord, as most of you know, was for four years in British Burma as Deputy Director of Agriculture, that is to say, he was in charge of a district. As you also know, Burma is one of the principal rice producing countries in the world and Mr. Lord had exceptional opportunities to study paddy cultivation on a very extensive scale in that country. From the reports that reach me from the Head of the Department not only has he taken a keen interest in the matter of research and experiment, but Mr. Lord is an eminently practical man, which is what we want if we are going to disseminate knowledge, which is worked out in detail at Peradeniya, among paddy cultivators of the country. I have been specially interested in the cultivation and selection of hill paddy. I personally have been a rice-eater for the last 43 years in the sense that my principal meal, whenever it was available, has always been rice and also, when that was available, curry. In the early days of my service it fell to my lot to make expeditions regularly, each of which lasted as much as a fortnight, to the uninhabited forests of the Malay Peninsula in company with a large number of rice-eating Malays. The ration that each Malay requires is such that one man is required to carry the food of himself and another man for 10 days; which meant that if your baggage was to be transported and your column was not to be unreasonably large that every man who carried a rifle and every man who carried ammunition and every man who had baggage that was not edible, had to have another man. It is a sum which works out with very considerable difficulty, and as I was responsible for not starving my people to death in places where we could not get food, I had to make certain that my calculations were correct.

When we went we took nothing but rice, chillies and salt, and it is extraordinary, when a man has been walking all day, what enormous quantities of rice, flavoured only with chillies and salt, he is capable of consuming. We used to take a few cartridges of dynamite with us and we used to sometimes put a charge into a hole in a stream and get some fish in order to vary our monotonous diet of chilly and salt. That is quite irrelevant, but what I was going to say is that being a rice-eater all my life—I have been a rice-eater since seventeen—and I have exercised a good deal of discrimination in the rice which I consumed and as in the Malay Peninsula, so also here, the only rice I admit to my house is hill-grown rice from the chenas, specially selected for me by some of my friends, the Chief Headmen Anyone who is a real rice-fancier knows that the most palatable rice that he can get is the rice from a chenaed hill, and I think that the Dissawe will bear me out that this is the experience of most of us.

I was astonished to learn that during the rice shortage here some of our town-bred young Ceylonese gentlemen found that they could not eat hill-grown rice. I can only tell them that their tastes had become shockingly vitiated—(laughter)—very like that of one who had been used to tin butter for a number of years declaring that fresh butter was obnoxious.

I would emphasise again the very great importance to be attached to the question of disseminating improved seed for paddy cultivation throughout the Island. I know of no activity of the Department, which is in my judgment more important than the work which it is doing in this particular line.