SOLAR DRYING TECHNOLOGIES

By

EMERICO MENDOZA, PH.D.*

Industries in the country have traditionally relied on the sun for drying. As an inexpensive and reliable source of energy the sun has been the major source of heat for drying crops, lumber, food and some industrial products and by products. Due to some inherent difficulties associated with direct sundrying, fast and effective methods of drying were developed using convenient fuel forms, thus, replacing traditional sun drying techniques. The high cost of fossil fuel and even electricity, however, urges the need to tap the abundant energy coming from the sun.

Solar dryers, although of recent development, has gained wide acceptance. The availability of designs which are appropriate to our conditions has decreased the capital and operating cost of solar dryers. Simplicity in design, use of locally available materials and adaptability to a wide range of drying requirements are features associated with available solar dryer designs. Although the technology is still at the promotive stage, it has already gained popularity in industries requiring drying operations.

Solar Radiation Availability

The availability of ample levels of solar radiation induces the application of solar thermal conversion technologies. In the Philippines, the potential use of solar collection devices span approximately seven continuous months from late November to early June. Records have shown that the country enjoys radiation availability which are as high as 15,000 Ly/month with more than 2,000 hours of effective annual collection time. Typical lows are approximately 6,000 Ly/month with maximum radiation falling from March to May. Under this classification, the climate types are as follows:

Type 1 — Pronounced wet and dry season. Dry from November to April and wet during the rest of the year.

Type 2 — Relatively dry from November to April and wet during the rest of the year.

*INSAET, U.P. Los Baños

Type 3 — Rainfall more or less evenly distributed throughout the year.

Type 4 — No dry season with very pronounced maximum rainfall from November to January.

Solar Thermal Conversion

Solar thermal conversion is considered as the most direct and least expensive among processes of converting solar energy into useful form. Although heat is considered to be a low quality energy, direct conversion of radiant energy to thermal energy is favored over other solar conversion processes from cost considerations. Of the two general methods of converting solar energy to the desired form—that is, heated air for solar dryers—air heating collectors have proven not only to be sufficiently efficient but also less expensive compared to water heating collectors. However, thermal energy storage capacity is sacrificed in air heating type collectors unless thermal storage systems like rocks or other materials with high thermal mass are employed. The simplicity in design and maintenance requirements associated with direct air heating type collectors further favor the adoption of these devices.

Collector Design

Heating air for solar dryer application is accomplished by passing cold air on radiation absorbing surface. Available designs range from simple flat absorbing surfaces to finned type configuration.

The absorbing surface is normally enclosed by a cover which normally displays good radiation transmissivity properties.

Two experimental collector designs were carefully developed for dryer use. The relative merit of using aluminum foil, GI sheets, ground rock and cement pavement as substitutes for expensive copper plates were proven in simulations studies. (Figure 2). Absorber covers or glazings were provided by polyethylene sheets. Except for the lack of strength, the polyethylene sheets proved to be effective glazing material.

Type I Collector

The collector consists primarily of a radiation transmissive material placed over an absorbing surface. Air passing in between the cover and the absorber gains heat resulting to higher temperature. Although relatively inefficient in design, this type of collector has proven to have air heating capabilities which could supply the drying air requirements from reasonable sized solar collecting areas.

Polyethylene film, ordinary window glass and GI sheets were used as cover while ordinary aluminum foil was used as absorber. Experiments have shown that ordinary glass and polyethylene gave equally better results compared to GI. As seen in Figure 4, a monotonic increase in air temperature is observed from these collectors with maximum air heating capacities between 30 to 45°F above available ambient temperature. The lower efficiency obtained from GI sheets as cover is explained by convective losses amounting to approximately 10% loss in efficiency. Thus, polyethylene has been chosen as the cover for the Type I collector performance as well as cost considerations.

Another variation of this type of collector was studied using polyethylene cover on pavement and gravel. Results indicated the good performance obtainable from this kind of solar energy collection. As found previously in designed collectors, the maximum path necessary for air to attain sufficient temperature levels is approximately nine feet (Figure 4). Studies are underway to evaluate the effect of gravel absorber for solar collection. The following figures show the effectiveness of these simple collectors in converting solar energy to heat. In all cases, the collectors designed could provide sufficient hot air for meeting the drying requirements of most crops.

Type II Collector

An improved design offering strength not obtainable with the simple design was also studied and field tested in different sites. The collector design reduces heat losses achieved with proper glazing. This is shown in Figure 5. As previously reported, the collector could deliver heated air at average efficiencies of 12% with maximum efficiencies reaching as high as 50%.

Dryer Performance

Batch type solar dryers prototypes with capacities of one ton and two tons have been extensively tested in several field sites: UPLB (14°10'N) Bulacan (14°55'N) and Nueva Ecija (15°20'N). The performance of the dryers in delivering heated air are illustrated in Figures 6 and 7. In the areas considered, the available drying time exceeds six hours for heated air delivery capacities of at least 110°F and at most seven hours if minimum drying air delivery capacities of 105°F are considered. Maximum temperatures of more than 125°F were obtained in the dryers indicating that higher drying capacities are obtainable from the designs.

The batch types were tested in drying rice, corn in cobs, ipil-ipil leaves, and peanuts. Generally, the drying times obtained were similar to those of artificial dryers using other sources of heat. The moisture content reduction of rough rice is exceptionally reasonable considering that most of the grains were totally dried on continuous 8 hour dryer operation. Furthermore, the quality of the dried products were comparable to those dried using other artificial means.

For purposes of comparison, Table 2 shows the dryer performance on some crops.

Table 1: TECHNICAL SPECIFICATIONS OF THE UPLB SOLAR CROP DRYERS

SITE	COLLECTOR AREA	BIN TYPE	CAPACITY, TONS
UPLB			
Original	144	Flat Bed	1
Modified	144 + 216*	Flat Bed	2
Pangasinan	144 + 224*	Louvered	2
Isabela	576	Flat Bed	2
Nueva Ecija	432	Flat Bed	2
Mobile Dryer**		LSU type	1 ton/hr.

*pavement
**portable

Table 2: DRYING PERFORMANCE OF THE BATCH TYPE DRYER FOR SOME COMMODITIES

COMMODITY	DRYING TIME, HOURS
Rice	8
Corn in Cobs	11
Ipil-Ipil	6 – 8
Soybeans	3 – 5

The moisture reduction of rice under continuous operating mood of the two-ton batch type dryer is shown in Figure 9 for the Nueva Ecija area in May 1980. During the period, close to seven hundred cavans of seed rice were dried in seventeen drying days. The initial moisture content of the seeds ranged between nineteen and twenty one percent.

Auxillary Heaters for Solar Dryers

In the absence of solar thermal storage units, auxillary heaters have been used in solar dryers. Low cost furnaces have proven to be efficient as auxillary heaters especially during periods of low solar radiation availability or for continuous operation of systems with no heat storage. A furnace developed in another research was used in the solar dryer.

Solar radiation quality is a major factor dictating the performance of solar converting devices. With a tropical climate, the country has a high diffuse radiation component favoring the choice of collectors of the flat plate type.

Periods that are available for maintaining desirable levels of solar collector performance varies with time of the year. In general, excellent conditions are available from late December to late May in the field sites when more than six hours per day of high solar radiation is obtainable. During the other half of the year, however, available radiation depend on climatic variables.

Available meteorological data are good bases for determining the probability of obtaining good solar collection performance. For example, the probability of obtaining good dryer performance for the UPLB campus is shown in Figure 2. Based on at least 50 percent probability leve, there are 51, 42, and 24 weeks in a year when 4, 5 and 6 hours of bright susnshine respectively, can be expected.

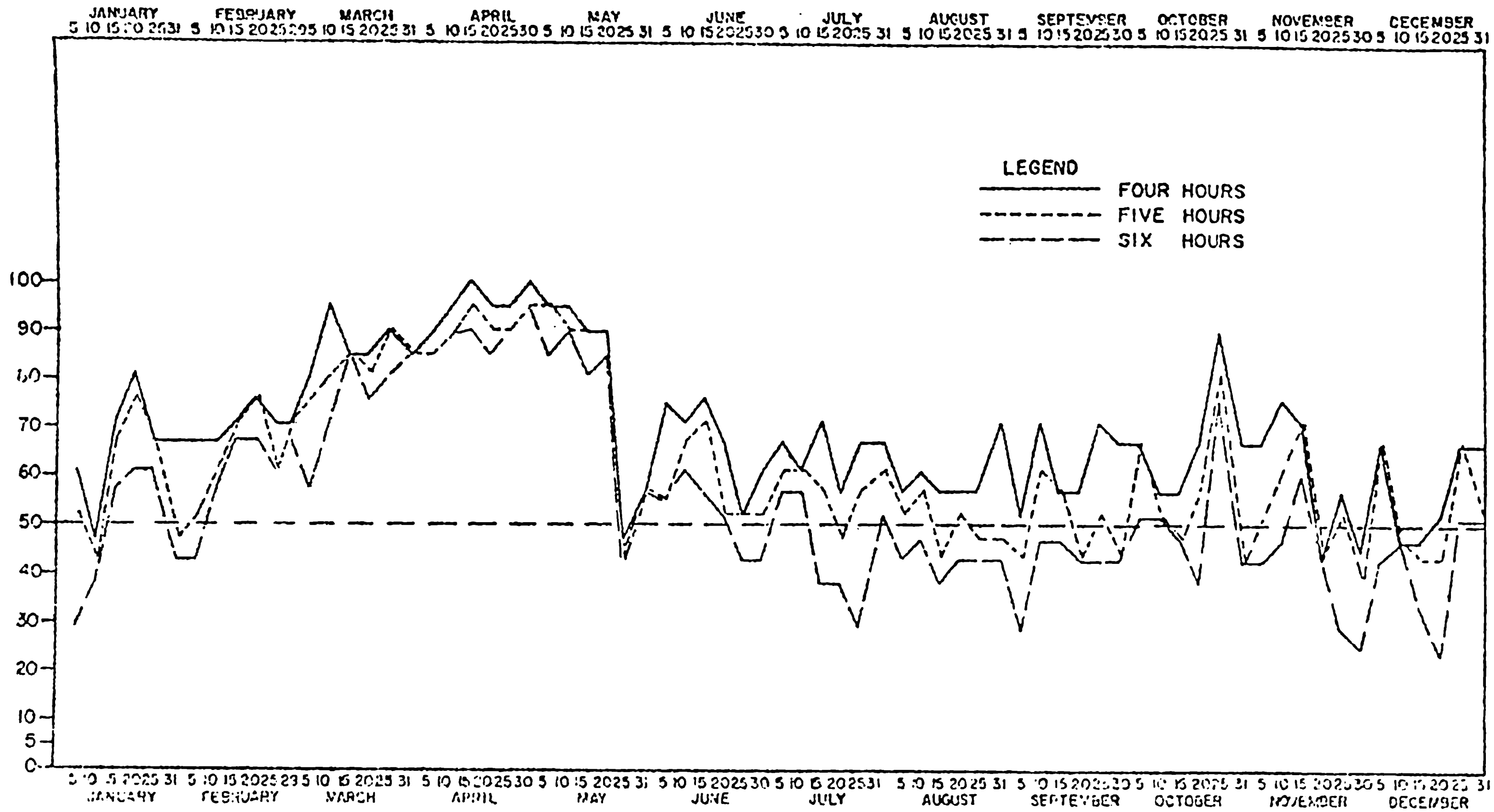

FIG. 1. PROBABILITY OF BRIGHT SUNSHINE (5DAY INTERVALS)

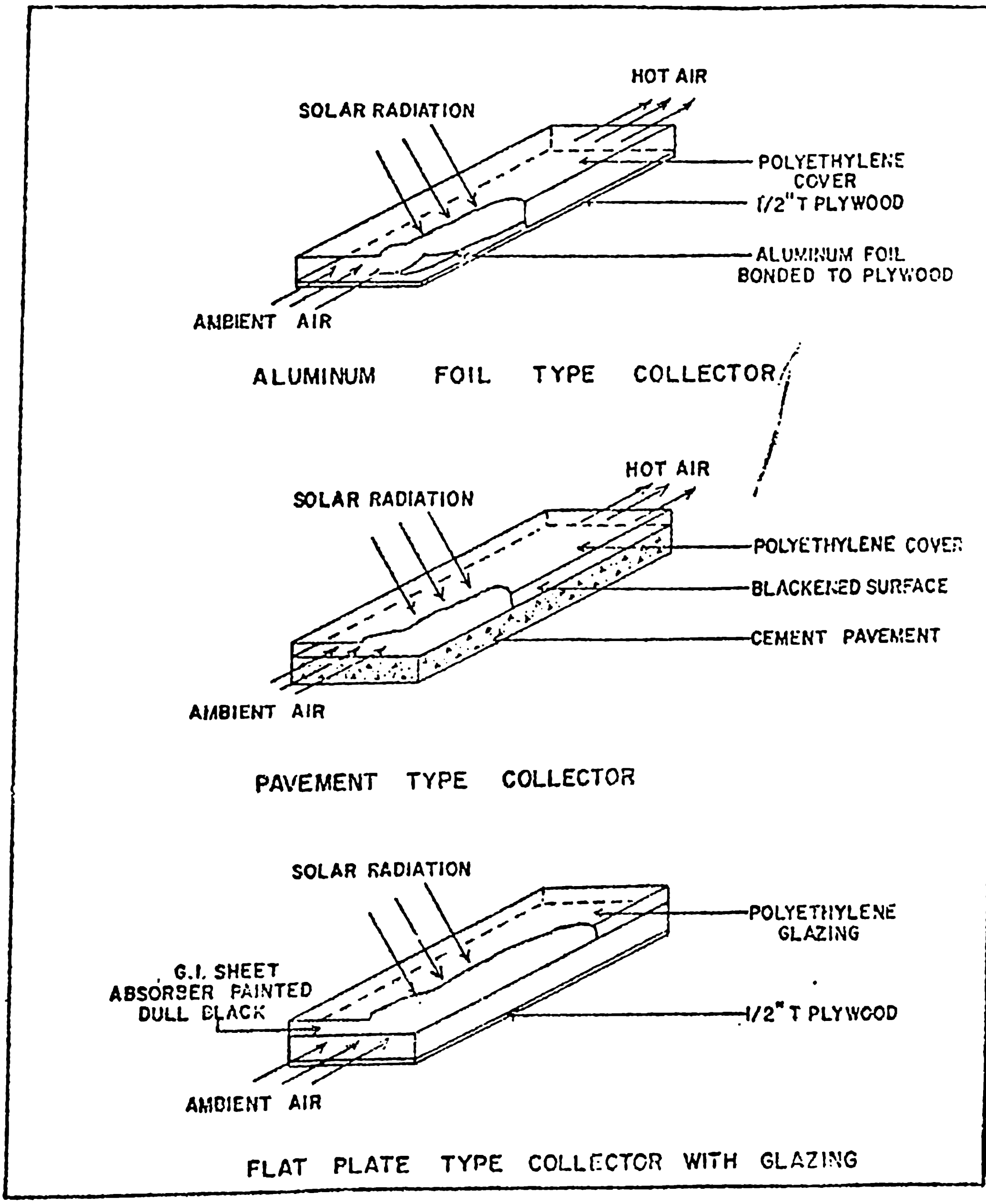

FIG. 2. LOW COST COLLECTOR DESIGN

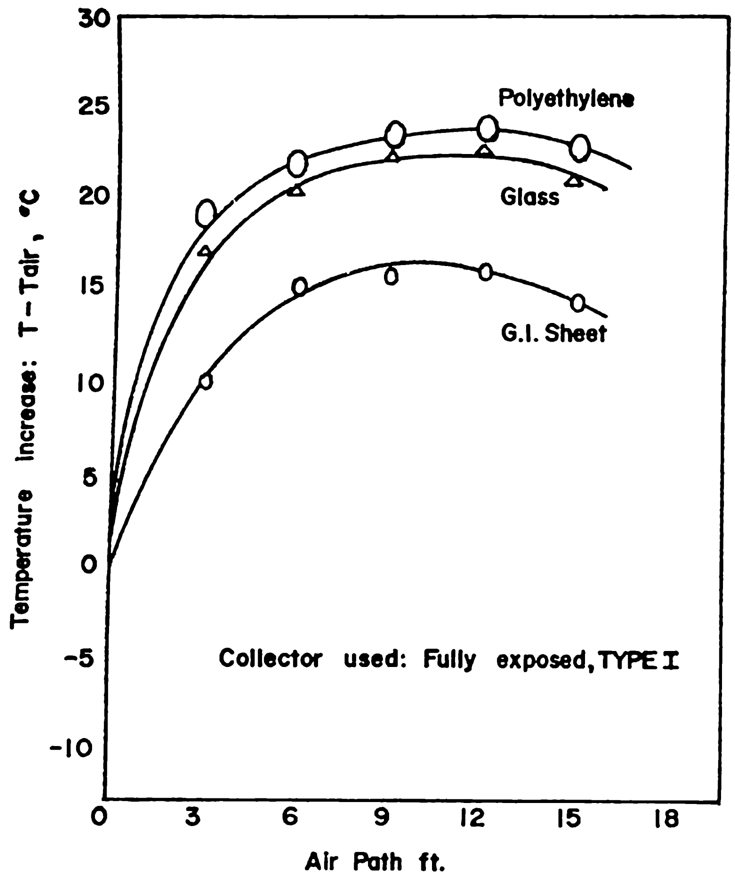

Fig. 3 Increase in air temperature along flow path in simple collector using aluminum foil as absorber.

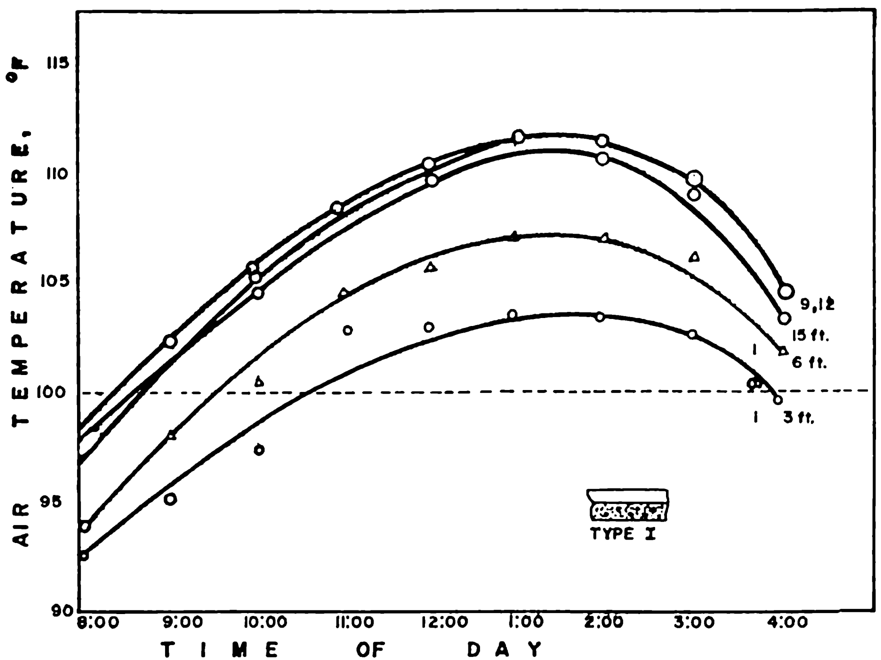

Fig. 4 Air temperature increase along flowpath in pavement type collector at any time of the day.

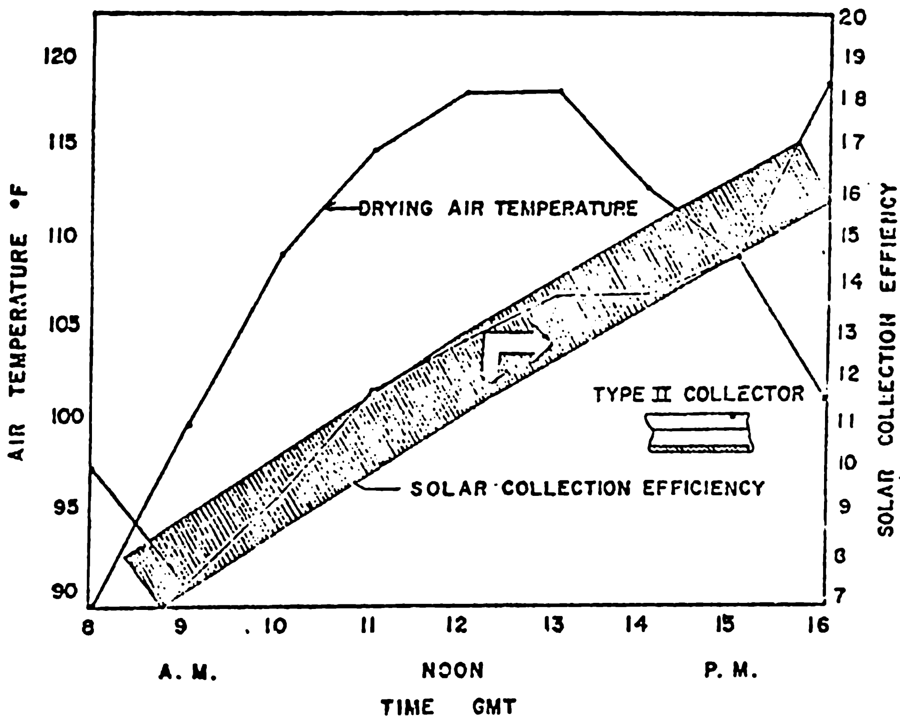

FIG. 5. TYPICAL SOLAR COLLECTOR PERFORMANCE AT UPLB

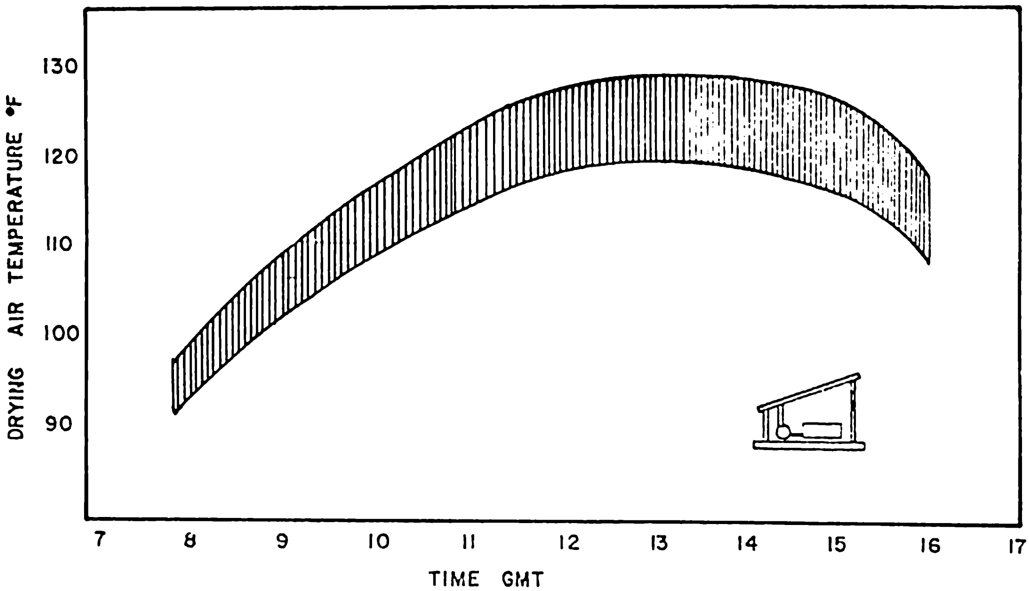

FIG. 6 . RANGE OF PEFORMANCE OF SOLAR CROP DRYER AT NUEVA ECIJA (15° 20'N)

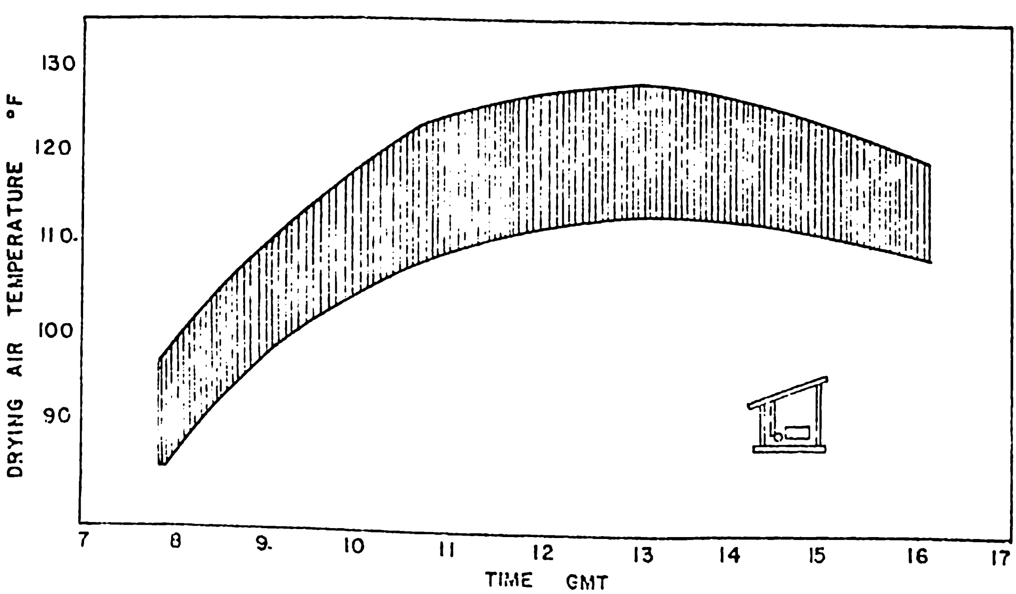

FIG. 7 . RANGE OF PERFORMANCE OF SOLAR CROP DRYER AT BULACAN (14° 55'N)

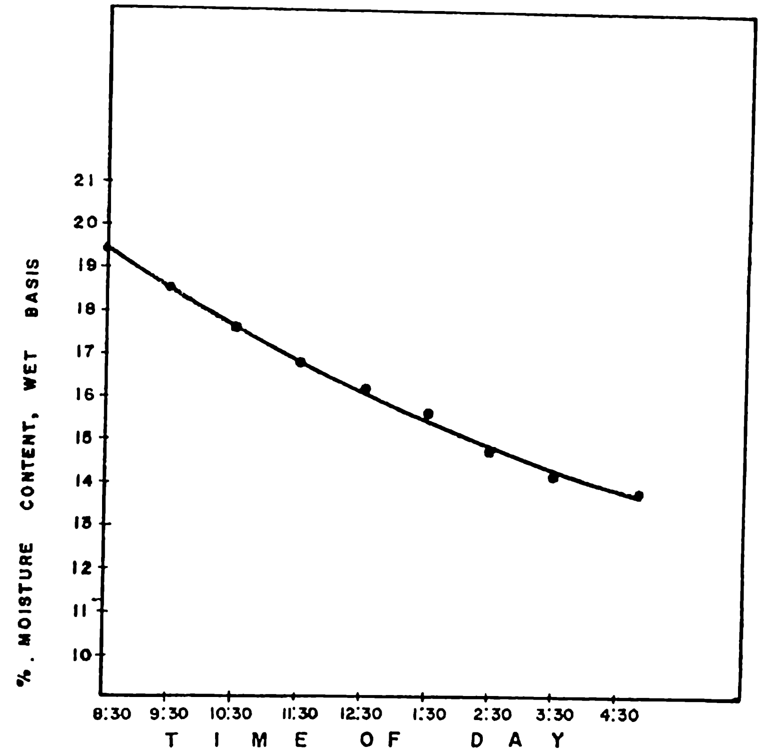

FIG. 8 MOISTURE REDUCTION OF PALAY FOR 8 HOURS OPERATION USING SOLAR ENERGY ONLY. AVERAGE FOR 17 OBSERVATIONS

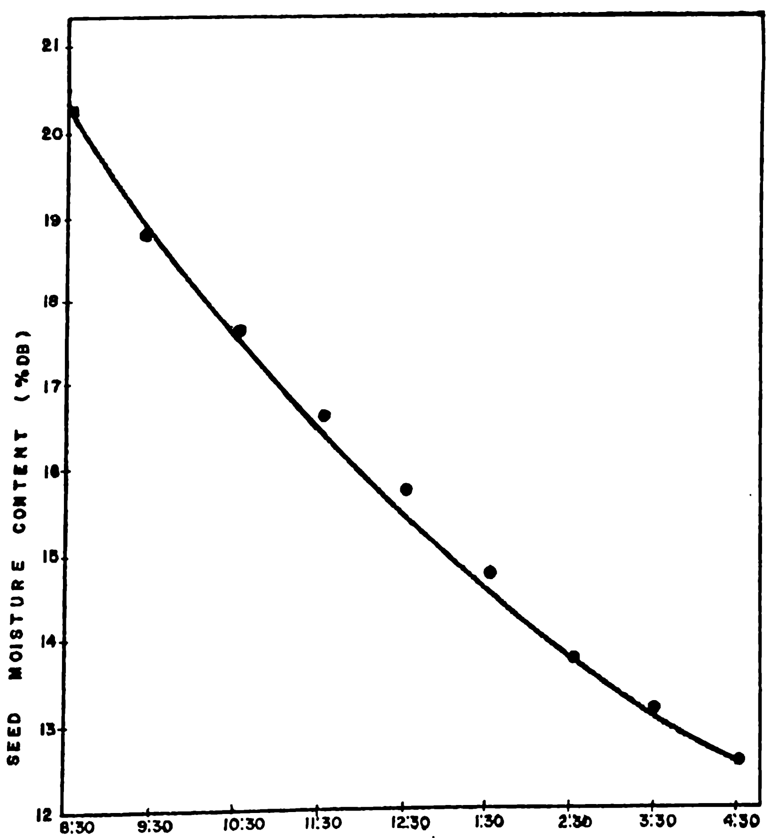

FIG. 9, DRYING PERFORMANCE OF SOLAR DRYER ON SEED GRAINS (HOURLY AVERAGE APRIL 20 26, 1960) MUNOZ, NUEVA ECIJA