"A REPORT ON AN INVESTIGATION INTO THE METHODS OF DRYING AND STORING RICE ADOPTED BY PEASANT CULTIVATORS IN THE ST. AUGUSTINE - STREATHAM LODGE DISTRICT: INCLUDING A PRELIMINARY EXPERIMENT ON THE EFFECT OF DURATION OF STORAGE UPON GRAIN BREAKAGE DURING MILLING."

By

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**CONTENTS.**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fore-word</td>
<td>4</td>
</tr>
<tr>
<td>Terminology</td>
<td>4</td>
</tr>
<tr>
<td>Introduction</td>
<td>5</td>
</tr>
<tr>
<td>World Production and Waste</td>
<td>5</td>
</tr>
<tr>
<td>Rice Production and Consumption in Trinidad</td>
<td>5</td>
</tr>
<tr>
<td>Storage, Milling, and Distribution in Trinidad</td>
<td>6</td>
</tr>
<tr>
<td>The Problems Involved in Storing Rice</td>
<td>6</td>
</tr>
<tr>
<td>1. Mould Development</td>
<td>6</td>
</tr>
<tr>
<td>2. Insect Infestation</td>
<td>7</td>
</tr>
<tr>
<td>3. Attack by Vermin</td>
<td>8</td>
</tr>
<tr>
<td>4. Breakage of Rice</td>
<td>8</td>
</tr>
<tr>
<td>a. Breakage During Milling</td>
<td>8</td>
</tr>
<tr>
<td>b. Breakage Before Milling</td>
<td>8</td>
</tr>
<tr>
<td>c. Parboiling</td>
<td>8</td>
</tr>
<tr>
<td>Objects of the Survey</td>
<td>9</td>
</tr>
<tr>
<td>Part 1. The Methods of Drying and Storing Paddy Adopted by Peasant Cultivators</td>
<td>10</td>
</tr>
<tr>
<td>A. The Survey Area</td>
<td>10</td>
</tr>
<tr>
<td>1. Agricultural Background</td>
<td>11</td>
</tr>
<tr>
<td>2. a. Climate</td>
<td>11</td>
</tr>
<tr>
<td>b. Topography</td>
<td>11</td>
</tr>
<tr>
<td>c. Soils</td>
<td>11</td>
</tr>
<tr>
<td>d. Drainage</td>
<td>12</td>
</tr>
<tr>
<td>e. Land Utilization</td>
<td>12</td>
</tr>
<tr>
<td>f. Communications</td>
<td>12</td>
</tr>
<tr>
<td>2. Rice Cultivation in the Survey Area</td>
<td>12</td>
</tr>
<tr>
<td>a. Size of Holdings</td>
<td>12</td>
</tr>
<tr>
<td>b. Cropping</td>
<td>13</td>
</tr>
<tr>
<td>c. Yields</td>
<td>13</td>
</tr>
<tr>
<td>B. Methods Used in the Investigation</td>
<td>13</td>
</tr>
<tr>
<td>C. Findings of the Investigation</td>
<td>15</td>
</tr>
<tr>
<td>1. Preparation for Storage</td>
<td>15</td>
</tr>
<tr>
<td>2. The Storage Period</td>
<td>18</td>
</tr>
<tr>
<td>3. Preparation for Milling</td>
<td>20</td>
</tr>
<tr>
<td>a. Drying before Milling</td>
<td>20</td>
</tr>
<tr>
<td>b. Parboiling in the Survey Area</td>
<td>21</td>
</tr>
<tr>
<td>Discussion and Conclusions</td>
<td>22</td>
</tr>
</tbody>
</table>
CONTENTS CONTINUED.

Part 11. Report on a Preliminary Test of the Effect of Duration of Storage Upon Rice Grain Breakage During Milling

A. Methods Adopted for the Experiment

B. Procedure and Results
  1. Collection of Samples
  2. Preparation of the Samples for Milling
  3. Milling
  4. Analysis of Breakage

C. Discussion

Summary

Acknowledgement

References

Appendix 1. Monthly Rainfall at the Imperial College from 1944 to 1953

Appendix 2. Questionaire used at Interviews with Peasant Cultivators

INDEX TO FIGURES.

Figure 1. Map showing the Position of the Survey Area
Figure 2. General Map of the Survey Area Facing p. 10
Figure 3. Map showing the Distribution of Soil Types in the Survey Area
FOREWORD.

The drying and storage of rice cultivated by peasants is a subject upon which little detailed work has previously been carried out in Trinidad. This survey is intended simply as a preliminary study of the subject, to show the scope of the methods used and problems involved, before any comprehensive investigation is undertaken.

It was inevitable that this work should be somewhat limited, both in the period over which the investigation could be conducted and in the area covered. It would therefore be unwise to apply the results obtained to all rice stored in the island without a more extensive study of the subject. It is believed however that the information and experience derived will prove of value in later work.

Terminology.

The nomenclature used throughout the paper is based on the recommendations made by the International Rice Commission of the Food and Agricultural Organisation of the United Nations which have been adopted by the United Nations Conference especially in Reference to the Control of Insect Damage to Rice (F.A.O. 1949). The following list is an abbreviated version of the one referred to, containing only the terms occurring in this paper.

Stalk Paddy: Unthreshed rice in the husk, harvested with part of the stalk.

Paddy: Rice in the husk after threshing.

Husked Rice: Rice from which the husk only has been removed, the grain still retaining the bran layers and most of the germ.

Home Pounded Rice: Rice from which the husk, germ, and bran layers have been partially removed without the aid of machinery.

Milled Rice: Rice from which the husk, germ, and bran layers have been substantially removed by power machinery.

Attempts are being made to increase rice production with the ultimate aim of making the island self-supporting in regard to this commodity. Several irrigation schemes have been instituted by the Government since the beginning of the war, notably at Bojacal, and a
INTRODUCTION.

World Production and Waste.

The importance of rice as the largest crop produced to feed a rapidly increasing world population is well known. In recent years a concerted effort has been made by world organisations and by individual governments to increase production of this commodity still further; as a result, estimates of world production since the war show that both the rice acreage and yield are rising, especially in the main consuming areas of Asia where the need is greatest. Increases however are also reported from European and African countries and from the New World; many countries which previously imported rice are now striving towards self sufficiency at a time when the indications are that world demands for this staple food will grow, and prices rise. In 1953 it is estimated that the record crop of 357,000 million lbs of paddy was harvested (U.S.D.A. 1953).

When such efforts are being made to increase world food production, it is important that steps are also taken to ensure that losses to the commodities concerned after harvest should be reduced to a minimum. The Food and Agricultural Organisation of the United Nations has done much to draw attention to the importance of avoiding waste, especially in the case of rice. According to one estimate made in 1948 (F.A.O. 1948), more than 22,000 million lbs. of paddy are lost annually due to insect and rodent infestation during storage, faulty storage methods, wasteful milling and wasteful methods of household preparation. If this enormous figure could be reduced by only 10 per cent., 2,200 million lbs more rice would be available for human consumption, a figure approximately equal to one third of the average annual amount handled in international trade.

Rice Production and Consumption in Trinidad.

In Trinidad, where the total consumption of rice in 1952 was estimated at 57,153,600 lbs (Trinidad Department of Agriculture: 1953), home production in the same year amounted to about 25,760,000 lbs. Since rice became unobtainable from the Far East during the Second World War, imports have been supplied almost entirely by British Guiana under a trade agreement originally signed in 1947.

Attempts are being made to increase home production with the ultimate aim of making the island self supporting in regard to this commodity. Several irrigation schemes have been instituted by the Government since the beginning of the war, notably at Bejucal, and a
smaller one serving part of the district concerned in this investigation, near St. Augustine. At the present time however, the policy is to increase production chiefly by the introduction of improved varieties and cultivation practices, coupled with a gradual but steady expansion of small schemes, especially in areas of large population.

Although production has been increasing steadily, the methods of cultivation are still primitive. The crop is grown almost entirely by peasants of East Indian origin, many of whom cultivate plots of less than four acres (Jolly; 1945). The cultivation of rice in Trinidad was, in fact, initiated by East Indians brought to the island as indentured labourers on the sugar estates, the Government taking little interest in the crop until imports became difficult to obtain during the second world war.

Storage, Milling and Distribution in Trinidad.

At the present time the storage of the whole of the home produced crop is in the hands of the peasant producers and retailers. Brewin has fully investigated the milling and distribution of home produced rice (Brewin; 1952), finding that milling is undertaken with dubious efficiency by an unnecessarily large number of small operators, and that the distribution of rice produced in the island is a complex affair lacking in any sort of organisation.

The Problems Involved in Storing Rice.

Little definite information has so far been gathered concerning the methods and efficiency of rice treatment and storage by peasants between the times of harvesting and milling; it is however known that the following factors are liable to cause losses and wastage over this period.

a. The improper drying of paddy after harvest, leading to mould development and rotting of the grain.

b. Conditions that allow the paddy to become damp during storage.

c. Infestation of the paddy by insects or vermin.

d. Incorrect drying and storage technique, leading to breakage of the grains at milling.

1. Mould Development.

In order to avoid deterioration of grain due to the development of mould fungi, the moisture content of the paddy must be brought below 15 per cent. as soon after harvest as possible; further, it must be maintained below that level throughout the storage period; (H.M.S.O.1940). Mould spores, which are always present on the grain surfaces and beneath
the epidermis, germinate quickly under damp conditions, raising the temperature of the mass and eventually causing partial germination and rotting.

2. Insect Infestation.

Dampness is also known to favour the spread of insect infestations, and although paddy is believed to be more resistant to insect damage than milled rice or any other cereal grain, both the Rice Weevil (Calandra, or Sitophilus, oryzae) and the Angoumois Grain Moth (Sitotroga cerealella) are known to cause considerable damage in the United States; (Balzer and Cotton; 1947).

a. The Rice Weevil is the most common pest of stored grain, being distributed throughout most of the world. It is a small dark brown weevil about one eighth of an inch long and possessing the characteristic snout. The snout assists the adult female in burrowing holes in the grain in which she lays her eggs, after which she covers the hole with a cap. The larvae hatch inside the grain and feed on the endosperm until they pupate, and eventually emerge once more as adults. The whole cycle takes about four weeks to complete under favourable conditions.

b. The Angoumois Grain Moth lays its eggs on the surface of grain, either in the field or in the surface layers of paddy in store. The young caterpillars on hatching burrow into the grain, feeding on the endosperm in a similar way to Calandra larvae. Where infestation is severe a certain amount of webbing of the grain may occur. The pupal stage occurs near enough to the surface of the grain for the adult to push its way out on emergence.

Although the optimum moisture conditions for these insects lie above 15 per cent moisture content, they can live and multiply where the grain is considerably drier; the Rice Weevil, for example, is known to be able to live in grain which has a moisture content as low as 8 per cent. Furthermore an insect infestation produces heat and moisture within a grain bulk, so that, under conditions where their activity remains unchecked, insects may raise the moisture content of grain above the level at which fungal spores germinate. In such cases the damage caused by the original infestation will far exceed the actual depredations of the insects themselves.
3. Attack by Vermin.

Rats exist in Trinidad in large numbers, attacking all types of foodstuffs and causing considerable damage to paddy, not only by destroying it but also by fouling. Their prolific breeding habits and ability to gnaw holes through wood and other materials make them exceedingly difficult to control successfully.


The final, but possibly most important, cause of grain loss to rice cultivators, is the breakage or shattering of the grain when it is milled, which leads to wastage on cooking. Important work has been carried out by Stahel in Surinam on this subject to determine the causes of breakage; (Stahel, 1935).

(a) Breakage during Milling.

Stahel found that the bulk of rice stored in Surinam had a moisture content of about 14 per cent, but that for milling the least breakage was obtained when the eleven varieties tested were first further dried to 10 or 11 per cent; furthermore, that the paddy had to be cooled after drying in the sun or breakage was again high.

Different varieties of rice show varying degrees of breakage when milled, the longer grained types such as Skrivimankoti or Rexora being usually the most prone to breakage. It is believed that the condition known as "Abdominal White", observable as a white streak down one side of some grains after milling, is associated with a tendency towards breakage in longer grained types. It was the more easily broken types that Stahel found were most commonly grown in Surinam and accounted for the need of a further period of drying immediately before milling.

(b) Breakage before Milling.

It is also known that cracking of the grain can occur before the rice reaches the mill as a result of the sun drying process. Stahel points out that this phenomenon, known as "Sun Cracking", is due to reabsorption of water by the grain after it is dried below a moisture content of 14 per cent. It is stated consequently, that before storage, paddy should never be dried below this level. In Surinam this infers that stalk paddy should not be left out in the field for more than two days after cutting when the weather is fine.

(c) Parboiling.

It is known that parboiling of rice results in a considerable decrease in grain breakage during milling and experiments carried out in the United States have shown that the improvement is most noticeable in
the case of long grained varieties. For example, the average increase in percentage weight of whole grain in all samples of Fortuna and Rexora varieties was 29.7% and 25.2% respectively; (Jones and Taylor, 1935).

The process of parboiling originated in the Far East as a preparation of rice for human consumption. Parboiling is carried out before milling when the rice is still in its husk, being always immediately followed by a drying period in which the grain is restored to the desired moisture content for milling. Methods vary appreciably in different parts of the world, but according to Jones and Taylor, the usual procedure is to soak the paddy, or rough rice, in cold, warm or hot water for 20 to 96 hours, after which the water is drained off and the rice steamed until the hulls begin to open slightly. In a later paper Kik stresses the great variation in methods used, (Kik, 1945), and refers to a process used in Southern India where the rice is soaked in water for 12 hours, and then put in earthenware vessels with about one part of water to three parts of rice and heated on a slow fire until the grains burst.

The effects of parboiling, in addition to loosening of the husk and improved milling quality, have been well summarised by Kik. It suffices to mention here only that the nutritive value of the rice as a human food is increased by the treatment.

Objects of the Survey.

1. To discover the methods used by peasant cultivators to dry and store the rice grown on their holdings.

2. To obtain some indication of the efficiency of these methods and the causes of loss or deterioration to the grain during the storage period.

3. To obtain as much general information as possible relevant to the preservation of rice after harvest by peasants in Trinidad, so that suggestions for improvement can be made, or to form the basis of any subsequent full scale investigation.
Figure 2. General Map of the Survey Area.

- **Provision Crops**
- **Rice-Fields**
- **Sugar Cane**

**Legend**:
- **Hard Roads**
- **Old Tracks**
- **House Mill**

**Scale**: 12 chains = 1 inch.
PART I. THE METHODS OF DRYING AND STORING PADDY ADOPTED BY PEASANT CULTIVATORS.

A. The Survey Area.

The area chosen for this investigation lies in the St. Augustine-Streatham Lodge district, on the South side of the Churchill-Roosevelt Highway and about seven and a half miles from Port of Spain. (See Figure 1.) An important reason for this rice growing district being selected lies in the fact that it is but half a mile from the Imperial College of Tropical Agriculture.

The extent of the area over which the survey was conducted is some three square miles. This includes about 130 houses with their adjoining plots of land and, to the South of these, the rice fields. The map given in Figure 2 shows the general layout, position of houses, and broad outline of land utilisation in the area.

Figure 1. Map showing the position of the Survey Area.
1. Agricultural Background.

A considerable amount of work has already been carried out by members of the College on peasant agriculture in this district. For detailed information on the environmental conditions and cropping the reader is therefore referred to a number of Students' dissertations, (Macdonald 1950, Horchim 195x, etc.). In this report it is intended to give only a brief outline of general agricultural conditions in the area.

a. Climate.

The climate is typical of the North West part of Trinidad, there being a marked dry season from January to April in most years. A table giving rainfall figures at the Imperial College over the last ten years appears in Appendix I.

b. Topography.

The survey area lies on the North side of the flat plain which forms the Caroni basin. Whilst the topography of most of the area is flat, and only a few feet above sea level, there is a slight tendency for the ground to rise as the Churchill-Roosevelt Highway is approached from the South. The slopes of the Northern Range rise steeply about one mile to the North and the edge of the Caroni swamp lies three miles to the South West.

c. Soils.

The Metamorphic rocks of the Northern Range form the parent material of the soils, these being derived from alluvial deposits washed down and subjected to water sorting on the plain below.

Figure 2. Map showing the Distribution of Soil Types in the Survey Area.
Generally speaking the soils along the Northern side of the area are more sandy, giving rise to such types as St. Augustine Loam, Golden Grove Sandy Loam and River Estate Sand; it is in this part that most of the houses have been built and most of the vegetable crops are grown. Towards the South where the land stretches into the Caroni Basin itself, the soils become heavier and more suited to rice cultivation; the types found here are Pasea Clay, NonPlaisir Heavy Clay and Cunupia Clay. (See Figure 3.)

d. Drainage.
The drainage properties of these soils vary widely, the lighter types being more free draining than the heavier rice land soils, which are distinctly impeded. Surplus water drains off the area from the North towards the Caroni River, which flows a few hundred yards to the South of the area. In wet periods the river is liable to flood and the whole area may be inundated.

e. Land Utilisation.
Almost all the inhabitants of the area are of East Indian origin, and the vast majority cultivate small areas of land varying from \( \frac{1}{2} \) to two acres near their houses. In most cases this is land which is not suitable for rice growing, the main crops being sugar, sweet potato, maize, pigeon pea, egg plant and cassava. A wide variety of other vegetables are also grown, but cultivation, in most cases, is aimed at keeping the family supplied with provisions; the number of cultivators who set out to grow produce for sale is small. In addition to this, most families rent or own a small area of rice land, but again the object of the majority is self sufficiency in rice rather than the production of a marketable product.

f. Communications.
The area of the survey is readily accessible by both main road and railway. The rice fields themselves however, are served only by mud cart tracks running down from the village; these become virtually impassable to wheeled traffic during wet weather, a factor which often presents a problem at harvest.

2. Rice Cultivation in the Survey Area.
Again it is not intended to dwell at length upon this subject, but to give only a brief outline of the system of cultivation. Several investigations of rice cultivation have been made previously, and the reader is referred to these should more detail be required. (Haughton, 1947 and Macdonald, 1950).

a) Size of Rice Holdings.
It was found that the size of holdings cultivated by 20 peasants interviewed varied between \( \frac{1}{2} \) and 1\( \frac{1}{2} \) acres. Within this range 11 holdings were of \( \frac{1}{2} \) an acre, and 6 of one acre or more.
b) Cropping.

One crop is planted during the year, this being sown between June and August, and, after transplanting, harvested between November and January. Some of the peasants who cultivate on irrigated land, also take a ratoon crop in years when the rice plants make a good recovery after harvest; yields from this however are usually small and many growers do not consider the practice worth while. On land which depends only on the rainfall for irrigation, a ratoon crop is usually cut of the question; in such cases many peasants grow provision crops of vegetables on their rice plots during the dry season.

c) Yields.

On being questioned, peasants gave their yields as varying between 16 and 28 Barrels per acre (of 2,400 to 4,200 lbs of paddy) in a good year, whilst in a bad year the yield varied from 4 to 20 Barrels (600 to 3,000 lbs).

It should be pointed out that these yields are calculated on the basis of "Tins" of paddy, there being six Tins to one Barrel. A Tin however is not a standard measure and its weight may vary slightly, although the Department of Agriculture states that tests have shown the weight to be fairly constant around a mean of 25.16 lbs. For the purposes of calculating the above figures a Tin was taken to weigh 25 lbs, and a Barrel 150 lbs.

The explanation given by peasants for so wide a variation in their yields, was that some of the land is "Bad Rice Land". On further questioning the writer took this to mean that some of the rice plots nearer the main road are on land which is beginning to rise slightly above the level of the plain; it is therefore difficult to retain water on them. It is also probable that the soil on such marginal areas is transitional between the clays of the rice fields and the loams of the higher lands.

B. Methods used in the Investigation.

1. The first stage was to make three exploratory visits to the neighbourhood in which the survey was likely to be carried out. These visits were made in the early part of December when the rice harvest was in progress, consequently the opportunity was taken to collect five samples of newly threshed paddy from different cultivators, for moisture content determination. As well as speaking to peasants in the rice fields and collecting information on their harvesting and threshing techniques, a number of houses in the village were visited in order to confirm that the majority of the inhabitants grew rice.

2. On the basis of general information obtained from these talks a
questionaire was prepared (See Appendix II.). During February and March 20 rice cultivators were interviewed at their houses, and in each case information obtained on their methods of threshing, drying and storage of rice. An attempt was also made to learn the difficulties encountered during these processes, and the causes of any loss that might occur between harvest and consumption of the grain.

At the same time each of the 20 rice stores was examined and note taken of the general condition and appearance of the grain.

3. In order to discover the efficiency of the methods employed, it was decided to take representative samples of paddy at the following stages during the storage period for moisture content and pest infestation analysis.

1) At threshing, prior to any drying treatment.
2) After four months storage.
3) After sixteen months storage.
4) Immediately prior to milling.

Had it been possible to take samples throughout the year, a more complete picture of grain condition trends during storage would have been obtained.

Since it was found that there were three distinct methods used by different cultivators in storing their rice, it was decided that the stages of storage should be further divided as follows:

a) Rice stored in Boxes.
b) Rice stored in bags.
c) Rice stored spread out on the floor.

In the collection of each of these samples grain was taken from different parts of the bulk in order to obtain a true picture as possible of its condition throughout the mass. The aim was to procure five samples from each type and stage of storage as follows:

5 samples of newly threshed rice.
5 samples of paddy after four months storage in boxes.
5 samples " in bags.
5 samples " on the floor.
5 samples of paddy after sixteen months storage in boxes.
5 samples " in bags.
5 samples " on the floor.
5 samples of paddy immediately prior to milling.

At the time of collection however it was found that very few peasants had rice left from the previous season, and that a very small minority stored their paddy on the floor. Consequently the actual samples obtained
were as follows:

5 samples of newly threshed rice.
6 samples of rice after four months storage in boxes.
5 samples of rice after sixteen months storage in boxes.
2 samples in bags.
2 samples on the floor.
5 samples of rice immediately prior to milling.

The samples were then taken to the laboratory and about 10 grammes set aside for the moisture content determinations on each. The method used was to take about 5 grammes of the sample after grinding and weighing, and to subject them to 4.5 hours oven drying at 115°C. The moisture content could then be calculated from the loss of weight on drying.

For the assessment of insect and rodent damage 200 grains were selected at random from the remainder of each sample, and after division into two lots of 100 grains each, those showing damage by insects were extracted and counted; at the same time note being taken of the numbers of live and dead insects. Following this the number of grains attacked by rodents was obtained, and finally a note made of the general condition of the grain.

4. Finally the owners of the two rice mills in the survey area were questioned on the type and condition of the grain they handle, with special reference to its breakage on milling and their views on its cause.

C. Findings of the Investigation.

As a result of interviews with peasants, personal observations in the survey area, and the quantitative work carried out, it is possible to give a general account of the handling of rice between harvesting and milling, and also to include reasonably accurate statements of the condition of the grain, within the somewhat limited scope of the survey.

1. Preparation for Storage.

At harvest time, the wet season is usually still in progress, although some cultivators try to make their harvesting period coincide with the "Petite Careme", or short drier season which usually occurs a few days before drying; there was however no sign of bud development and the cultivator stated that provided he could dry it within the next
in November. Wet weather is however generally expected, and the rice crop must therefore be taken from the fields as quickly as possible when dry days do occur. It is partly for this reason, and partly due to the danger of theft of rice from the fields after it has been cut, that the practice of 'Stooking' the rice in the field, as employed in Surinam and elsewhere, is not followed here. The general procedure is to cut the rice one day, stack it in loose heaps with all the heads pointing in the same direction overnight, and to thresh it the following day.

Threshing is usually carried out in the field unless the weather is unusually bad, when some growers say that they may bring it back to the village and thresh under cover. In either case the same method of threshing is always used; a bamboo 'table' is erected and handfuls of stalk paddy are beaten upon it so that the grain and chaff fall between the bamboo rods on to a sheet of sacking beneath.

Cleaning of the paddy is often carried out in the field before it is put into sacks and taken to the house, but again this process may be postponed until the crop is under cover. It is usually cleaned again in any case after drying, before being stored. The method of extracting chaff and other dirt from the paddy is primitive and usually carried out by the womenfolk. It consists of shaking the paddy on a wooden tray so that the wind blows away the unwanted debris and the good grains fall to a sack spread out on the ground.

Once the grain is in the house its treatment depends on how wet it is, and upon the weather during the following days. The main object is to get the paddy dry as soon as possible, so that it may be stored away until needed. If the weather at harvest was wet and the grain damp, it is immediately spread out on the floor of the living room where some wind can blow over it; this is to prevent, as far as possible, the development of mould. Usually however, the moisture content is not high enough to give rise to deterioration for a short period; in such cases the grain is allowed to remain in sacks until the weather is suitable for drying.

The samples taken from newly harvested grain, given in the table of moisture contents below (See Table 1.), were all taken in a fine weather harvest period. It was found that under these conditions the average moisture content of the paddy was about 20 per cent.

One sample of very wet grain was seen spread out on the floor of a house before drying; there was however no sign of mould development and the cultivator stated, that provided he could dry it within the next
day or two, he did not anticipate much trouble with it.

The drying of the paddy before storage is carried out by spreading a thin layer of grain on sacking in the sun. The peasant often has some difficulty in finding a suitable drying floor on his own land, and consequently the practice has developed of drying paddy on public roads. No peasant in the whole survey area was found to have a specially constructed drying floor.

The length of time for which the paddy is left in the sun depends upon its initial moisture content, and it was found that the usual duration of drying was from one to three days, provided that the weather remained good. The drying of paddy is the duty of the women-folk, and while it is in progress they must turn it every two or three hours and be ready to bring it under cover in the event of rain.

When the paddy is sufficiently dry, a point which the peasant can tell with remarkable accuracy by cracking grains with his teeth, it is put away in store until such time as it is needed for milling and consumption.

In no case did a peasant state that it was ever necessary to dry the grain a second time, in order to maintain its condition during storage; in fact the general view of all cultivators was that once the paddy had been treated in this fashion it could be kept for an unlimited number of years.

It is interesting to note the remarkable uniformity of the moisture contents of the twelve samples taken after four months storage (See Table 1.), and to correlate these with Stahel's critical figure of 14 per cent, drying very much below which, prior to storage, increases the incidence of "Sun Cracking".

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<tr>
<th>Sample No.</th>
<th>At Harvest</th>
<th>After Four Months Storage</th>
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<tr>
<td>5</td>
<td>21.96</td>
<td>14.51</td>
<td>13.84</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>13.62</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Means</td>
<td>20.09</td>
<td>13.87</td>
<td>13.76</td>
<td></td>
</tr>
</tbody>
</table>
2. The Storage Period.

Of the twenty householders interviewed, fourteen stored their paddy in boxes. This method was recognised by everyone as being the more satisfactory, chiefly because it prevented damage from vermin more successfully than storage in sacks. Where the house is built high enough, the storage box is almost invariably situated on the ground beneath, so that although it has complete cover from rain, there is free air circulation round the store.

Boxes are generally constructed specially for this purpose from boards of \( \frac{1}{2} \) or \( \frac{3}{4} \) inch thickness, no attempt being made to make cracks airtight, although in most cases the boards are close fitting. The shape and size of such stores varies according to the acreage of rice grown, and cannot be said to conform to any standards. In most cases the lids or coverings are virtually non-existent, and at best, form only a shelf on which household articles are kept. It is usual for the boxes to be raised some six inches above the ground on stones or blocks of wood.

The remaining six families stored their grain in thick hessian sacks, but two of these had a considerable proportion of their paddy stored on the floor of a loft in a layer about six inches deep. It was found that in both these cases the paddy was soiled and showed considerable evidence of damage by rats.

The examination of the rice in store on a qualitative basis showed that in all cases it was surprisingly dry and free from severe insect attack. No insects were in fact seen, and the only damage to grain seemed to have been caused by vermin. The paddy in six of the stores however was found to be dirty, but this was stated by the owners to be due to the crop being layered before harvesting, and to have no ill-effect on the milled sample.

The results of the quantitative determinations on samples collected showed that, with only one exception, the moisture content of all stored paddy is maintained at a perfectly satisfactory level. In the case of a sample taken from sixteen month old paddy which had been stored on the floor, the moisture content was found to be 16.16 per cent. This must be recognised as too high a figure for safe storage, and although there appeared to be no significant mould development, some webbing of the grain had occurred and one dead specimen of *Sitotroga cerealella* (Angoumois Grain Moth) was discovered in the sample taken.
The figures in Table 2, show the percentage number of grains damaged by insects and vermin in the samples analysed. From these, it can be seen that insects probably do not cause a significant amount of damage to peasant stored paddy in this area. This is borne out by statements made by the cultivators, who say that they are very seldom troubled by infestations, and then only when they have wet grain on their hands during a period of weather which prohibits drying.

Table 2. Percentage Number of Grains Damaged by Insects and Vermin in Samples Taken at Two Stages, and Under Three Methods of Storage.

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>After four months storage</th>
<th>After sixteen months storage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In Box</td>
<td>In Bag</td>
</tr>
<tr>
<td></td>
<td>Insects, Vermin</td>
<td>Insects, Vermin</td>
</tr>
<tr>
<td>1.</td>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
<td>2.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4.</td>
<td>1.0</td>
<td>3.5</td>
</tr>
<tr>
<td>5.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6.</td>
<td>0.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>

It appears that the chief cause of loss during storage is due to the activity of rats. The majority of peasants said that they were troublesome both in soiling grain and in their feeding; the figures in Table 2, bear this out to a certain extent, although over half the samples taken showed no sign of vermin damage.

On being questioned concerning the steps they were taking to reduce damage by vermin, the cultivators became vague. A few make an effort to trap rats and most of them keep cats for the purpose. Poison bait is not generally used and storage boxes are still left open at the top. In the one case recorded where vermin damage was severe, there seemed to be no marked difference between the storage box used and those of other householders; the owner kept no cat, but he was not exceptional in this.

The length of time for which paddy is stored varies, as it is taken from store in small lots for milling and consumption, according to
The demands of the family. Less than half the householders said that the rice they grew satisfied their demands every year, but it was common to find that after a good crop their stocks lasted well into the following year; under these circumstances the storage period lasts up to about eighteen months.

Only three cultivators said that they sold rice regularly, and one stated that he sold it when he had a surplus; the remainder denied any suggestion that they ever parted with any of their rice. It is unusual for rice to be sold before it is milled; the four who marketed their produce much preferred to have it milled first, and then to sell it privately.

3. Preparation for Milling.

a) Drying Before Milling.

Before the paddy is milled it is first dried again in the sun in a similar way to that employed in the original drying period; if this is not done, severe shattering of the grain occurs during milling. Peasants realize that the proportion of broken grain that they get back from the mill is partly dependent on the way they treat the paddy in this final drying period, they are usually careful therefore to ensure that it is dried to exactly the right degree. They judge this by again cracking grains in their teeth, rubbing them between their fingers, and also by twisting their bare heel on paddy as it lies out to dry. When the grain cracks cleanly and can be shelled out by rubbing, it is judged fit for milling. The peasants also state that care must be taken not to over-dry the paddy at this stage, as this will again increase breakage. Finally before taking it to the mill, they allow the paddy to cool, some leaving it overnight and taking it to the mill the following morning.

The average moisture content of the five samples taken after this drying period was 11.24 per cent; it is however probable that, with adequate cooling, drying down to 9 per cent would not impair the milling quality.

In carrying out a small scale test on samples of paddy provided by peasants, the writer found the rate of drying on a hot sunny day to be surprisingly rapid. In 4½ hours during the morning the samples lost an average of 4.54 per cent moisture content; a drying rate of over 1 per cent per hour. (See Table 3. Page 25). It was also found comparatively easy to tell when the grain was dry enough, using the peasants' methods.

It is the general practice amongst householders to take only as much paddy to be milled at one time as will keep the family supplied for two or three weeks. In most cases this entails milling in batches of about 25 lbs, (or one 'Tin').
b) Parboiling in the Area.

Parboiling is sometimes employed as a preparation to milling, partly because the peasants prefer the flavour of the product, and partly because the breakage in milling of parboiled paddy is considerably less. Three out of the twenty peasants interviewed were found to parboil regularly, whilst a further four said that they sometimes did; it does not, therefore, appear to be the practice of the majority.

The method of parboiling used in the area is extremely crude. A tin containing three parts of paddy to one of water is heated over a slow fire for about 12 hours without boiling; some of the water is then poured off and the remainder boiled until the husks of the grains begin to burst. The paddy is then spread out to cool and dry in the sun in the ordinary way; a process which may take as long as two or three days before the moisture content is near the desired 10 per cent level.

It is believed that this method of parboiling may lead to some fermentation of the grain during the process, a factor which may be responsible for the unpopularity of parboiled rice in the area.

In the course of conversation with the rice cultivators, the writer found a commonly accepted opinion to be that rice, which had undergone a longer period of storage, was less liable to crack on milling, than paddy milled shortly after harvest. As this factor is not included in Stahel's report on the causes of breakage, it was decided that a brief test might prove worth while. This was carried out, and a report is included as Part 2. of this paper.
DISCUSSION AND CONCLUSIONS.

There can be little doubt that the findings of this survey have been more favourable than was previously expected. Losses of grain due to insect infestation and dampness during storage were found to be negligible, whilst the damage caused by rats in the majority of cases was not great.

It is felt however, that vermin are a greater potential threat to stored paddy in the survey area than is apparent from the results obtained. In order to overcome this problem it is suggested first, that all peasants be encouraged to store their paddy in boxes rather than sacks, and that floor storage be especially discouraged. Furthermore, simple modifications to the boxes already in use, such as the provision of tight fitting lids and the blocking of gaps in the boarding, would, if maintained, do much to prevent the entry of rats. Ideally boxes lined with rust-resistant metal sheeting might prove the ultimate answer to the problem, and where vermin damage is considerable the cost would probably prove worth while.

It is the writer's opinion that, in this area, vermin would be more successfully controlled by such modifications to the stores themselves, rather than by resort to poisons and traps. It is also felt that the peasants would be more willing to take the necessary steps to improve their stores, then they would to face the cost, and co-operation, entailed in a widespread poisoning programme, unless this was desirable for reasons apart from rice storage.

From any other viewpoint it would be difficult to dispute the efficiency of the methods employed in this area for drying and storing paddy, as they appear this year. There can be few systems by which grain is dried more cheaply, or stored more successfully. It is possible however that a more detailed investigation into the extent of losses in a really wet harvest period might reveal a weakness in the system. In such a season much paddy might well be harvested wet, and if sun drying was virtually impossible for a prolonged period, damage to the grain would be great.

Although peasants do not report any loss of paddy while it is drying on roads, it is felt that that there must be occasions on which the grain is scattered by passing vehicles. It would undoubtedly be better if cultivators could be persuaded to construct their own drying floors; these could then be used for sun drying other locally grown crops in addition to rice, and the roads would be left unobstructed. The writer however, does not believe that this could be achieved without some form of legislation against the use of roads for drying.

Finally it should be pointed out to peasants that because of the risk of moisture reabsorption after the second drying period, it may be unwise to keep paddy overnight before milling.
PART II. REPORT ON A PRELIMINARY TEST OF THE EFFECT OF DURATION OF STORAGE UPON RICE GRAIN BREAKAGE DURING MILLING.

As previously stated, it was found during the course of the survey, that a number of peasants held the view that the longer paddy is stored, the better the milling quality becomes, in that breakage of the grain during the hulling process is reduced. It was decided that a simple test might reveal whether there were any grounds for this belief.

A. Methods Adopted for the Experiment.

As the two stages of paddy in store that were readily available at the time were grain that was four and sixteen months old, it was decided to make a straight comparison of breakage during milling between five samples of each of these two groups.

It was thought that paddy should be obtained from the peasants themselves for this purpose, rather than from the College Farm, where cultivation and storage practices are somewhat different. Further it was decided to use one of the mills in the survey area for the tests, as it was presumably upon the basis of samples milled there, that the belief had sprung up. In order to ensure that such a mill could be used for the experiment, a visit was made to one of the millers, and his co-operation having been enlisted, a trial run was carried out. The result was satisfactory, it being found that about 5 lbs of paddy were needed to allow the mill to deal with each sample properly. The type of mill used was a McKinnon No. 4. Huller, driven by a single cylinder diesel engine. The cleaning out of the huller after a trial sample had passed through was found to present no difficulty.

1. Collection of Samples.

In collecting the samples from the ten households every effort was made to ensure that they were as alike as possible in respect to moisture content, general condition, and date of harvesting within each of the two groups. Rice grown in the area cannot be said to conform to
any single type or variety, each grower producing a wide range of grain types. It was therefore impossible to restrict sampling to any single type of rice, but only to attempt to get mixtures as nearly similar as possible. The peasants were most willing to part with samples, refusing either payment or exchange.

From the time of collection onwards, all samples were kept in sealed 'Kilner Jars', except when being dried; this was done in order to prevent any possible changes of moisture content.

As soon as possible after collection about 5 grammes of each sample were taken for moisture content determination; the method used being identical with that previously described. The results of these determinations appear in Table 3. on the following page, and it can be seen that they all fall within a range of 1.28 per cent around the mean of 13.60 per cent moisture content.

2. Preparation of Samples for Milling.

The following day being ideal for sun drying, the samples were spread out on sacking over tarmac at 9.00 a.m. During the course of the morning they were turned every hour and tested by biting and rubbing. Most of the samples seemed to be sufficiently dry after 4½ hours, and these were replaced in the jars. The remainder were left until judged to be in a similar condition, when they also were returned to the laboratory.

Moisture content determinations carried out on the samples after drying (See Table 3.) show the narrow range to have been maintained at 1.17 per cent, but there appears to have been a slight tendency to overdry. This was not however judged to be sufficient to justify a repetition with fresh samples, but it was decided to leave the grain in sealed glass jars until the following day, in order to allow it to cool completely.


The following morning the samples were taken to the survey area and milled. In each case the first grain coming from the mill chute was discarded, and it was not until the grain was flowing evenly that a small jar of the milled sample was collected and sealed. The mill was thoroughly cleaned out between each sample.
Table 5. Results of an Experiment, using ten Samples of Paddy divided into Two Treatments, to find whether Duration of Storage Affects Grain Breakage at Milling.

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Initial Moisture Content</th>
<th>Moisture Removed</th>
<th>Separation after Hulling</th>
<th>% Wt. of Brewers Grains</th>
<th>% Wt. of Broken Rice</th>
<th>% Wt. of Whole Rice</th>
</tr>
</thead>
<tbody>
<tr>
<td>RICE STORED FOR FOUR MONTHS</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>14.07</td>
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<td>4.90</td>
<td>1.44</td>
<td>46.37</td>
<td>52.19</td>
</tr>
<tr>
<td>2.</td>
<td>13.40</td>
<td>9.06</td>
<td>4.34</td>
<td>1.60</td>
<td>30.75</td>
<td>67.65</td>
</tr>
<tr>
<td>3.</td>
<td>15.04</td>
<td>8.72</td>
<td>4.32</td>
<td>1.71</td>
<td>25.34</td>
<td>72.95</td>
</tr>
<tr>
<td>4.</td>
<td>14.05</td>
<td>9.28</td>
<td>4.77</td>
<td>1.28</td>
<td>35.20</td>
<td>63.52</td>
</tr>
<tr>
<td>5.</td>
<td>13.17</td>
<td>8.40</td>
<td>4.77</td>
<td>1.30</td>
<td>24.17</td>
<td>74.53</td>
</tr>
<tr>
<td>Mean</td>
<td>13.55</td>
<td>8.95</td>
<td>4.62</td>
<td>1.47</td>
<td>32.37</td>
<td>66.17</td>
</tr>
</tbody>
</table>

| RICE STORED FOR SIXTEEN MONTHS | | | | | | |
| 6. | 12.65 | 8.74 | 4.91 | 6.02 | 43.31 | 50.67 |
| 7. | 13.66 | 9.57 | 4.09 | 4.08 | 45.10 | 50.82 |
| 8. | 14.23 | 8.93 | 5.30 | 2.67 | 30.31 | 67.02 |
| 9. | 13.82 | 9.39 | 4.43 | 3.34 | 21.05 | 75.61 |
| 10. | 12.95 | 9.39 | 3.56 | 3.00 | 29.15 | 67.85 |
| Mean | 13.66 | 9.20 | 4.46 | 3.82 | 35.78 | 62.39 |


After the unhusked grain and chaff had been removed from the milled samples, the remainder was divided into the three categories defined by the International Rice Commission, (F.A.O., 1949). These are as follows:

1. Whole Rice: Grains which are all greater than three-quarters of a whole grain.

2. Broken Rice: Pieces of grain smaller than three-quarters of a whole grain.


This was done by taking each sample of about 60 grammes, and after exact weighing, subjecting the whole of it to two minutes shaking on a 1/16th inch sieve. The particles which passed through the sieve
were weighed and considered as Brewers' Grains.

The remaining grains were then divided by eye into those which were greater than three-quarters of a whole grain and those which were less. Each group was then weighed, and the percentage weight of each of the three categories was calculated for each sample. The results are given in full in Table 3.

C. Discussion.

Although the results of the experiment are, on the whole, inconclusive, due to the wide range of breakage figures obtained from both groups, it can be stated with reasonable certainty that, under rice handling conditions practised in the area, it is not a general rule that the length of storage period has any effect on breakage during milling.

Possible reasons for the considerable differences in breakage between samples are as follows:

1. Lack of uniformity of hulling in the mill. Although care was taken to leave adjustments unaltered during milling, both the miller and writer were inexperienced in its use for experimental purposes.

2. Although every effort was made to obtain samples of rice which had received as nearly identical treatment as possible up to the time of the experiment, there may have been differences in time of harvesting, type of grain, or drying after harvest, which were not apparent when the samples were collected.

Should further need arise to investigate this question, it is suggested that uniform types of rice are grown and handled under controlled conditions throughout, and that a larger number of samples are milled, including replications from the same bulk. Also it would be advantageous to obtain samples at more stages during the storage period. If these conditions were fulfilled, the results could be analysed statistically, and experimental errors, especially in the milling process, eliminated.
A Brief Survey was undertaken in the rice growing area of St. Augustine to discover the means by which peasant cultivators dry and store the rice they grow. Although the methods were found to be primitive, they seemed successful, and losses between harvest and milling were slight; more damage being caused by vermin attack than by either dampness or insect infestation.

During the course of the survey, a limited number of quantitative determinations were carried out on samples of paddy taken at intervals during the storage period. The results of these show the sun-drying process to be efficient, and the storage methods good enough to maintain the grain at a safe moisture content, free from insect infestation.

Concerning the preparation of paddy for milling, the parboiling process carried out by some cultivators was investigated, and special attention paid to any means employed by peasants to reduce grain breakage during milling.

As the result of a popular belief amongst cultivators that the longer paddy is stored the less liable it is to break, a small-scale experiment was conducted in an attempt to determine the effect of duration of storage upon breakage at milling. The results of this investigation proved inconclusive.
ACKNOWLEDGEMENT.

The writer wishes to express his gratitude to Professor T.W. Kirkpatrick and Mr. M. Breese, for their assistance and advice throughout the course of this work.

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<table>
<thead>
<tr>
<th>Year</th>
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<tr>
<td>1940</td>
<td>H.M.S.O.</td>
<td>&quot;The Storage of Foodstuffs in the Colonial Empire.&quot; Colonial Office.</td>
</tr>
<tr>
<td>1945</td>
<td>Kik M.C.</td>
<td>&quot;Parboiling.&quot; Rice Journal; 48; 12.</td>
</tr>
<tr>
<td>1955</td>
<td>Stahel G.</td>
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</tr>
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<td>U.S.D.A.</td>
<td>&quot;Office of Foreign Agricultural Relations. Foreign Crops and Markets; 66 No. 9.&quot;</td>
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</table>
APPENDIX I.

MONTHLY RAINFALL AT THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE
FROM 1944 TO 1955.

(Data extracted from the Meteorological Records, Department of Soil Chemistry; I.C.T.A.)

Monthly precipitation in inches.

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<td>3.17</td>
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<td>1.34</td>
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<td>1.60</td>
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<tr>
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<td>12.61</td>
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<td>11.05</td>
<td>14.05</td>
<td>7.96</td>
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<td>6.71</td>
<td>3.35</td>
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<tr>
<td>Year Total</td>
<td>66.50</td>
<td>66.10</td>
<td>74.24</td>
<td>48.61</td>
<td>72.32</td>
<td>70.56</td>
<td>76.97</td>
<td>95.10</td>
<td>54.86</td>
<td>68.52</td>
</tr>
</tbody>
</table>

20. What is the longest time you have ever stored rice?
21. During storage, do you get any trouble from insect infestations?
22. Do weevil attack your paddy?
23. Do you ever find mould on your paddy?
24. Do you parboil your paddy?
25. What is your method of parboiling?
26. Which mill do you send your paddy to?
27. Do you usually get very much breakage of your grain when it is milled?
28. Do you give the rice any other treatment, that you haven't so far mentioned, between the times of threshing and milling?
29. How much rice do you usually sell?
30. In what form do you sell it?
31. Where do you sell it?
32. What price do you usually get for it?
33. Do you dry the paddy again before milling?
34. Are you satisfied that the methods you use are the best ones for dealing with rice after it is harvested?
APPENDIX II.

QUESTIONNAIRE USED AT INTERVIEWS WITH PEASANT CULTIVATORS

1. What Acreage of Rice do you grow ?
2. What was your yield last year?
3. What is your yield in a good season ?
4. What is your yield in a poor season ?
5. Do you ever take a ratoon crop ?
6. What is your average yield from a ratoon crop ?
7. How often do you take a ratoon crop ?
8. What is your method of threshing ?
9. How soon after cutting the rice do you thresh it ?
10. What is done with the cut rice in the mean time ?
11. When do you Clean the threshed paddy ?
12. How soon after threshing do you dry the paddy ?
13. Do you spread it out on the floor in the meantime ?
14. What is your method of drying ?
15. Do you ever need to dry the grain again, except for the final drying before milling ?
16. Do you ever spread it on the floor after drying ?
17. What is your method of storage ?
18. How long will the paddy keep under these conditions ?
19. How long do you usually store paddy ?
20. What is the longest time you have ever stored rice ?
21. During Storage, do you get any trouble from insect infestations ?
22. Do Vermin attack your paddy ?
23. Do you ever find mould on your paddy ?
24. Do you parboil your paddy ?
25. What is your method of parboiling ?
26. Which mill do you send your paddy to ?
27. Do you usually get very much breakage of your grain when it is milled ?
28. Do you give the rice any other treatment, that you haven't so far mentioned, between the times of threshing and milling ?
29. How much rice do you usually sell ?
30. In what form do you sell it ?
31. What price do you usually get for it ?
32. Do you dry the paddy again before milling ?
33. Are you satisfied that the methods you use are the best ones for dealing with rice after it is harvested ?