PN AAZ-823
56073

Economic Development Foundation

March 6, 1984

Mr. Laurence Ervin
Senior Energy Advisor
USAID
Roxas Boulevard, Metro Manila

Dear Mr. Ervin:

We are submitting this progress report on the project, "Development of a Low Cost Grain Dryer".

Experimental runs on the pilot dryer installed at the EDF Laboratory in Bicutan, Taguig, Rizal had been completed as of January 31, 1984. The design of the full size dryer (20 cavans capacity) has also been finalized and a brochure developed (see Appendix).

The prospects of technology transfer are very encouraging. Prospective farmer-users invited to one of the drying runs showed keen interest in the dryer. Inquiries have also been received from various parts of the country for information on the dryer.

The next step in the project - field testing - will be carried out in Tarlac and Nueva Ecija. Arrangements with farmer-cooperators are also being finalized. Hopefully, the first four units will be set up by the end of March.

Very truly yours,

CESAR N. SARINO
President

MAR 21 1984

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I. PROJECT SUMMARY

Following are the highlights of the research project to develop a simple low-cost grain dryer for small rural farmer.

A. Objectives and Scope of the Project

The project aims to develop a low-cost grain dryer which is affordable by small farmers. Such a dryer should cost lower than commercial models priced over US $1,000, is simple to operate and maintain, and its energy and other operating requirements available in the area where it will be used.

Before being introduced on a large scale, the dryer's performance will be evaluated in laboratory and field tests.

The project is estimated to be completed in 18 months starting July 1983 until December 1984.

B. Methodology

The project called for the construction of pilot model dryers and the conduct of drying runs at varying grain depth and drying temperatures to determine optimum drying conditions.

The results of these runs were compared with those of traditional sun drying. Further tests were made on the grains' acceptability for milling, head rice recovery, and germination potential. Finally, the samples from each drying run were milled using Engelberg and Stake SB-2B small-scale mills and the rice product evaluated.

C. Schedule of Activities

The schedule of activities follows:

PROJECT ACTIVITIES

I. TECHNOLOGY DEVELOPMENT (July-December 1983)

A. Design Preparation

B. Fabrication, Testing and Debugging of Test Models

C. Technology Packaging

II. FIELD TESTS (January-October 1984)

A. Phase I (First crop, January-May, 1984)

1. Selection/Cooperator of Site
2. Construction
3. Monitoring of Operation
4. Assessment and Evaluation

B. Phase II (Second crop, June-October 1984)

1. Modification
2. Monitoring of Operation
3. Assessment and Evaluation

III. TECHNOLOGY TRANSFER (June-October 1984)

1. Promotion

2. Extension Service

- o Technology Assistance
- o Monitoring

3. Assessment and Evaluation

IV. REPORT PREPARATION (November-December 1984)

Project Status

Construction of the first pilot model was started in July 1983 and the first drying run made on August 11 of the same year. All the other required runs followed immediately and were completed on November 14, 1983. Simultaneously, tests were conducted on the quality of the dried palay. All the other activities for the first model dryer (i.e., firewood-fueled) have been carried out.

Construction of the second model dryer (rice hull-fed) is expected to be finished by the end of January.

Ten (10) sites were initially identified and meetings with possible proponents started to get their reaction to the concept. Final selection of the sites is expected to be made soon; likewise, arrangements with the proponents will be firmed up.

Actual construction of the field models will start simultaneously on the second week of February and is expected to be finished by the second week of April. Field runs and evaluation of field performance will be made from March to October 1984.

II. TECHNICAL ASPECTS

This section presents the technical results of the study.

A. Basic Dryer Design

The dryer is of the induced-draft convection type. Two dryer designs were considered: one, firewood-fueled; the other, rice-hull fed. The final choice of a design will depend, of course, on the availability of the fuel material in the area.

The dryer, which has a minimum capacity of 20 cavans, consists of a furnace, an air heating element (drums or barrels) and a dryer bed.

Pilot Model

The pilot model (See Figure 1) is a firewood-fired dryer. It has a total drying area of 6.7 sq.m. (72 sq.ft.) and can hold up to 5 cavans of palay.

Adobe blocks line the outside walls of the dryer while the furnace and the chimney base are of concrete hollow blocks. Empty 200 li oil drums are used for the heater; a 4-inch soil pipe for the chimney.

The drying bed consists of a two-layered screen of 1/16 inch and 1-inch wire mesh fastened to 2" x 3" and 2" x 2" wood frames.

Drying Process

The drying process is illustrated in Figure 2.

Fuel rice hulls or wood wastes are burned in the furnace. The hot flue gas generated passes through the heater tube (empty oil drums), heating its walls, then exits at the chimney at the opposite end of the dryer.

At the base of the dryer, fresh air is inducted through small openings. On contact with the heated tube the air temperature is raised to 40-70°C. Fanned by a slight draft, the hot air moves across the grain mass absorbing moisture from the grains in the process.

The drying temperature can be regulated by varying the flow of air to the furnace and the amount of fuel and checked with the thermometer.

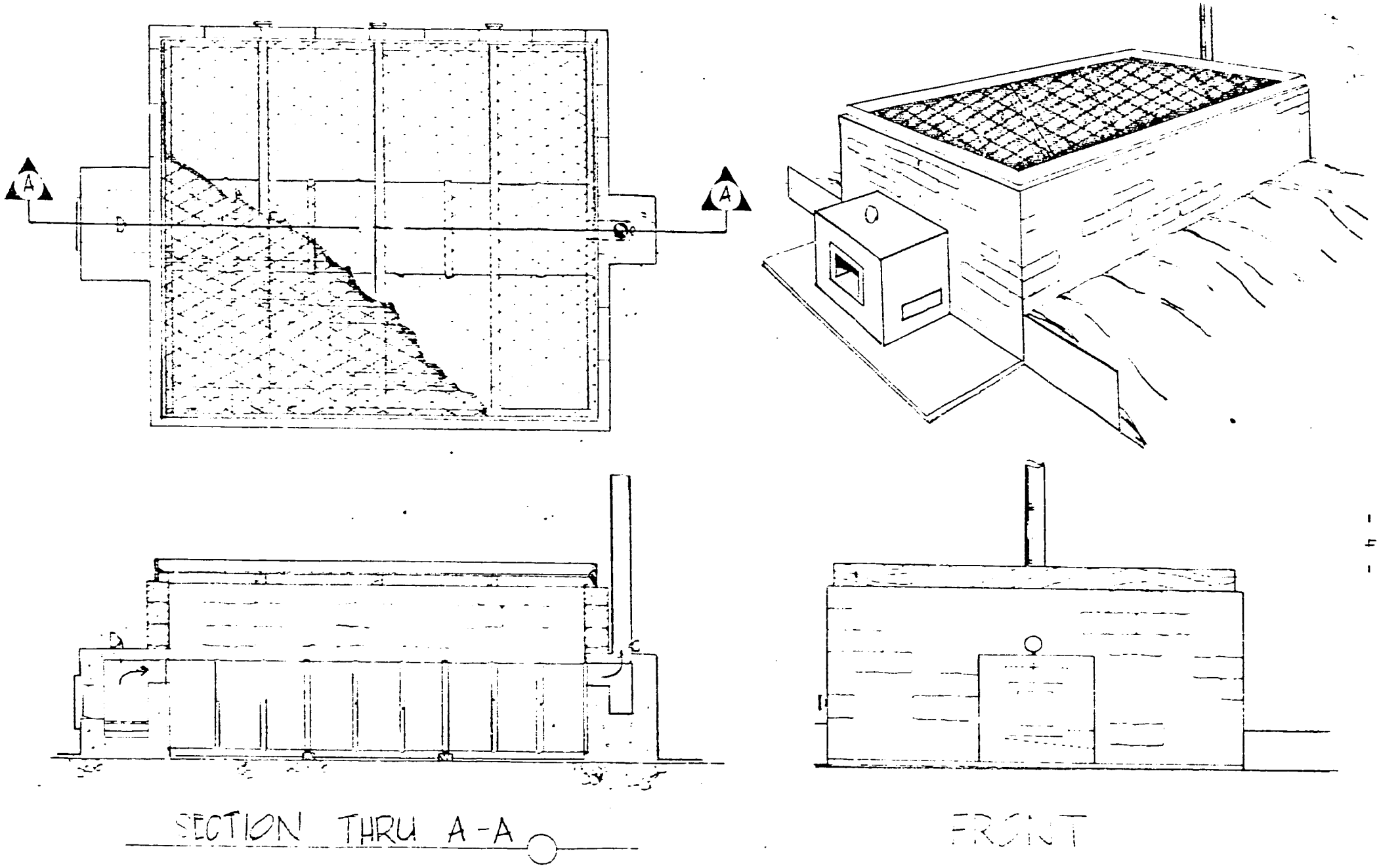
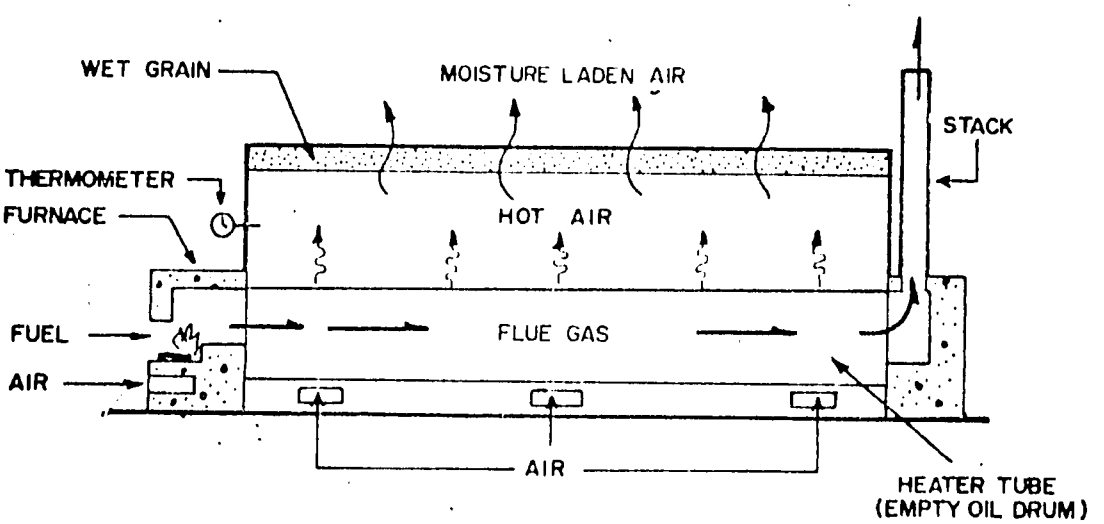


Figure 1

PILOT LOW COST GRAIN DRYER

Figure 2

SCHEMATIC DIAGRAM OF THE DRYING PROCESS



B. Pilot Experiments

The pilot experiments sought to determine the following:

-- Optimum grain depth/dryer loading
-- Optimum drying temperature
-- Drying capacity/drying cycle
-- Fuel requirement/type
-- Quality of dried palay.

1. Optimization of Grain Depth

Unlike in mechanical dryers where blowers force the heated air through the densely-packed grain mass, the pilot dryer relies only on natural draft to move the hot air across the grain mass. Because of this limitation the optimum grain depth has to be determined. (Initial estimates show that the grain depth could go up to 100 cm or 4 inches.)

2. Optimization of Drying Temperature

Drying temperature affects the drying rate in three ways:

a) Heating the air lowers its relative humidity, thereby increasing its capacity to absorb more moisture.

b) When in contact with the grain, the heated air raises the grain temperature and increases the vapor pressure of the moisture within the grain resulting in the faster movement of the moisture from grain mass to the surface.

c) Heating hastens the transfer of moisture from the surface of the grain to the heated air.

Theoretically, the higher the drying temperature the higher the drying rate will be. However, too much heat could cause thermal stress within the grain resulting in grain cracking or poor quality grain.

3. Drying Capacity/Cycle

The drying capacity/drying cycle at optimum conditions were determined.

A continuous 24-hour drying operation was considered in order to maximize the utilization of the heat built up in the dryer.

4. Fuel Requirements

Two fuel types were studied: fuel wood and rice hulls. Fuel consumption per cavan (50 kgs.) of dried material was determined.

5. Palay Quality

The following tests were conducted to determine the quality and acceptability of the dried products:

a) Milling test

-- Total milling recovery
-- Total head yield

b) Germination test

The samples from each drying run were milled on Engelberg and Satake SB-2B small-scale mills and the final product evaluated using the following formula.

The equation for total milling recovery (TMR) is as follows:

$$TMR = \frac{WHR + WBR}{W_h + W_b + WHR + WBR}$$

where:

WHR = Weight of head rice

WBR = Weight of broken rice

W_h = Weight of husk

W_b = Weight of bran

Percentage head rice recovery (HRR), on the other hand, was determined by the equation:

$$HRR = \frac{WHR}{WHR + WBR}$$

For the germination test, the percentage germination is expressed as:

$$\% \text{ Germination} = \frac{\text{No. of seeds that germinated}}{\text{No. of seeds originally soaked}}$$

In the germination tests, grain samples were taken from each run, counted and soaked overnight in water. The soaked grains were then wrapped in moist padded tissue paper and allowed to germinate for 2 to 3 days. The germinated seeds were counted and the percentage germination determined.

C. Pilot Plant Results

Fifteen (15) drying runs were conducted under the following drying conditions:

- Drying at 60°C and varying grain depth
- Drying at 50 mm. grain depth at varying drying air temperatures.

In the first set of experiments, due to the unavailability of newly harvested palay (i.e., undried), previously dried samples were used. The grains were soaked in water for two hours, drained and left overnight to simulate newly harvested condition (i.e., a 24% moisture content). This was duplicated later using newly harvested samples.

In the second part of the experiment, variation was introduced in the method of drying. The dryer was divided into two compartments: in one compartment the grain mass was turned up at intervals to expose the wet grains to the surface; in the other, the palay was left as is.

The results of the pilot experiments are as follows:

1. Effect of Grain Depth on the Drying Rate

Data gathered in the pilot runs are presented in Table 1.

Similar results were obtained in the drying characteristics of rewetted and newly harvested palay. In both cases, drying time ranged from 8 hours for thin layers of palay to over 15 hours for thick layers.

The data points were plotted in Figures 3 and 4.

Assuming a cut-off moisture content of 14% (the equilibrium moisture content), the effective drying time at different loadings were estimated. Computed results are shown in Table 2 and Figure 5.

Table 1

DRYING OF PALAY AT VARYING GRAIN DEPTH
(Drying Temperature = 60°C)

Grain Depth mm	Dryer Loading Cavans	Moisture Content,%* Initial	Final	Drying Time hrs.	Drying Rate MC/hr.
a) Rewetted (soaked)					
25	2	23	10	9	1.44
38	3	23	13	8	1.25
51	4	23	13	12	0.83
51	4	23	12	13.5	0.81
64	5	23	13	23	0.43
b) Newly harvested					
25	2	22	13	8	1.12
31	2.5	22	14	8	1.00
38	3	22	13	9	1.00
51	4	22	13.5	10	0.85
64	5	22	14	17	0.47

* For storage over several months, the moisture content should be around 14% (the equilibrium moisture content.)

Figure 3

PRELIMINARY DRYING EXPERIMENTS ON REWETTED PALAY SAMPLES
AT VARIOUS DRYER LOADINGS
(Drying Temp. = 60°C)

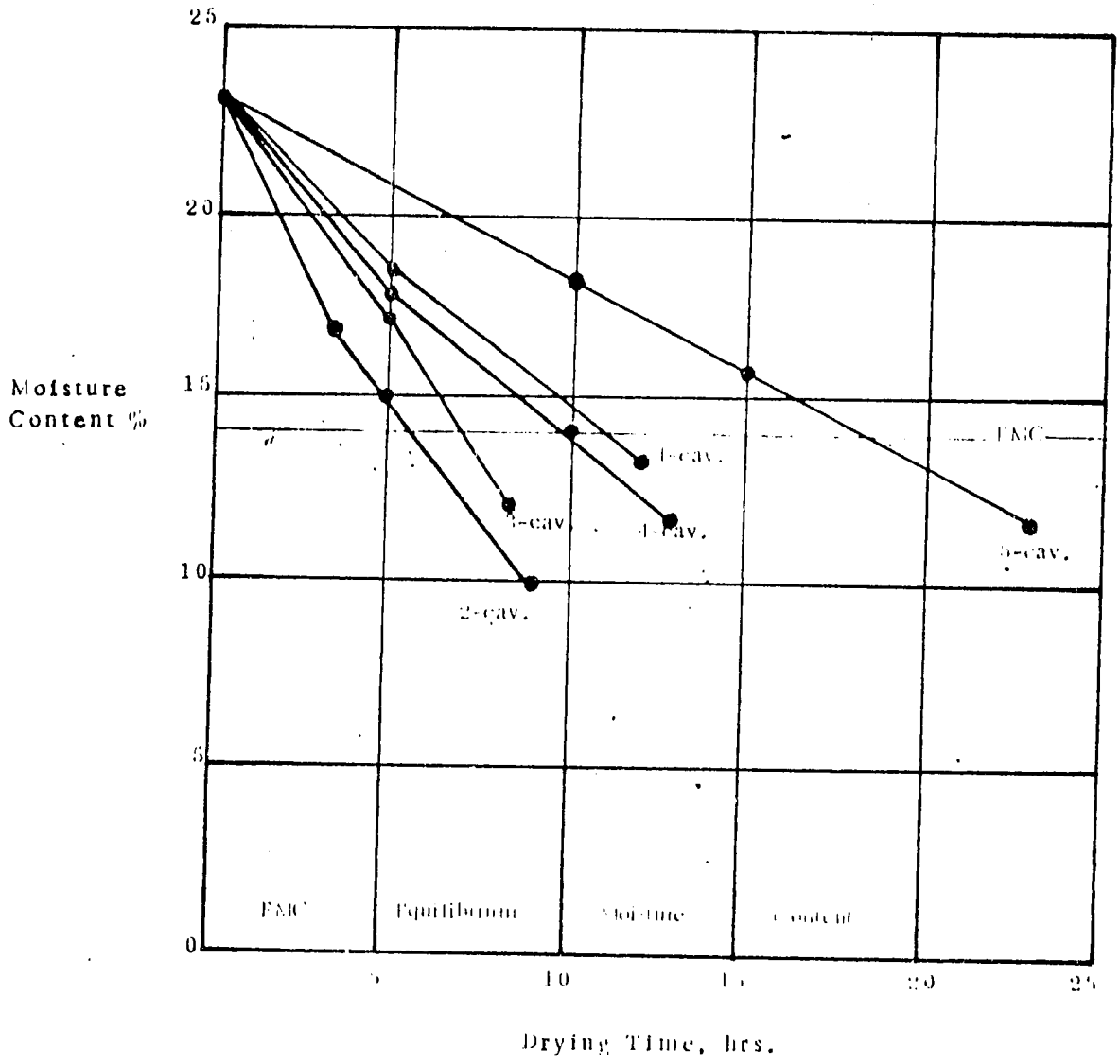


Figure 4

RATE OF DRYING OF NEWLY HARVESTED PALAY
AT VARIOUS DRYER LOADINGS
(Drying Temp. = 60 °C)

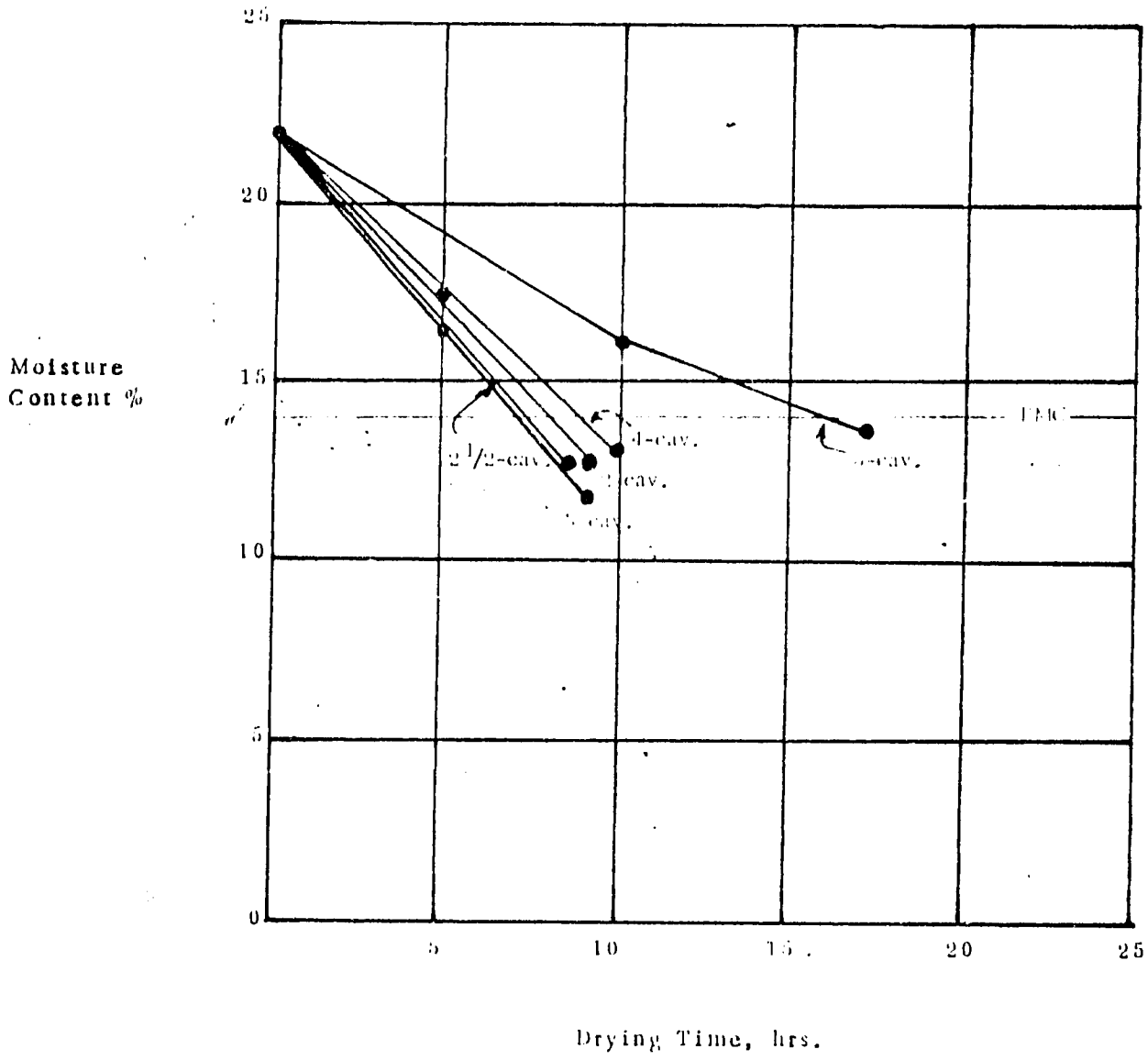


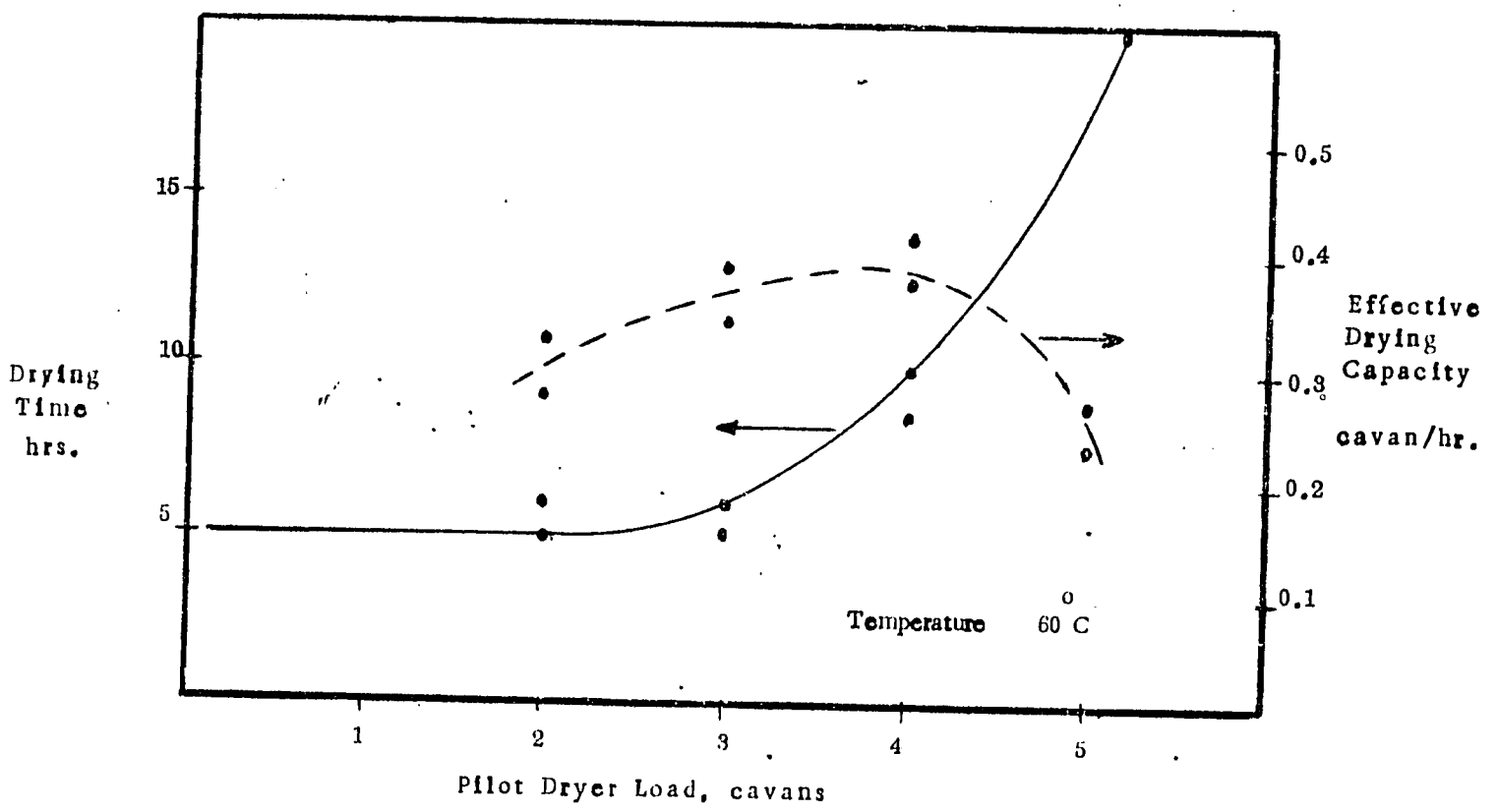
Table 2

EFFECT OF GRAIN DEPTH ON THE DRYING RATE
(Drying Temperature = 60°C)

Grain Thickness	Drying Loading Cavans	Drying Time Hours	Effective Drying Capacity, cavans/hr.
a) Rewetted (soaked)			
25	2	6	.33
38	3	7	.42
51	4	10	.40
64	5	18	.27
b) Newly harvested			
25	2	7	.28
31	2.5	6.5	.38
38	3	6.5	.46
51	4	8.5	.47
64	5	16.0	.31

Figure 5

EFFECTIVE DRYING CAPACITY AT VARIOUS DRYER LOADING



The plot (Figure 5) shows a gradually increasing time required to dry the batch of wet palay for loading up to 3 cavans. Loadings greater than 3 cavans resulted in a steep increase in drying time, reaching 20 hours for a 5-cavan load.

The effective drying capacity of the pilot plant at various dryer loadings is also shown in Figure 5. Optimum capacity is attained at 4 cavans load and a grain depth of 50 mm.

2. Effect of Drying Temperature on the Drying Rate

Pilot runs at varying drying air temperatures are shown in Table 3.

The grain depth was kept constant at 50 mm. at a loading of 4 cavans. Results confirm the earlier premise that drying rate is hastened by increasing temperature. The increase in the drying rate, however, is not proportional to the increase in the drying air temperature as there is only one hour gain in the drying with 50% increase in drying air temperature. Also increasing the drying temperature could result in grain damage. (This is discussed further in the next section.)

On the aspect turning up the grains while, drying, results showed minimal gains in the drying rate. (Effect of grain mixing on milling recovery heed rice yields and germination characteristics is discussed in the next section.)

3. Fuel Consumption

The fuel consumption for each run was also recorded to determine the drying time and the amount of fuel required.at various loads to attain the equilibrium moisture of 14%.

Table 5 gives the fuel consumption data at constant grain depth (50 mm.) and temperature (60°C).

It will be noted that the initial (2-cavan) run actually consumed more fuel than subsequent runs at higher loads because of the normally higher fuel requirement during start-up.

Table 3

DRYING OF PALAY AT VARYING DRYING AIR TEMPERATURES
Grain Depth 50 mm. (2 inches)

Drying Temperature 0°C	Moisture Content		Drying Time Hours	Drying Rates MC/hr.
	Initial	Final		
55	23	14	10	0.90
60	23	12	12	0.92
65	23	12	11	1.00
70	23	13	10	1.00
75	23	13	9	1.10

Table 4

EFFECT OF DRYING TEMPERATURE ON DRYING RATE

Temperature	Drying Time, Hrs.	Effective Drying Capacity Cavans/hr.
55	10	0.40
60	10	0.40
65	9	0.44
70	9	0.44
75	8.5	0.48

Figure 6

RATE OF DRYING OF NEWLY HARVESTED PALAY
AT VARIOUS DRYING AIR TEMPERATURES
(Dryer Load = 4 cavans)

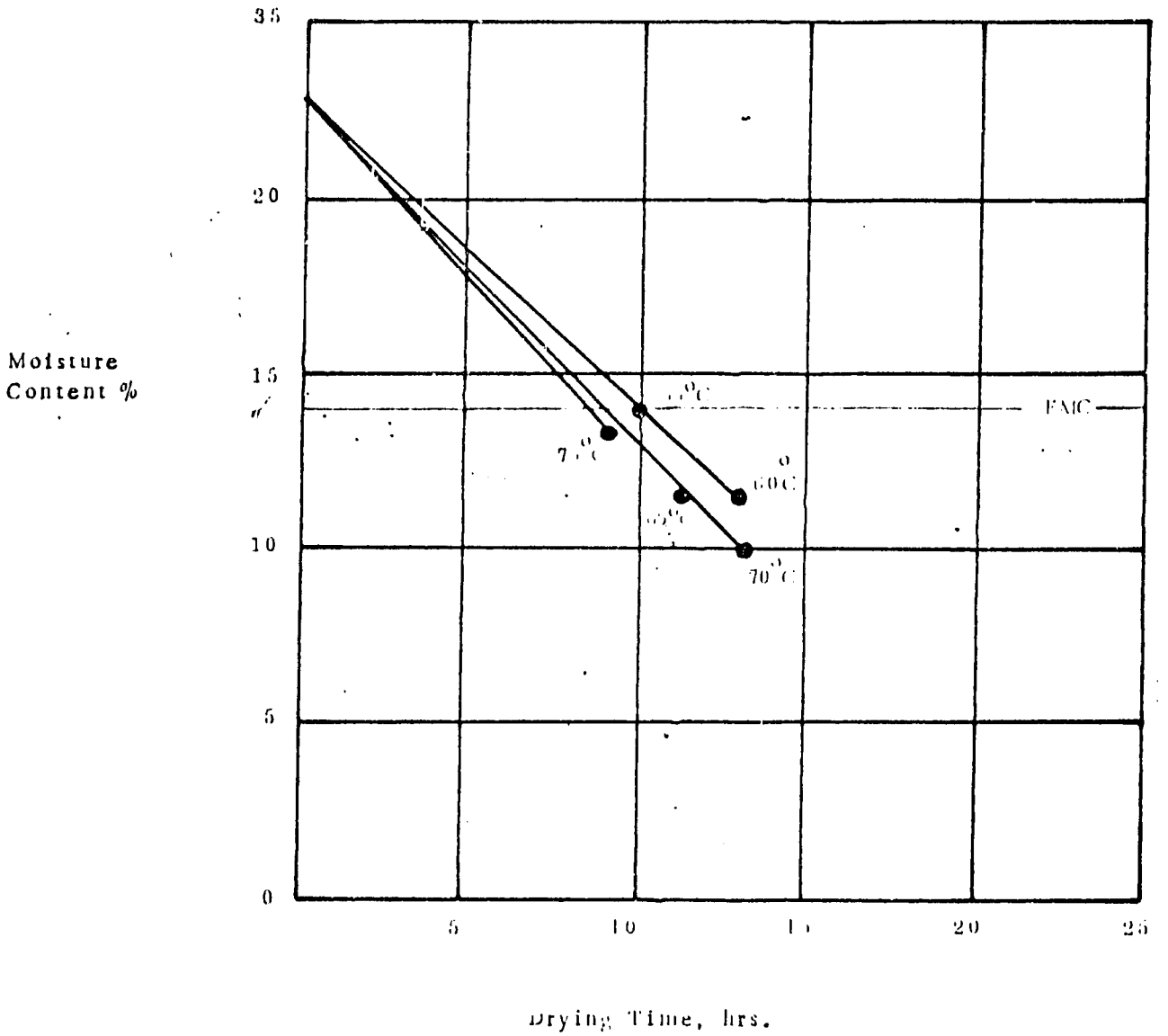


Figure 7

GRAIN DRYING TIME AT VARYING
DRYING TEMPERATURE

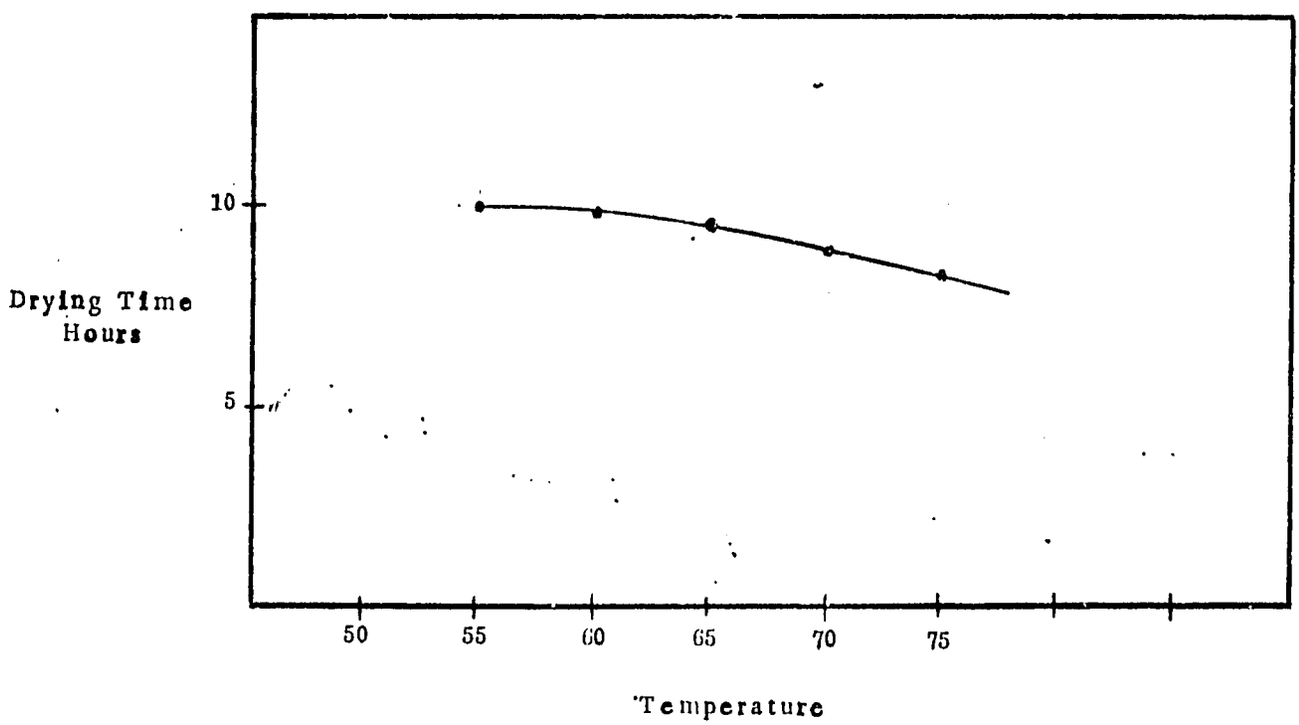


Table 5

FUEL (FIREWOOD) CONSUMPTION
(Newly Harvested Rice)

	Total Fuel Used Kgs.	Total Drying Time hr.	Fuel Rate kgs./hr.	Required Drying hrs.	Fuel Required kgs.
I. At constanttemperature (60°C)					
a) 2 cavans	44.0 kgs.	8	5.5	7.0	38.5
b) 2-1/2 cavans	39.0 kgs.	8	4.87	6.5	31.7
c) 3 cavans	43.0 kgs.	9	4.77	6.5	31.0
d) 4 cavans	56.0 kgs.	10	5.6	8.5	47.6
e) 5 cavans	75.5 kgs.	17	4.44	13.0	57.7
II. At constant grain depth (50 mm.)					
a) 55°C drying temperature	54.0 kgs.	10	5.4	10	54.0
b) 60°C drying temperature	57.0 kgs.	12	4.75	10	47.5
c) 65°C drying temperature	55.0 kgs.	11	5.0	9	45.0
d) 70°C drying temperature	59.0 kgs.	10	5.9	9	53.1
e) 75°C drying temperature	63.0 kgs.	9	7.0	8.5	57.1

4. Palay Quality

To determine optimum conditions for milling and germination of the dried palay, samples were subjected to milling and germination tests.

a) Milling Test. Samples from each drying run were sent to the College of Agricultural Engineering, University of the Philippines at Los Baños.

Samples of 10 kgs. each were milled in two types of mills: the Engelberg mill and the Satake SB-2B small-scale rice milling machine. Before testing, the dried rice sample was cleaned in a Strecker and Scharader double-action pre-cleaner.

Total Milling Recovery

The test results indicate a higher total milling recovery from the dryer sample[1/] than from the sundried sample.[2/]

Table 6 shows the results of the milling test.

Table 6

TOTAL MILLING RECOVERY OF RICE

Drying Method	Milling Method	
	SB-2B	Engelberg
Pilot Dryer	64.2	64.5
Sundrying	63.3	63.3

The total milling recovery are consistently higher in rubber roller-hulled samples compared to kiskisan-hulled samples. (See Table 7). Brewer rice and bran are normally entrained with the hull in kiskisan mills, thus lowering the total milling recovery.

1/ Includes the five runs on the newly harvested palay dried at 60°C samples from each run were tested. (i.e., 2, 2-1/2, 3, 4 and 5 cavan).

2/ For comparative purposes, two cavans were also sundried.

Table 7

TOTAL MILLING RECOVERY OF DRIED RICE

Drying Temperature 0°C	Type of Mill			
	Rubber Roll		Kiskisan	
	Mixed	Not Mixed	Mixed	Not Mixed
55	61.2	61.5	60	50
60	64.4	64.4	60	60
65	61.5	58.9	50	52.9
70	65	63.9	58.9	50
75	67	64.7	--	66.7

Head Rice Recovery

Head rice recovery reflects the extent of internal checking of rice grain during drying and storage. Internal checking can be caused by thermal or moisture stresses. This thermal stress during the drying process made the rice grain crack resulting in fissures and broken rice when milled.

The head rice yield analysis at all temperature levels (See Table 8) shows the advantages of turning up the grains during drying. With the rubber roller type mill, samples turned up during drying fall under Philippine grades 2 and 3 categories while unturned samples do not even make it to Grade 3. Drying at 75°C however gave high head rice yield for both turned and unturned samples.

It appears that turning up the grains during drying significantly increases head rice yield but not the total milling recovery.

Table 8

HEAD RICE YIELD OF MILLED RICE

Drying Temperature °C	Type of Mill			
	Rubber Roll		Kiskisan	
	Mixed	Not Mixed	Mixed	Not Mixed
55	52.5	34.2	59	40
60	64.9	48	58.3	50
65	64.4	48	40	55
70	70	41.7	69	50
75	63	77.5	--	60

b) Germination Test. This test was conducted in the samples of the last five of the drying runs (i.e., at five different drying temperature settings). The results determine ideal drying temperature for grains to be used as seedlings.

The results of the germination test are tabulated in Table 9.

At 55°C the turned-up dried sample attained the highest germination rate of 88%; the unturned sample had a lower 74% germination rate.

At 60°C, 82% germination was attained from the turned up dried sample against 74% from the unturned sample.

Comparing all the results of the germination tests, it can be seen that the ideal drying temperature for seedling purposes is 55°C to 60°C.

Table 9

RESULTS OF THE GERMINATION TEST

Temperature °C	% Germination	
	Mixed	Not Mixed
55	88	74
60	82	74
65	62	42
70	72	66
75	65	62

III. SITE SELECTION, FARMER IDENTIFICATION AND PROMOTION

This section of the report discusses the activities aimed at promoting the use of the low-cost grain dryer among rural farmers. The selection of sites and farmer cooperators is also taken up.

A. Project Assumptions

The following assumptions guided the promotions effort:

1. Farmers encounter problems in grain drying particularly during the rainy harvest season. They have not solved this problem because they could not afford the high priced mechanical driers now available.

2. Farmers are willing to try using a grain dryer which is cheap to construct and economical and convenient to operate.

3. An effective tool for introducing and diffusing farm technology in the rural areas is by actual demonstration.

4. Use of the existing leadership structure could facilitate the introduction, promotion and diffussion of the farm technology.

5. Farmers' participation in the design of the dryer could promote the feeling of involvement and identification with the project, hence facilitate its acceptance.

B. Site Selection

Criteria

The following criteria were applied in the selection of the specific area(s) and farm(s) for the project:

1. The area is planted with high yielding variety paddy rice.

2. Multiple cropping (at least 2 crops per year) is practiced.

3. The climate in the area is predominantly wet, particularly during the harvest season.

4. Individual farmers and/or active farmers' cooperative associations are willing to participate in the project.

5. Fuel materials (rice hulls, woodwastes, etc.) must be readily available in the area.

The provinces of Tarlac and Nueva Ecija were pre-selected because aside from being in the rice basket, they appeared to meet all the criteria.

Once the provinces were selected, community workers are fielded to identify barangays which fall within the criteria and to introduce the low-cost grain dryer to officers of farmers' organizations and individual farmers. Interviews and group conferences were conducted to identify problems and to document the existing grain drying practices. The farmers were asked whether, as an organization or as individuals, they were willing to cooperate in designing and testing a dryer which could help solve their grain drying problems. During these meetings, the fieldmen identified the farmers' organizations and the individual farmers who were willing to cooperate in field testing the dryer.

Follow-up conferences with the selected cooperators were made by a CO/CD consultant to firm up commitment and define the roles and functions of EDF and the cooperators. During the meetings, the farmer's reactions, comments, suggestions and preferences were recorded and passed on to the design engineers who are incorporated the farmers' ideas in the design of the grain dryer.

2. Selected Barangay Sites

Based on the selection criteria for this project, the following barangay sites were selected:

Barangay	Municipality	Number of Demonstration Dryers
Tarlac Sites		
San Bartolome	Mayantoc	2
Talimundoc, San Miguel	Concepcion	1
San Manuel	Tarlac	1

Barangay	Municipality	Number of Demonstration Dryers
Nueva Ecija Sites		
San Roque	Guimba	1
Bantug	Guimba	1
General Ricarte	Llanera	2
San Isidro	Zaragoza	1
Concepcion	Zaragoza	1
TOTAL		10

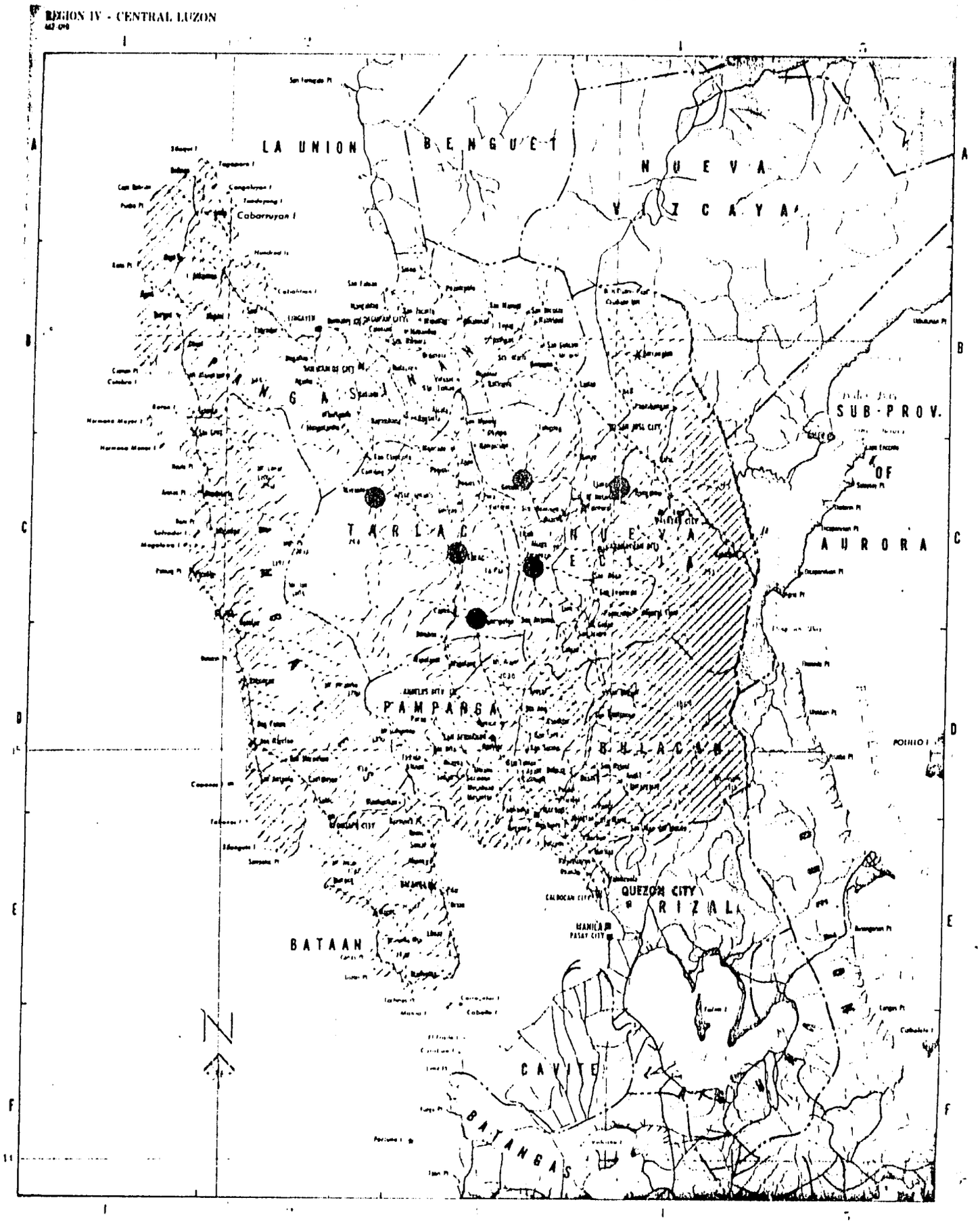
a) Location and Distance. The 10 sites are located in 6 municipalities, 3 in Tarlac (Mayantoc, Concepcion and Tarlac) and 3 in Nueva Ecija (Guimba, Llanera and Zaragoza.) From the map one can see that these municipalities are strategically located in the heart of Central Luzon.

If Tarlac, Tarlac were to be made the central point of reckoning, the approximate distances and direction of the other municipalities are as follows:

Municipality	Approximate Distance	Direction	Route
Mayantoc, Tarlac	35 km.	Northwest	via Romulo Highway
Concepcion, Tarlac	25 km.	Southeast	via McArthur Highway and Provincial Road
Zaragoza, Nueva Ecija	20 km.	East	Highway to Zaragoza
Guimba, Nueva Ecija	35 km.	Northeast	via Gerona
Llanera, Nueva Ecija	70 km.	East and Northeast	via Zaragoza thru Maharlika Highway and Provincial Road
	60 km.	East and Northeast	via Zaragoza and Aliaga

Figure 8

SELECTED DEMONSTRATIONS SITES



b) Distance from Fuel Source. The distances of the demonstration sites from the nearest kono rice mill, which produces rice hulls (the fuel preferred by most of the cooperator), are as follows:

Barangay Site	Kono Rice Mill	Approximate Distance (km.)
San Bartolome	Mayantoc town proper	4.0
Talimundoc, San Miguel	same barangay	0.5
San Manuel	same barangay	0.5
Concepcion	neighboring barangay	1.0
San Isidro	same barangay	0.1
San Roque	Guimba town proper	2.0
Bantug	- do -	3.0
General Ricarte	neighboring barangay	1.0

C. Selection of Cooperators

Criteria

The farmer cooperators (institutions or individual farmer) from these sites were then identified based on the following criteria:

-- Leadership status (He is an officer of a farmers' organization or a progressive farmer using modern farming technology).

-- Willingness to field test the low-cost grain dryer

-- Willingness to share in the construction of the dryer

-- Availability of space in his homelot

-- Willingness to share information about the operation of the dryer.

The Cooperators

Based on the specified criteria, the following 10 cooperators were selected:

	Name	Address
1.	Fortunato Rivera	Bantug, Guimba, Nueva Ecija
2.	Manuel de Guzman	San Roque, Guimba, Nueva Ecija
3.	Bernardo Sumalbag	Ricarte, Llanera, Nueva Ecija
4.	Eleuterio Sumalbag	Ricarte, Llanera, Nueva Ecija
5.	Romulo de la Cruz	Concepcion, Zaragoza, Nueva Ecija
6.	Florencio Abarra	San Isidro, Zaragoza, Nueva Ecija
7.	Esmeraldo Saldita	San Bartolome, Mayantoc, Tarlac
8.	Eufemio Salamanca	San Bartolome, Mayantoc, Tarlac
9.	Catalino Calara	Talimundoc, San Miguel, Concepcion, Tarlac
10.	Juanito Villafuerte	San Manuel, Tarlac, Tarlac

Other individuals who have shown interest in cooperating in field-testing the dryer are the following:

-- Mr. Rodrigo R. Custodio - Ricarte, Llanera, Nueva Ecija

-- Mrs. Pugat - MCDO, La Paz, Tarlac

The qualifications of the cooperators are described briefly in the Annex A.

D. Promotion

As a part of the promotional activities, people were consulted about the harvesting schedule, grain drying practices and problems, their opinions and suggestions, and how they could participate in the experiment. The results of these activities are as follows:

1. Harvesting Schedule

The harvesting schedule in 1984 will depend on the NIA irrigators schedule. The farmers said that NIA has announced that the start of the irrigation table will be delayed in 1984.

Based on this tentative schedule, the expected harvest dates in the selected site are the following:

Sites	No. of Demonstration Dryers	Tentative Harvest Schedule
Tarlac Site		
San Bartolome Mayantoc, Tarlac	2	March, April/August September, October
San Manuel Tarlac, Tarlac	1	March/October
Talimundoc, San Miguel Concepcion, Tarlac	1	February, March/ September, October
Nueva Ecija Site		
San Roque, Guimba	1	March, April, May/ September, October
Bantug, Guimba	1	April, May/September, October
Ricarte, Llanera	2	June-July/November, December
San Isidro, Zaragoza	1	June-July/November, December
Concepcion, Zaragoza	1	June-July/November, December

The Mayantoc and Guimba sites have their own irrigation system so their harvest schedules are not dependent on the NIA irrigation schedule.

2. Grain Drying Practices

Sun drying is the prevailing system of grain drying in Nueva Ecija and Tarlac. The facilities used are open concrete pavements constructed by government agencies, barangay organizations or private individuals. In areas near concrete highways, farmers use the highway for sun drying palay. However, since most of the selected demonstration sites are far from the highway, the farmers instead use available spaces such as concrete basketball courts and other privately owned concrete pavements. Other use mats made of buri, bamboo, plastic or empty sacks which they spread on any available space in their backyard.

Small farmers dry their palay themselves but big farmers and palay dealers employ laborers. The drying cost, which includes handling, putting the palay in sacks and stock them in the storeroom or bodega, is ₱0.50 per sack of palay, counted before drying. This amount is paid by palay dealers but individual farmers used to pay more, up to ₱1.00 per sack, if the supply of laborers is scarce.

During the rainy season, the farmers still rely on sunlight for drying their palay. They usually spread their palay on available concrete pavements but they should be quick enough to gather the palay when sudden rain comes in the afternoon. When there is no sunlight and the rain continues for several days, the farmer spreads his palay stocks on the floor inside his house to aerate it, with or without the aid of an electric fan or a blower.

When the harvest season falls on the dry season, the farmers dry their unthreshed palay in the paddy. This practice minimize the drying effort and facilitates threshing by machine.

3. Grain Drying Problems

The farmers' drying problems during the rainy days include the following:

a) Lack of available drying spaces

b) Sudden rain which soak the palay and cause health problems to the laborers

c) Lack of drying facilities which forces the farmers to sell the palay at a lower price to avoid further losses. Furthermore because farmers have to pay production loans, they have to sell part of their produce without much delay.

4. Farmers' Reaction/Comments

a) Initial Reactions. Initially, the farmers were not very enthusiastic because about 90 per cent sell their palay immediately after harvest without drying. They dry only the remaining palay stock (about 20 cavans per family) which is stored for home consumptions while waiting for the next harvest.

In Guimba the farmers said that they have already seen a similar model which was good for drying tobacco only. They thought the dryer being introduced might not be applicable to drying of palay.

The dryer was rejected in Sto. Rosario, Concepcion because the farmers were afraid that it might not perform well. The concern of the farmers generally centered on the following:

1) Cost of project. In almost all areas, the farmers were very particular about the cost of the project.

2) No indebtedness. In Talimundoc, Concepcion the farmers were willing to try the project on one condition: that the farmers would not incur another form of indebtedness because of this project.

3) Ownership. In other areas the farmers asked, "Who will own the project after completion?"

4) Capacity. The farmers in Guimba reacted negatively when they learned that the capacity of the dryer is only 5 cavans. They prefer a bigger model and agreed to put up a 20-cavan capacity model.

b) Suggestions. In subsequent meetings, however, the cooperators reacted more positively to the project and gave the following suggestions:

1) Capacity. Most of the farmers wanted a 20-cavan capacity dryer.

2) Fuel. Nearly all preferred rice hulls as fuel.

3) Fuel conveyor. Several farmers suggested that a tunnel-type conveyor with release lever be constructed to facilitate feeding rice hulls into the furnace.

4) G.I. roofing for the dryer. They suggested that G.I. roofing be included in the design of the model. They were not in favor of using cogon or nipa roofing since these might be a fire hazard.

5) Others. A farmer suggested indirectly that the dryer model should not be like the one rejected in their municipality because it was costly to construct, operate and maintain and it affected the quality of the dried palay.

The farmers also expressed their desire to see a laboratory model constructed by EDF at PTRI, Bicutan, Taguig, Metro Manila.

Finally, they showed their enthusiasm for the project when they suggested that the model dryers be constructed in their respective backyards soon.

5. Working Arrangements Between the EDF and the Cooperators

In the construction of the dryer, the cooperators were of the understanding that EDF would furnish the construction materials while the cooperators would furnish the land (site) and underwrite the cost of labor. The cooperators agreed to furnish the skilled or semi-skilled workers because they could acquire the know-how to construct the dryer from other farmers in their barangay if the demonstration models turned out to be good and effective.

The cooperators have agreed to discuss with EDF the management aspect of the project, how they could return the initial investment in the cost of construction materials. They also expressed their readiness to share with the EDF their own notes and observations about the use and operation of the dryer.

Basically, their decision to join was prompted by their desire to be co-experimenters in the search for a solution for one of their pressing problems.

ANNEX A

QUALIFICATIONS OF COOPERATORS

1. Fortunatc Rivera. He is the president of the federated irrigators association in Guimba. He cultivates about 7 hectares of riceland and has started a tilapia fish farm. He is a progressive farmer and likes to try new ideas in farming. Reasons for joining the experiment: He wants to try the new technology which he believes might be beneficial to the farmers in his barangay. Preference: 20-cavan capacity using firewood as fuel.

2. Manuel de Guzman. He is the auditor of the irrigators association in San Roque. He has proven his honesty and leadership and can be considered the prime mover of the organization. He operates a hand tractor and a rice buying station. Reason for joining: He wants to encourage farmers to plant early and harvest early and not be afraid of rain during harvest time. Preference: 20-cavan capacity with rice hulls as fuel.

3. Bernardo Sumalbag. He cultivates a 4-hectare farm lot. He is the silent type but follows modern rice farming practices. Reason: He likes to try the new technology. Preference: 20-cavan capacity with rice hulls as fuel.

4. Eleuterio Sumalbag. He is the Barangay Captain of Ricarte and cultivates about 9 hectares of riceland. He needs a low-cost dryer. In fact he was about to construct a concrete solar dryer but prefers to try the low-cost dryer first. Preference: 20-cavan capacity with rice hulls as fuel.

5. Romulo dela Cruz. He is the Samahang Nayon President and is a board member of the Area Marketing Cooperative. He cultivates about 2 hectares of riceland and is recognized as a leader in his barangay and in the town of Zaragoza. Reason for joining: He believes that the farmers in his barangay need an effective grain dryer especially during the wet harvest season. Preference: 5-cavan capacity with rice hulls as fuel.

6. Florencio Abarre. A progressive farmer, he is the Secretary-Treasurer of their Samahang Nayon. He has a source of rice hulls just about 100 meters from his backyard. Reason for joining: He wanted to try the technology which could solve the perennial drying problems of the farmers in his barangay. Preference: 20-cavan capacity with rice hulls as fuel.

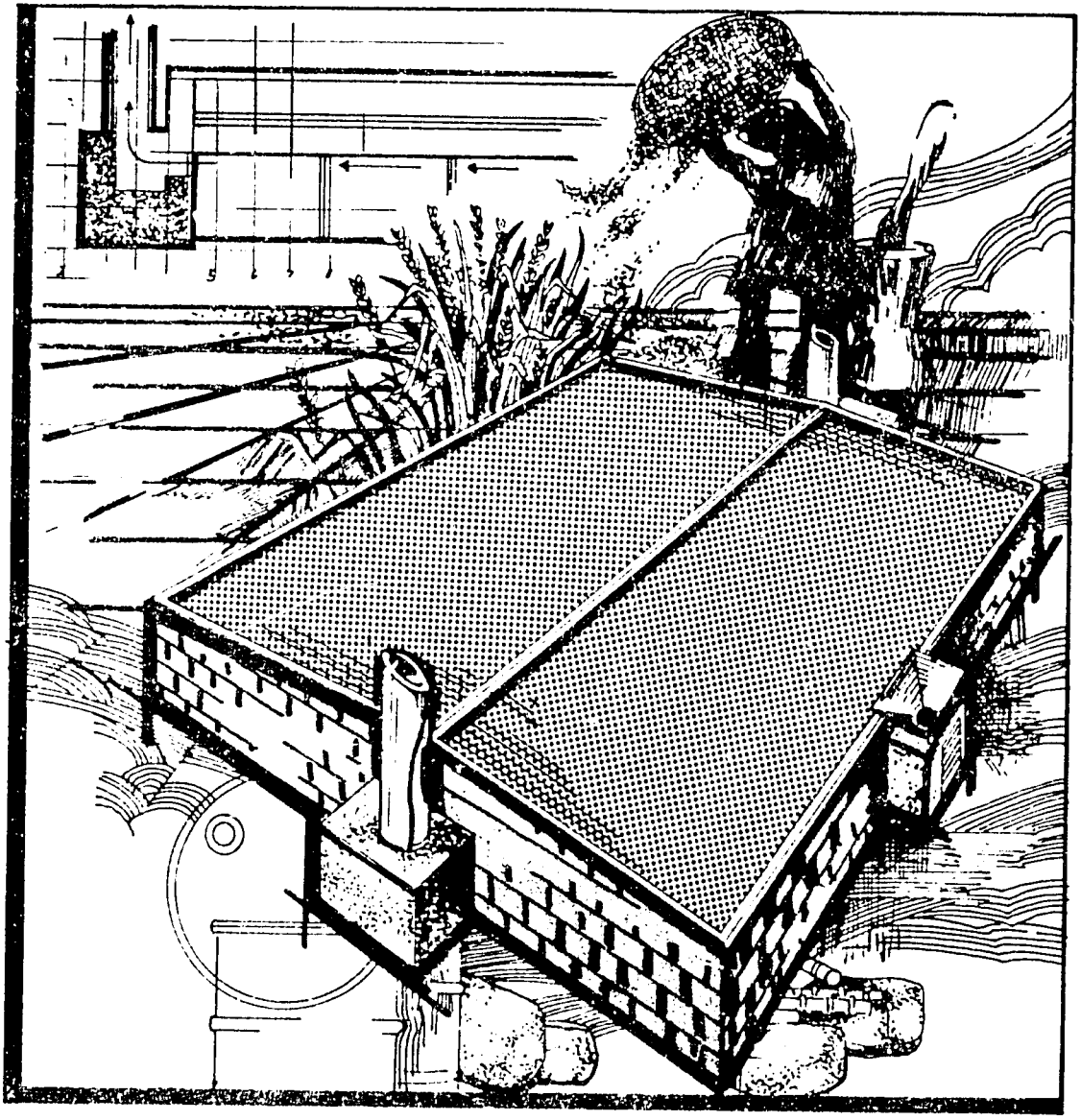
7. Esmeraldo Saldita. He is the Barangay Captain and Samahang Nayon President of San Bartolome, Mayantoc, Tarlac. He cultivates about 4 hectares of riceland. Reason for joining: He had attended a post-harvest technology seminar sponsored by the National Food Authority and is very receptive to the idea of field testing the grain dryer. Preference: Use of hollow blocks instead of adobe; 50-cavan capacity using firewood as fuel; combination furnace which uses firewood or rice hulls.

8. Eufemio Salamanca. The Municipal Development Staff Coordinator of Mayantoc, he cultivates about 4 hectares of riceland. He expected the low-cost dryer to be constructed during the harvest months of November and December 1983. Reason for joining: He believes that the project would solve grain drying problems especially during the rainy days. Preference: 20-cavan capacity using rice hulls as fuel.

9. Catalino Calara. The Samahang Nayon President. He cultivates about 3-hectares of riceland. Reasons for joining: He believes it is a good project especially for the Samahang Nayon. Preference: 20-cavan capacity using rice hulls as fuel.

10. Juanito Villafuerte. He is one of the progressive farmers in the barangay. He has a rice farm of about 10 hectares and has been eagerly awaiting the construction of the demonstration model. Reason for joining: The farmers need the low-cost dryer especially during the wet harvest season when palay stocks are damaged for lack of drying facilities. Preference: 20-cavan capacity using rice hulls as fuel.

LOW-COST GRAIN DRYER



A Project of the ECONOMIC DEVELOPMENT FOUNDATION
Funded by the U.S. AGENCY for INTERNATIONAL DEVELOPMENT

Despite the fact that the Philippines is a rice-producing country - harvesting about 140 million cavans (7 million MT) of rice annually - rural rice farmers incur considerable grain losses arising from inadequate grain drying facilities.

A number of mechanical grain dryers have been developed but these have not been widely adopted mainly because of their prohibitive cost: ₱20,000-₱40,000.

This grain dryer - a modified version of a Nigerian design - provides rural farmers with a simple, low-cost and easy-to-construct dryer that will use locally available fuels - firewood, rice hulls, other agricultural residue.

Depending on the initial moisture content, it can dry 20 cavans of palay in 8-12 hours.

The procedure of operation, bill of material and construction drawings are provided in this manual.

PROCESS

The drying process is illustrated in Figure 1.

Fuel rice hulls or wood wastes are burned in the furnace. The hot flue gas generated passes through a heater tube made of empty oil drums and exits at the smoke stack on the other end.

At the base of the dryer are ports through which fresh air enters. As the air comes into contact with the heated tube, its temperature is raised to 40-70°C. The rising hot air, fanned by a slight draft from the air ports, moves across the grain mass on the drying tray absorbing moisture in the process.

Dryer temperature is controlled by regulating the amount of fuel and/or the flow of air to the furnace. A thermometer gives the temperature reading.

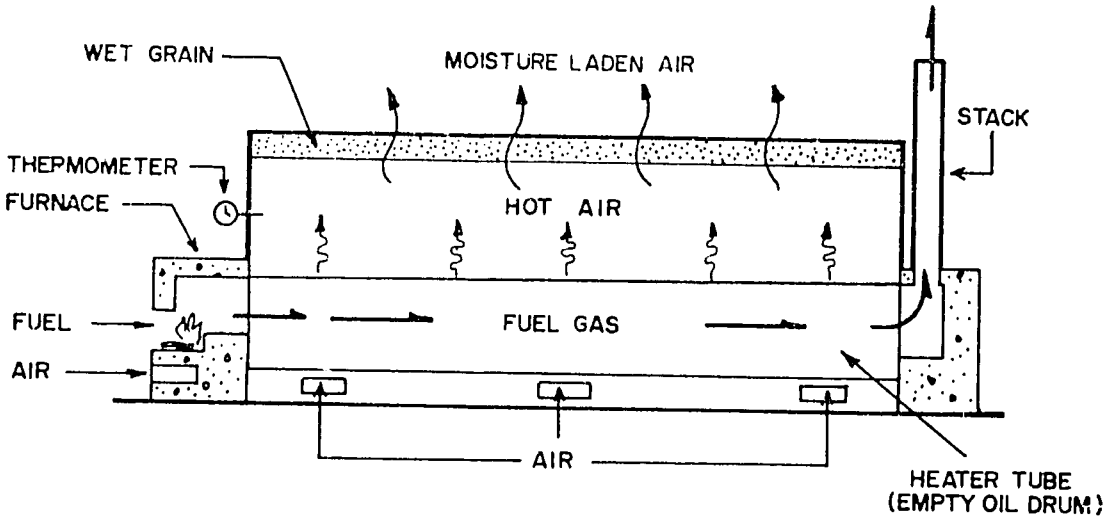


Figure 1

DRYING PROCESS

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PROCEDURE

1. Spread the wet palay evenly on the drying tray to a depth of 5 cm (2 inches)

2. Build the fire in the furnace. It may take some time to reach the operating temperature of 45-50°C but it is important to tend the fire at all times during drying. Too large a fire might scorch the grain; a medium-size flame will give the best heat distribution.

3. Remove the accumulated ash at regular intervals.

4. Dry the grain until the moisture content is about 14%, determined using a moisture meter. Experienced farmers, however, can tell the moisture content just by cracking the grain between their teeth.

5. The dryer heat can be optimized by loading a fresh batch as soon as the one before it has dried.

6. When drying is completed, empty the furnace (hopper and combustion chamber) of husk and put out the fire.

SPECIFICATIONS

Capacity	:	20 cavans of palay
Drying Time	:	8-12 hrs. depending on initial moisture content
Fuel	:	rice hulls or wood wastes
Dimensions		
Length	:	7.30 m. (24 ft)
Width	:	3.70 m. (12 ft)
Height	:	1.2 m. sloping down to 0.75 m.
Drying Tray	:	6.40 m. x 3.70 m. (21 ft x 12 ft)
Grain Depth	:	50 mm. (2 inches)
Drying Temp.	:	$50^{o}C$
Fuel Consumption		
Rice Hulls	:	_____ kg/hr.
Wood wastes	:	_____ kg/hr.

BILL OF MATERIALS

Masonry	Quantity
Cement	15 bags
Hollow blocks	250 pcs.
Adobe stone	60 pcs.
Steel bars	10 pcs.
Sand	2 cu.m.

Carpentry	
Lumber	Pcs.
2 x 3 x 14	15
2 x 6 x 12	2
2 x 3 x 12	4
1 x 4 x 12	4
1 x 4 x 14	2
Wire Mesh	30 yards
Chicken wire	30 yards
GI sheet	2 pcs.

Others	
Empty oil drums	6 pcs.
Smoke stack	4 pcs.
Gate	1 pc.
Thermometer	1 pcs.
Misc. (nails, etc.)	

Labor	
Mason	10 man days
Carpenter	5 man days
Miscellaneous	5 man days

DRAWINGS

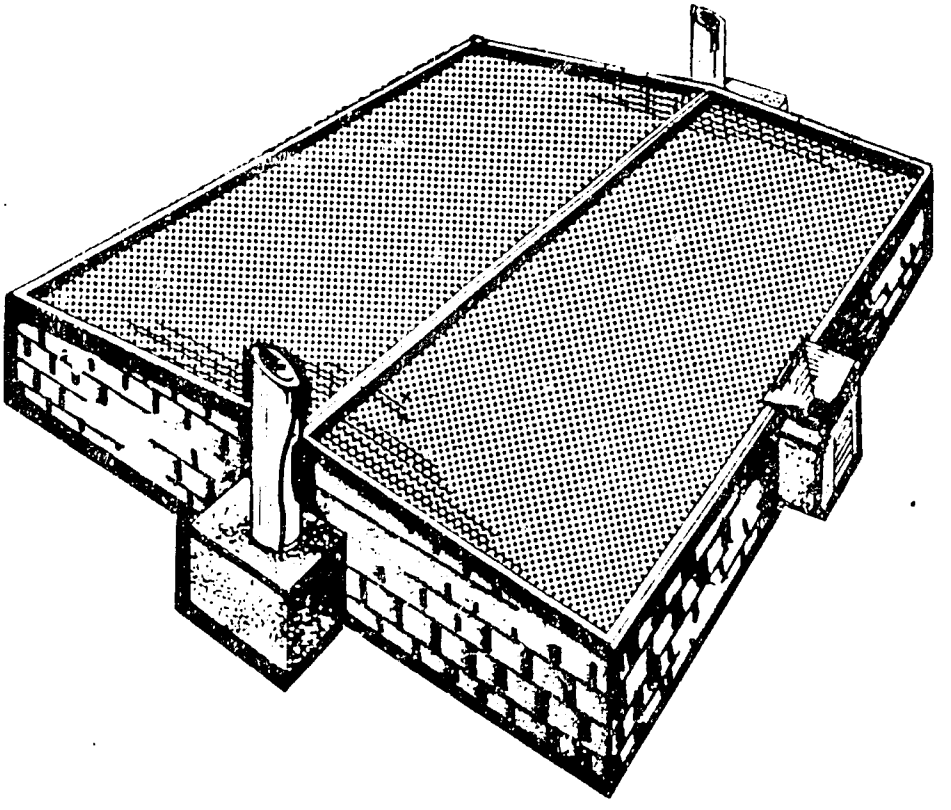
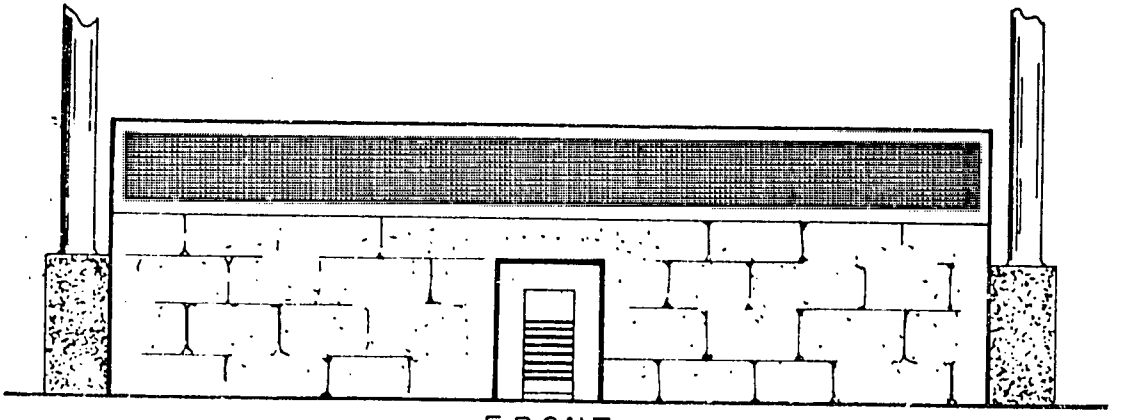
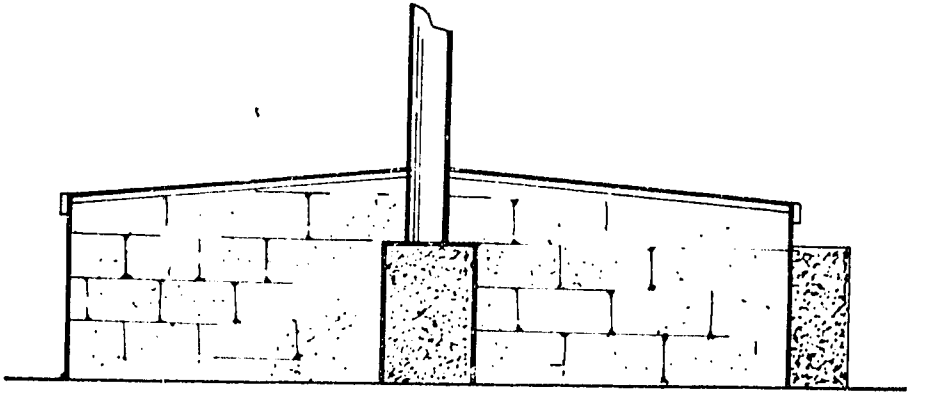


Figure 2

ISOMETRIC VIEW



FRONT



SIDE

Figure 3

FRONT AND SIDE PERSPECTIVE

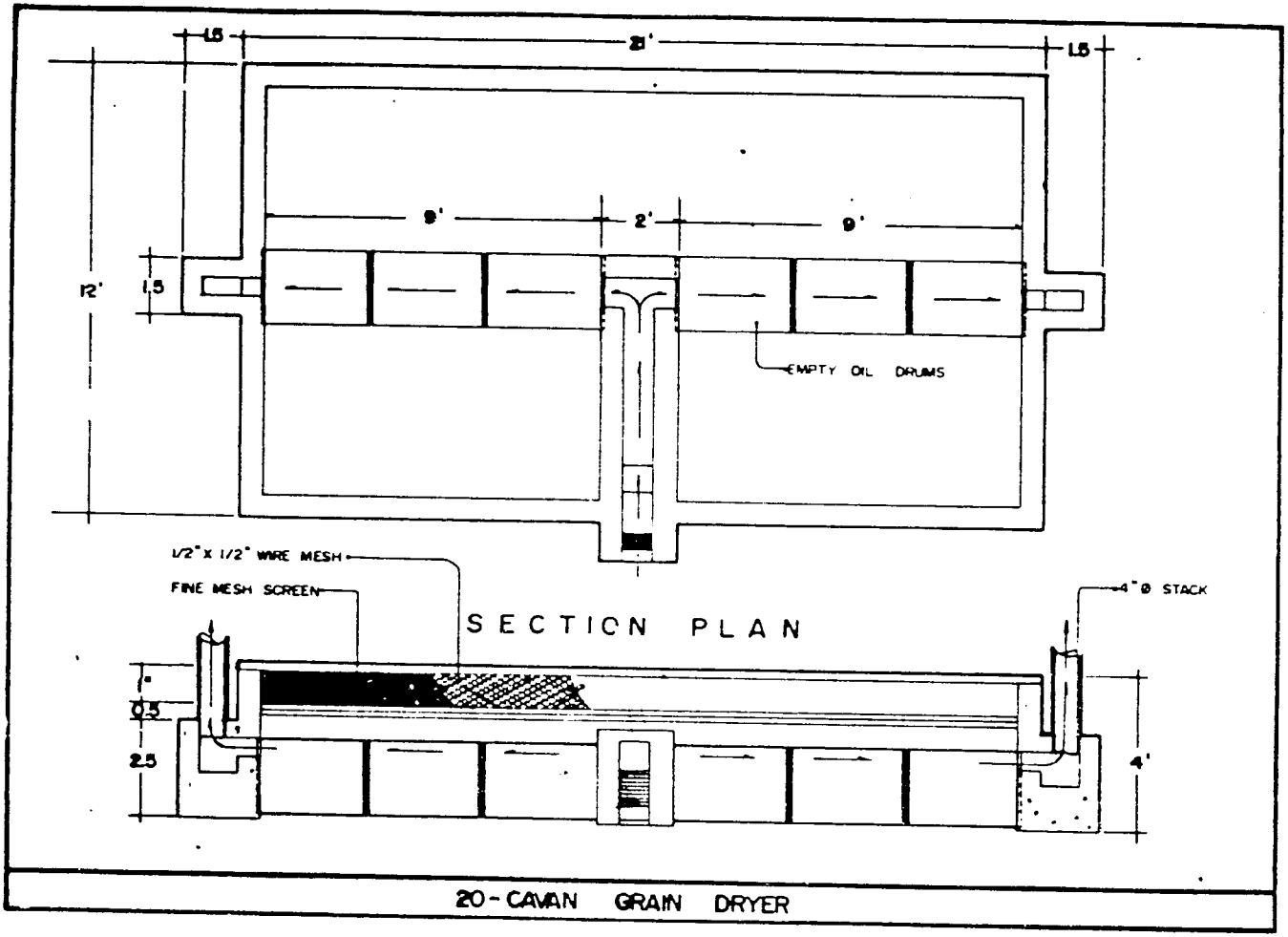


Figure 4

SECTION PLAN