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Innovative On-Farm Solar Dryer for Paddy

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Abstract

Food grains are generally harvested at moisture content of 18-25% (wb) whereas safe storage of cereals occurs at nearly 13-14% (wb) and pulses at 7-8% (wb). Thus excess moisture in harvested grains needs to be removed in short time. A Solar powered air inflated grain dryer was developed at ICAR-IARI, New Delhi with inflatable drying chamber. The drying chamber was made up of UV stabilized top transparent sheet and bottom thick polythene sheet. A solar operated DC Axial fan (dia. 40 cm) was used for blowing unit. The moisture reduction of 22-14% in 100 kg of paddy (PB 1121) was found to be 7.5-9 hours. The total cost of the dryer was Rs. 10850. Thus the Solar powered air inflated grain dryer is a low cost portable dryer which is manufactured using easily available materials and can eliminate all the disadvantages occurring in the sun drying.

Key words: ....

Drying is a physiochemical method of moisture removal from the product. Drying is helpful in preserving food product for long time; it prevent product from contamination. In cereal crop drying is done after harvesting in order to remove the excess moisture and attain safe moisture content for storage. Various drying methods are being used across the globe depending upon the crop to be dried, amount of moisture to be removed, economic and technical feasibilities.

In India sun drying is the most common method for drying of cereals after harvesting. It involves spreading of cereals in sun on mats, roofs and drying floors. This method has lot of disadvantages such as the drying can be done only when the sunlight is available *i.e.* the day time. It also depends largely on weather parameters and thus drying gets affected. Exposure to dirt, microbes and animals lead to degradation of final dried product. The idle time in between session allows growth of unwanted microorganisms. Sudden rains, strong winds might ruin whole batch of cereals and in sun drying frequent mixing is also required in order to get uniform drying. The drying rate and final moisture content cannot be controlled in sun drying.

Large amount of the grain produced is lost as post-harvest losses due to inappropriate handling and practices after harvesting. One-third of the food produced (1.3 billion ton), is lost globally during postharvest operations every year1. The post-harvest losses in two major food grains, i.e. rice and wheat are about 75 per cent of the total post- harvest losses occurring at the farm level and about 25 per cent at the market level[2].

Food grains are generally harvested at moisture content of 18-25% (wb) whereas safe storage of cereals occurs at nearly 13-14% (wb)

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and pulses at 7-8% (wb). Thus excess moisture in harvested grains needs to be removed in short time. The average solar radiation incident over India is 4-7 Kwh / m² / day with an annual radiation ranging from 1200 kwh / m² with 250-300 clear sunny days. Thus solar energy can be put to effective usage for drying of grains[3].

Currently farmers small handlers and millers often trade paddy directly after harvesting to avoid product losses, fresh paddy often fetches lower prices to producers. Thus use of solar dryer emerges as a primary alternative for small farmers. The use of solar dryers in the drying of grains can significantly reduce or eliminate product wastage, improve post-harvest handling at cheaper cost at the same time enhance productivity of the farmers towards better revenue derived. The quality of products dried in this way is excellent, due to the fact that the food is not in direct sunlight (cabinet or in-house dryer). The time consumed in solar drying is also comparatively lower compared to sun drying[4].

In India sun drying on mats, roofs, roads or drying floor is most common method of grain drying. This method has lot of limitations as it can only be done when sunlight is available and the grain is exposed to dust, dirt, microbes and insects resulting in loss of quality. The idle time between the sessions also allows growth of unwanted microbes. The drying rate and final moisture content cannot be controlled in sun drying[5]. The mechanical dryers consume fuel are relatively costlier and non-flexible in operation. This provokes need for a solar powered grain drying system constructed using locally and available materials and provides flexibility in operation and ease of handling.

Inflatable solar air collectors also find potential application in drying of agricultural commodities. These work on the principle of solar dryers and can provide technical and financially viable solution for drying in energy deficit areas. Solar collectors used in agriculture can be classified as cylindrical or semi cylindrical plastic tunnels inflated by a constant flow of air and ventilated horticultural greenhouses. The inflatable solar collector develops a semi cylindrical format when air is injected in the confined space between the two covers walls[6].

Inflatable solar air heating collectors are compact, lightweight, inexpensive, self-supporting and self-erecting / storing. The performance of these collectors depends mainly on the air flow characteristics and geometry of the structure[7]. Thus need for a portable dryer which can be used on the farm, operates on low cost, minimizes labour requirement and maintains product quality still prevails in our country.

The Solar powered air inflated grain dryer (Fig. 1) is a low cost portable dryer which is manufactured using easily available materials and can eliminate all the disadvantages occurring in the sun drying. This dryerhelps in controlled

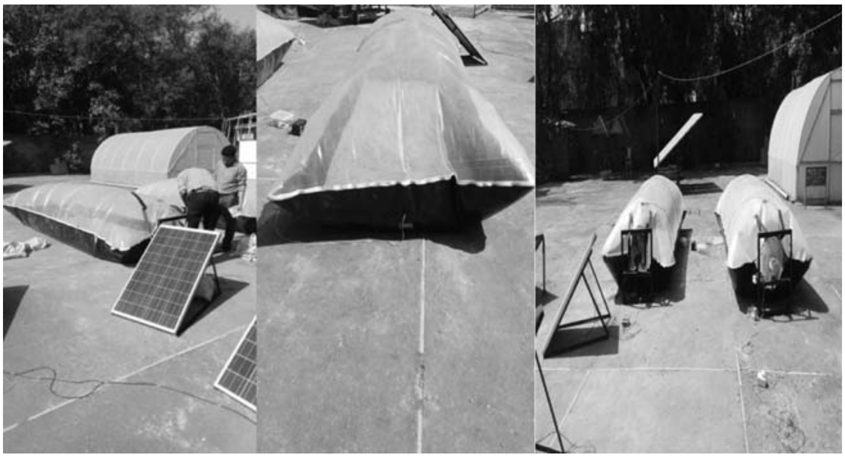

Fig. 1: Solar powered air inflated grain dryer

drying with safe drying of cereals against unexpected rain and other common contaminants. It also helps product from spoilage due to birds, dust and other contaminants.

UV stabilized transparent polythelene sheet (thickness 200 micron) and Black polythelene sheet of 5 m length and 2 m as width was used for fabrication of the dryer. The light weight of the sheet used promoted the portability of the dryer. The transparent sheet allowed short wave solar radiations to pass through it and enter the dryer. Both the sheets were then zipped with the help of a heavy duty zip leaving and opening for inlet and exhaust. At the inlet part a 12V DC fan (diameter 40 cm) was placed for supplying the air into the dryer. The fan was operated with the help of a 100Wp / 12V solar photovoltaic panel. Detailed specifications of the dryer are shown in Table 1. Higher flexibility of the top transparent sheet allowed the drying chamber to inflate smoothly and hence form a quonset tunnel while the air is blown through the chamber.

Table 1. Specifications of the developed solar powered air inflated grain dryer.

Parameters	Specifications (Depth 2 cm)
Length of drying chamber	5 m
Width of drying chamber	2 m
Drying bed dimensions	4.2 × 1.4 m
Blowing unit	DC axial fan
Maximum height of inflation	81 cm
Drying area (m^2)	5.88 m^2
Capacity (kg)	50 kg
Specific capacity per unit drying area (kg / m^2)	8.503

Fifty kg of Paddy (PB-1121) with initial moisture content 22±0.3% was dried in solar powered air inflated grain dryer and sun drying on the concrete floor simultaneously. The grain bed maintained during drying was 4 cm in both solar powered air inflated grain dryer and sun drying. Equal amount of samples were collected at every 30 minutes time interval from the dryer and sun drying which was used for determination of moisture content and the drying rate. The sun drying process occurred at ambient temperature.

Average solar intensity was measured at surface (tilt) of solar PV panel (1.1 m × 0.6 m) at every 30 minutes interval from 9:30 AM to 5:00 PM. The average solar intensity measured was 614 W / m^2 and the peak value of solar intensity occurred between 12:30 PM to 1 PM with an average value of 786 W / m^2 (Fig. 2). The average voltage and current observed were 16.51 V and 3.55 A respectively. The power generated was calculated by multiplication of the current produced and voltage developed (Fig. 3). This solar intensity was sufficient for operating the axial fan.

Temperature and humidity data were collected with the help of a developed data logger (Fig. 4). Temperature of ambient air was found

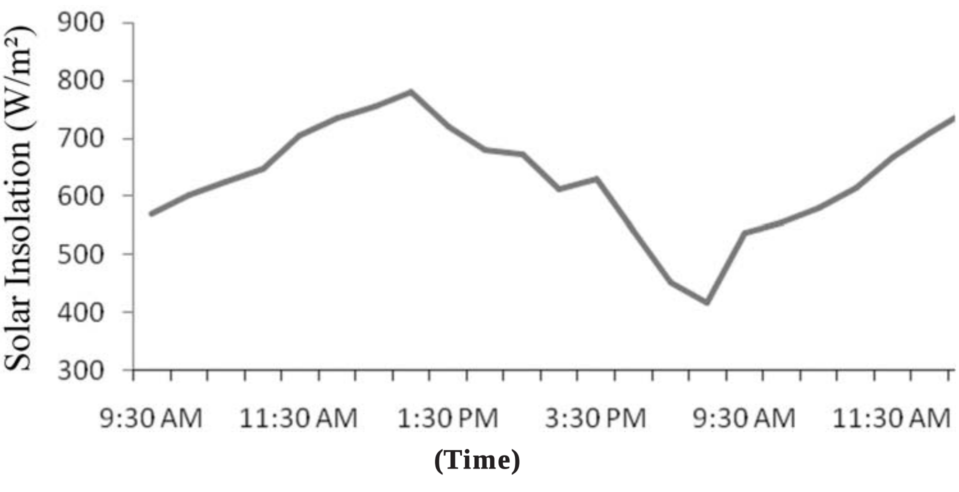

Fig. 2: Variation of solar insolation received with time

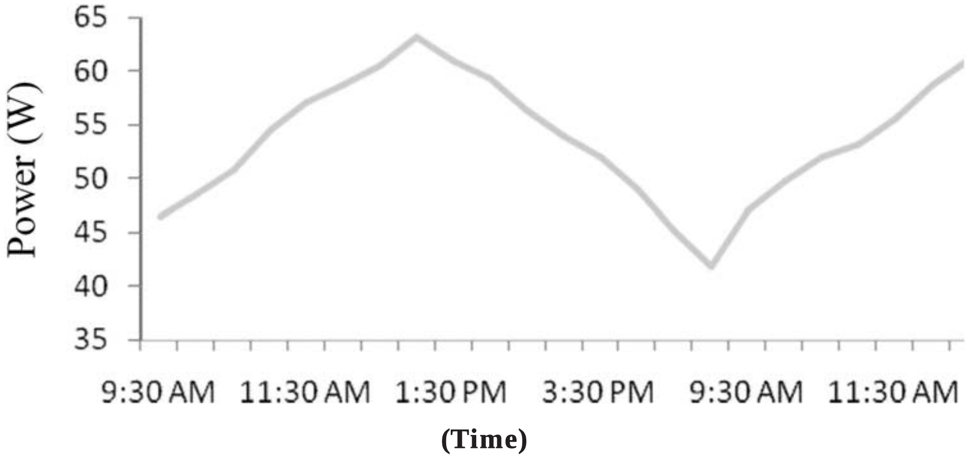

Fig. 3: Power generated over time

to be dependent on the solar intensity. The maximum ambient temperature was recorded between 2 PM and 2:30 PM. Among the temperatures measured at various intervals (1m, 2.5m and 4m) of length the temperature measured at 2.5 m length showed the highest value. The relative humidity of ambient air was found maximum at the morning and gradually decreased to lowest value between 3:30 PM to 4:00 PM. After 4 PM an increasing trend was observed in ambient air relative humidity. The relative humidity of drying air at point 1m along the length was found to be lower than the ambient air because of the rise in temperature. The temperature of drying air in the dryer was found to increase with time reaching its peak value at 1.00 PM. The temperature of drying air ranged between 29.8-38.2°C compared to ambient air temperature ranging from 25.7-34°C (Fig. 4).

The drying rate for paddy was calculated at each 30-minute interval and comparison was made between the developed dryer and sun drying. It was found that the drying rate in the dryer was significantly higher (P=0.0019) as compared to sun drying.

The dried paddy was de husked and its quality was evaluated on the milling yield and head rice yield obtained. Analysis of variances at 5% level of significance showed that there was no significant difference (P=0.033) in the milling yield produced in the paddy dried in the dryer compared to sun drying but head rice yield of paddy dried in the dried showed significant difference (P = 0.002) compared to the sun drying (Fig. 6 and 7). The time required for drying of paddy up to milling moisture content of 14% in the dryer ranged from 7.5-9 hours as compared

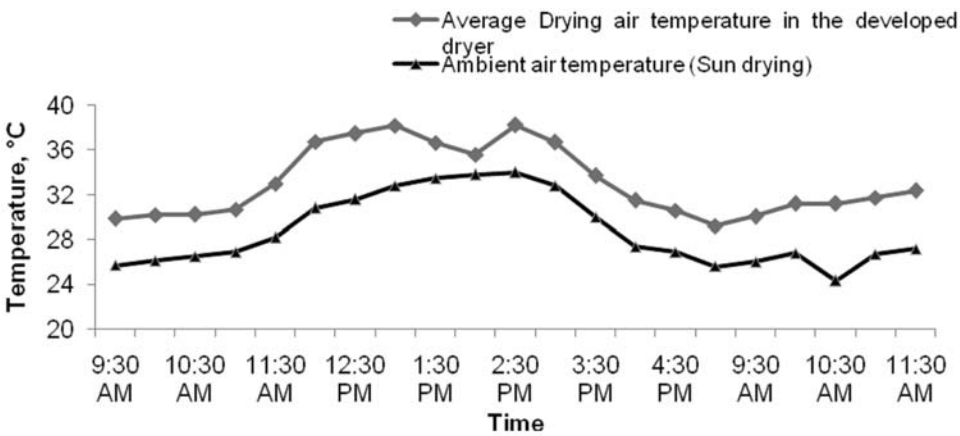

Fig. 4: Temperature profile of average drying air temperature in the developed dryer and during sun drying

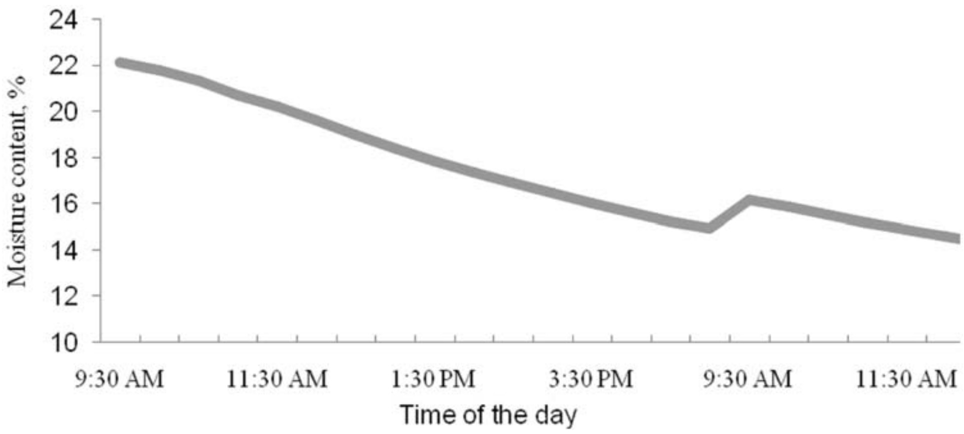

Fig. 5: Hourly variation of moisture content of Paddy

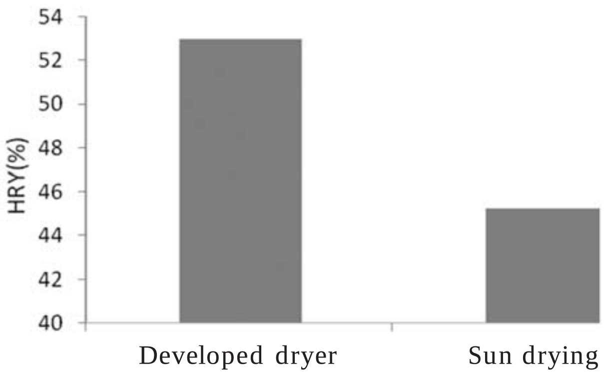

Fig. 6: Head rice yield of sun drying and developed dryer.

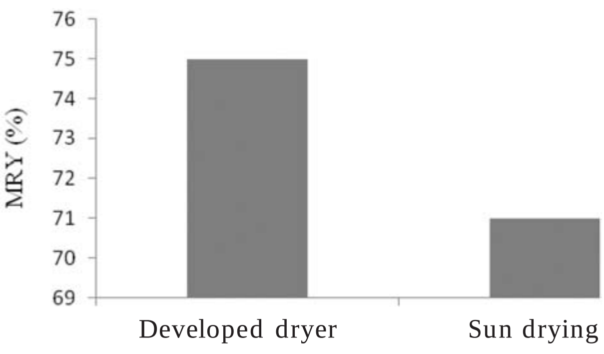

Fig. 7: Milling rice yield of sun drying and developed dryer.

to 11-12.8 hours in sun drying (Fig. 5). Therefore the dryer helped in drying of the produce in a short time.

Table 2. Cost of various components of solar powered air inflated grain dryer.

Component	Cost (Rupees)
Upper transparent UV stabilized polyethene sheet	800
Bottom thick black polyethene sheet.	900
Axial fan (solar powered DC)	1900
Metal frame	300
Heavy duty zipper	250
Mixing rake	400
Miscellaneous cost	200
Manufacturing cost	800
Solar panel	5300
Total cost	10850

Cost economics

Total cost of manufacturing the dryer including the cost of labour required was Rs. 10850.

The dryer can be used for 2400 hours annually for various grains. The profit obtained can be increased by increasing the batch capacity of the dryer and utilizing it for more number of days in the year.

Conclusion

The developed solar powered air inflated dryers provides a promising alternative for on farm drying of grains because of its low cost of construction, easy operation, green energy utilization and portability. The developed dryer can be used more efficiently in the rural areas where sun drying is still a major practice. It is particularly very useful for the poor farmers in rural areas where there is no electricity or its supply is erratic to use the solar dryer with the help of solar energy. In addition the portability of the dryer enables its easy handling and movability.

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