Solar Drying of Paddy*

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INTRODUCTION

The problem of drying paddy which has been cut during the monsoon season is widely believed to be responsible for heavy post-harvest grain losses and to detract from the financial benefit of increased "boro" and "aus" cultivation.[1] Without adequate drying the paddy is susceptible to mold growth. Further, due to the lack of dormancy in "aus" varieties, germination and sprouting can also occur shortly after cutting. To avoid these problems the paddy must be dried from 23-26% moisture to less than 14% moisture. In those regions of Bangladesh where parboiled rice is popular there is the additional problem of drying the paddy after parboiling.

The Mennonite Central Committee (MCC) has been active in the field of solar food drying since 1977. The objective of this work has been to develop village level fruit and vegetable solar drying techniques which are culturally acceptable, economically attractive, safe and efficient. Details of this work can be found in MCC reports (1978, 1979, 1980) and Clark (1976, 1980). Through this work the MCC has gained considerable year-round experience in solar drying systems, although the emphasis has not been on cereal crop drying.

During the past three years many enquiries have been made as to the suitability of these solar drying techniques for use with "aus" paddy in the monsoon season. The solar dryer used for fruit and vegetable drying (Clark, 1980) can hold only 20-30 kilograms of paddy, and the internal temperature of the dryer, 65-70°C, is reported to be too high for paddy drying. However as an adjunct to the fruit and vegetable drying program, an indirectly heated solar dryer has been sought as a way to avoid bleaching of green vegetables and fruits. A solar paddy dryer, developed at the Asian Institute of Technology in Bangkok (Exell et al, 1979) is an indirectly heated dryer of this sort. In late June 1980, the Secretary for Agriculture, Mr. Obaidullah Khan, suggested that the MCC do some work on the priority areas of solar paddy drying. Accordingly in July 1980, after contact with AIT, a solar paddy dryer was constructed near the MCC Agriculture Project Office at Maijdi, Noakhali. The purpose of this dryer was twofold: (1) to test the suitability for paddy drying under local conditions; and (2) to experiment with the modification and use of the dryer for the indirect solar drying of fruits and vegetables.

This report deals with the construction of, and operational experience with, this dryer during the 1980 monsoon season. Further experimentation with the dryer is being carried out by the MCC at the present time to determine its utility for fruit and vegetable drying.

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1 Boro is the local Bangali term for rice which is planted in January and harvested in May. "Aus" refers to rice which is planted in April-May and harvested in July-August.

DRYER CONSTRUCTION

In constructing the solar paddy dryer, plans supplied by AIT were followed with only minor modifications. This design is shown in Fig. 1, taken from Exell's paper. To construct the dryer a level and cleared site 20 feet square was selected. This site has two requirements. It must be *dry* — at least one foot above water level in the fields, and preferably higher; and it must be *unshaded* from 8 a.m. to 4 p.m. These requirements were not easily satisfied in a high rainfall, densely wooded area like Noakhali.

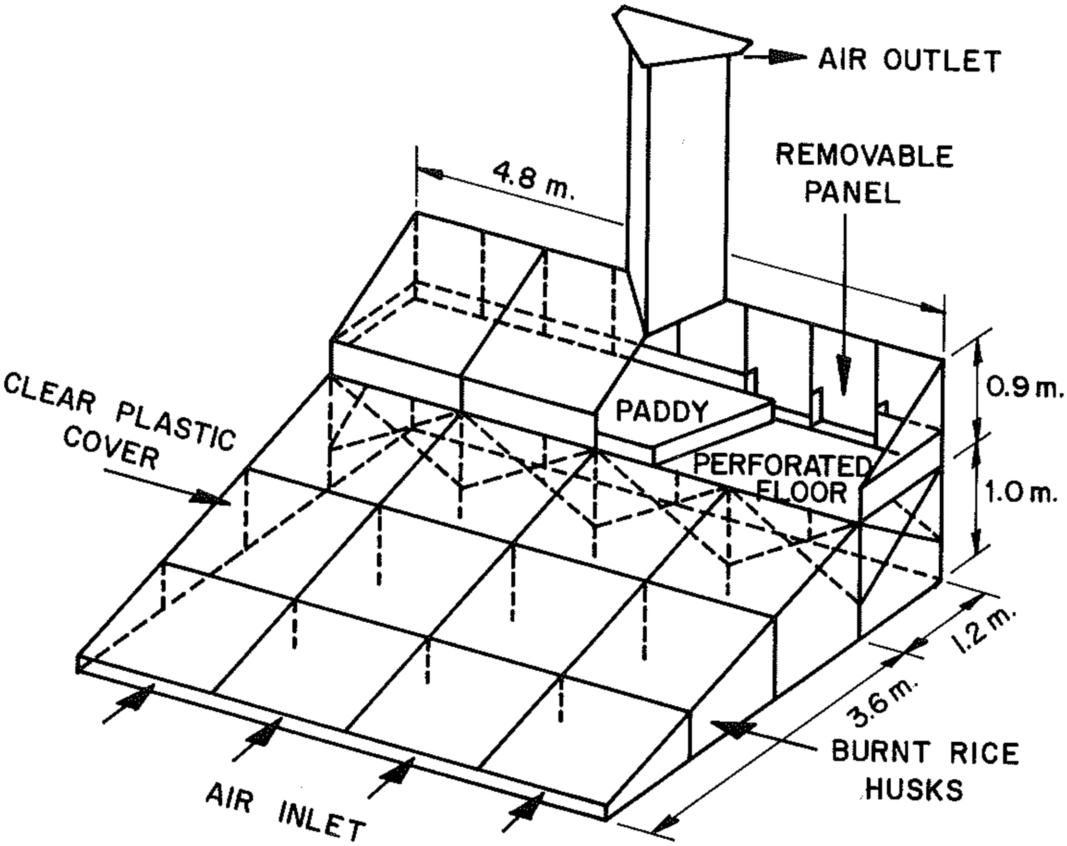

Fig. 1 The A.I.T. solar paddy dryer

The dryer required two weeks, one supervisor and three part time labourers, and US$88 to construct. No attempt was made to minimize cost, except that a woven bamboo screen was used in place of a metal screen on the floor of the paddy bed. A list of the items making up the construction cost is given in Table 1.

Table 1: Solar paddy dryer construction costs

Material:	Quantity	Cost (US$)
1) Bamboo	80 pcs "dooli"[2]	11.25
	10 pcs "boro"[3]	14.06
2) Polyethylene film (low density, 100 micron)	56 sq. meters (10.5 pounds)	10.69
3) Woven bamboo ("chatae")	4 pcs.	4.50
4) Wire, rope, cord		3.38
5) Charcoal	6 tins	1.41
Burnt rice husk	2 sacks	2.25
		Total Materials = US$ 47.54

Labour	Time (man days)	Cost (US$)
1) Dryer making	10	11.25
2) Bamboo screen making	21	23.63
3) Carrying costs		5.63
		Total Labour = US$ 40.51

Note: Bangladesh currency has been calculated at the official mid-1981 rate of 1 US$ = 17.77 taka.

The following modifications were made to AIT's original design: (1) Due to heavy rains and the less than desirable elevation of the dryer site, the ground was very wet at times. To prevent the dryer's heat from being lost in drying the underlying soil, a floor made of 100 micron clear polyethylene film was used. (2) Clear polyethylene film was used to construct the chimney as black film was not available. (3) Initially charcoal was used to blacken the floor of the dryer as burnt rice husk was not available. Later when the much cheaper rice husk became available it was used to supplement the charcoal.

DRYER OPERATION

The dryer was completed in the first week of August, past the peak of "aus" harvesting in Noakhali District. As the principal aim was to determine if the dryer was effective and to demonstrate its use to all interested parties, the offer was made to dry anyone's paddy free of cost. This was at a time when considerable paddy had not yet been dried and the weather was quite unpredictable (showers with sunny periods). The response to this offer was good. During a six week period approximately 120 "maunds" (4,488 kg)[4] of paddy were dried, mostly in 1-4 maund (37.4-149.6 kg) lots. As it was not possible to separately place more than two lots in the dryer at one time, the maximum loading was 6-8 maunds (224.4-299.2 kg), only half of the rated capacity of 13 maunds (486.2 kg). Towards the end of the six week drying program several lots of

2 "Dooli" is the local Bengali term for thin bamboo of the type generally used for woven bamboo panels.
3 "Boro", in this context, refers to stout bamboo which is used for pillars and uprights.
4 A "maund" is 37.4 kg.

parboiled paddy were also dried. Drying usually required one day (7-8 hours). Sometimes when small lots were being dried only a few hours were required, and two batches could be dried in a single day.

The response of the farmers was mixed. They were very pleased that their rice was being dried. Many of their neighbours had already lost large quantities of rice due to sprouting and mold. However, despite the losses being incurred by single farmers (as high as US$169), the dryer's construction cost, large size, and perhaps its relative novelty and complexity, seemed to dissuade most from contemplating building their own dryers.

Technically, the solar paddy dryer performed as reported by the AIT. Although no carefully monitored experiments have yet been conducted using the dryer, data obtained from other solar food drying trials conducted in the month of August are shown in Table 2.

Table 2: Typical meteorological and solar data for August

Time	Air Temp (°C)	Relative Himidity (%)	Solar Radiation (kW/m^2)	Cloud Cover (tenths)
9:00	31	90	0.32	9
9:30	30	93	0.16	9
10:00	32	83	0.52	8
10:30	31	83	0.36	8
11:00	30	85	0.10	10
11:30	31	93	0.83	7
12:00	31	86	0.49	9
12:30	31	86	0.16	9
13:00	32.5	90	0.25	8
14:00	35.5	83	0.29	7
14:30	33	80	0.37	7
15:00	32	86	0.23	8
15:30	31	93	0.29	9
16:00	31	96	0.04	9
16:30	30	90	0.12	8

Notes: (1) Relative humidity was measured by stationary wet and dry bulb mercury-in-glass thermometers.
(2) Solar radiation was measured by Model 766 Solar Meter, Dodge Products, Houston.

Integration of the solar radiation measurements shows the total radiation received during the period 9:00 to 4:30 p.m. to be 8.2 MJ/m^2. This energy is sufficient to evaporate 3.3 kg of water for each square metre of collector area. The AIT dryer has a collector area of approximately 24 square metres and thus can potentially evaporate 79 kilograms of water. In drying 8 maunds (299.2 kg) of paddy from 25% to 14% moisture content (wet basis), 41 kg of water are lost. During the drying trials in August, on a day similar to that reported in Table 2, eight maunds (299.2 kg) of wet paddy were dried. This corresponds to an overall thermal dryer efficiency of 52%, close to the 50% reported by Exell, 1979.

Several practical problems arose from constructing the dryer strictly according to the plans provided by AIT. In future dryers these problems will need to be solved.

(1) *Unloading Paddy from the Dryer* – Using a locally made bamboo screen for the floor of the dryer resulted in considerable grain being caught in the screen. To remove the grain the dryer operator had to enter the drying chamber and sweep the grain out with a broom. At 120°F inside the dryer this was a most unpleasant task.

(2) *Non-uniform Drying of Paddy* – Buckling in the floor of the dryer resulted in an uneven depth of paddy in the dryer. A stronger, flatter dryer floor is needed.

(3) *Pooling of Rainwater on the Collector Cover* – In heavy rain the plastic cover of the collector tended to sag and trap water. The more water that was trapped the greater the sagging, leading to further water accumulation. A stronger cover frame is needed.

Vandalism from children throwing stones at the dryer was not a serious problem due to the toughness of the polythylene film. The dryer, which faced south, was not affected by southerly cyclonic storm winds despite the fact that these winds reached 50 mph on one occasion.

During one sunny day when there was no paddy to dry, the dryer operator placed baskets of soaked paddy inside the dryer under the dryer floor. After one day of storage at dryer temperature (52°C) he reported that the grain had been to some extent parboiled. The report has not yet been verified by further experimentation. However, in the light of the significance of such a low temperature parboiling technique, this deserves further attention.

CONCLUSIONS

On the basis of the preliminary work reported above it can be concluded that:

(1) Solar drying of paddy during the monsoon in Bangladesh is feasible. The paddy dryer developed by the AIT is, with minor modifications, effective for this purpose.

(2) The cost of such a dryer, constructed in Noakhali District is, at most, US$90. On-going work suggests that simple modifications can reduce this cost to under US$57. Such a dryer can dry at least 8 maunds (229.2 kg) a day of wet paddy under monsoon season conditions.

(3) Farmer interest, despite the dryer's potential to reduce their risk, is not automatic. As the dryer does not directly produce additional revenue unless used for contract drying, it may be necessary to find ways that solar dryers could be used as the basis of a commercial enterprise.

RECOMMENDATIONS

In the light of the present and increasing losses of paddy due to insufficient drying capacity in the country, the solar drying of paddy should be pursued as a low-cost effective solution to this problem. To do this the following work will need to be done:

a) Test the scale sensitivity of the AIT paddy dryer. Can it be used as the basis for a 2-maund (74.8 kg) capacity dryer? A smaller dryer would be more attractive in areas where high land is at a premium.

b) Test the feasibility of using the solar paddy dryer, suitably modified, to give higher internal temperatures for drying other foods in the off-season. This would increase its attractiveness as a commercial venture.

c) Reduce the cost and, if possible, the complexity of construction of the dryer.

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Note: References 2, 4, 5 and 6 are available at the office of the MCC.