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Assessment of solar drying techniques for reduction of post-harvest losses in paddy rice

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Abstract

Drying is the single most important step in preventing post-harvest rice losses. This research compared three drying methods open sun drying, solar cabinet dryer, and shade drying for their effect on moisture removal rate, grain cracking, and milling quality of paddy rice (BRRI dhan28) in Mymensingh, Bangladesh. Trials were conducted during the Boro season harvest (April-May 2023). The solar dryer achieved a mean drying rate of 1.14%/hour compared to 0.78%/hour for open sun and 0.31%/hour for shade drying. Head rice yield after milling was 64.7% for solar-dried paddy versus 58.3% for open sun and 61.2% for shade-dried samples. Grain cracking was lowest in solar-dried samples at 8.3% compared to 14.7% for open sun drying. Moisture distribution was also more uniform in solar-dried grain (SD = 0.94%) than in open sun samples (SD = 1.82%). Solar cabinet drying offers a practical, low-cost improvement over traditional open sun methods for Bangladeshi smallholder farmers.

Keywords: Solar drying, paddy rice, post-harvest losses, head rice yield, grain cracking, drying rate, moisture uniformity, Boro season, milling quality, smallholder farmers

Introduction

Post-harvest losses in rice remain one of the most solvable yet neglected problems in South Asian agriculture. Bangladesh produces over 36 million tonnes of paddy annually, but an estimated 12-14% is lost between harvest and market, with improper drying accounting for roughly half of these losses ^[1]. The Boro season harvest coincides with pre-monsoon hot weather, giving farmers a narrow window to reduce grain moisture from 22-26% down to the safe storage level of 14% ^[2].

Open sun drying on roads and courtyards remains the dominant practice among smallholders, but it exposes grain to contamination, uneven drying, and sudden rain damage ^[3]. Mechanical dryers are effective but too expensive for most small-scale producers. Solar cabinet dryers offer a middle path they use the same energy source as open drying but in a controlled enclosure that raises air temperature by 10-15°C above ambient, speeds moisture removal, and shields grain from dust and animals ^[4, 5].

Grain cracking during drying is a direct cause of reduced head rice yield at milling, which in turn lowers the market price farmers receive ^[6]. The rate and uniformity of moisture removal are the main factors controlling crack formation ^[7]. This research compared open sun drying, a locally fabricated solar cabinet dryer, and shade drying across key quality indicators to determine whether affordable solar drying technology can meaningfully reduce post-harvest losses for Bangladeshi rice farmers.

Research area description

All trials were carried out at the Grain Quality Laboratory and adjoining open field of Bangladesh Agricultural University (BAU), Mymensingh (24.7434°N, 90.4203°E). The site sits on the Old Brahmaputra Floodplain at 18 m elevation. The drying area was a concrete pad (10 × 6 m) adjacent to the laboratory building, free from overhead shading. The solar cabinet dryer a locally fabricated unit with polycarbonate glazing, painted black metal absorber plate, and natural convection venting was positioned on the same pad for identical solar exposure.

Climatic conditions during drying trials

Trials ran from 18 April to 12 May 2023. Ambient temperatures ranged from 29.4°C to 37.8°C during drying hours (08:00-16:00). Relative humidity was 48-72%. Mean solar radiation measured 612 W/m², with peak values reaching 870 W/m² around midday. Inside the solar cabinet, air temperature averaged 12.6°C above ambient. Wind speed was 2.1-4.8 km/h. Two days of intermittent cloud cover occurred during the trial period, which were documented and accounted for in drying rate calculations.

Material and Methods

Material

Freshly harvested BRRI dhan28 paddy with initial moisture of 23.4-25.1% was collected from the BAU research farm within 6 hours of cutting. The solar cabinet dryer (1.2 × 0.8 × 0.6 m) was fabricated at the BAU workshop using locally available materials: galvanized iron frame, 4 mm polycarbonate sheet, and matt black painted absorber. Jute mats and polyethylene sheets were used for open sun and shade drying setups. A Delmhorst G-7 grain moisture meter, digital balance (Shimadzu BL-320H),

and Satake rice mill (THU-35A) were used for quality assessments [8].

Methods

Three treatments were tested: open sun drying (5 cm layer on polyethylene), solar cabinet drying (single layer on mesh trays), and shade drying (under roofed open-sided shelter). Each treatment had four replicates of 10 kg paddy. Grain was stirred every 30 minutes in open sun and shade treatments. Moisture content was recorded hourly. Drying continued until moisture reached 13.5-14.0%. Head rice yield was determined by milling 500 g samples in a Satake mill and separating whole grains (≥3/4 kernel length) from broken [9]. Grain cracking was assessed by examining 200 grains per replicate under a light box. Moisture uniformity was evaluated as the standard deviation of 20 individual kernel moisture readings per replicate [10]. Drying rate was calculated as percentage moisture loss per hour. Data were analyzed with one-way ANOVA and Duncan's multiple range test (p<0.05) using Statistix 10.

Results

Table 1: Drying performance and grain quality parameters across three drying methods

Parameter	Open sun	Solar dryer	Shade	p-value
Drying rate (%/h)	0.78b	1.14a	0.31c	<0.001
Time to 14% MC (h)	13.2b	8.7a	31.6c	<0.001
Head rice yield (%)	58.3c	64.7a	61.2b	0.002
Cracked grains (%)	14.7a	8.3c	11.6b	<0.001
Moisture SD (%)	1.82a	0.94c	1.43b	0.003
Discolored grains (%)	3.8a	1.2c	2.6b	0.008

The solar dryer outperformed both alternatives across all measured parameters (Table 1). It dried paddy to safe moisture 34% faster than open sun and produced 6.4 percentage points

more head rice yield. Grain cracking was reduced by nearly half. Different letters indicate significant differences at p<0.05.

Table 2: Hourly moisture reduction pattern across drying methods

Hour	Open sun	Solar dryer	Shade	Ambient °C	Cabinet °C
0	24.3	24.1	24.2	30.1	42.7
2	22.6	21.8	23.6	32.4	45.8
4	20.8	19.2	22.8	35.7	49.1
6	18.7	16.8	22.1	36.8	50.3
8	16.4	14.3	21.3	34.2	47.6

Moisture removal was fastest during peak solar hours (10:00-14:00) for both sun-exposed methods (Table 2). The solar

cabinet consistently maintained temperatures 12-14°C above ambient, driving more rapid and even moisture extraction.

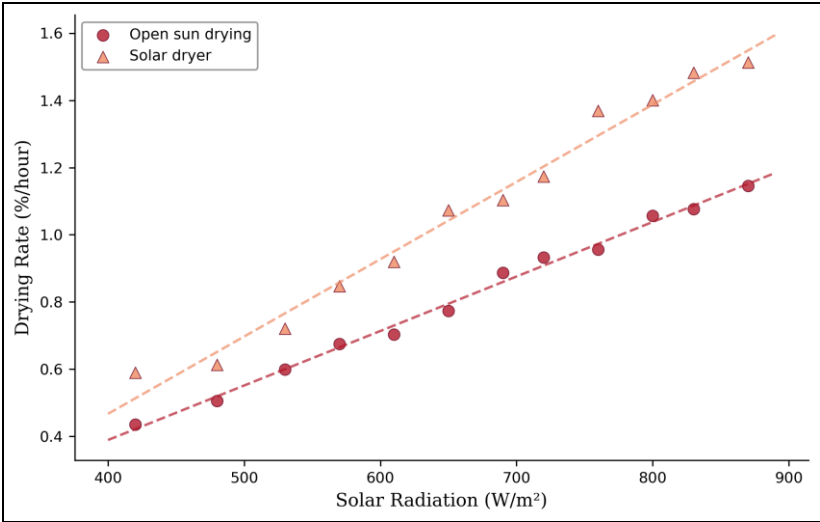


Fig 1: Relationship between solar radiation intensity and drying rate for open sun and solar dryer methods

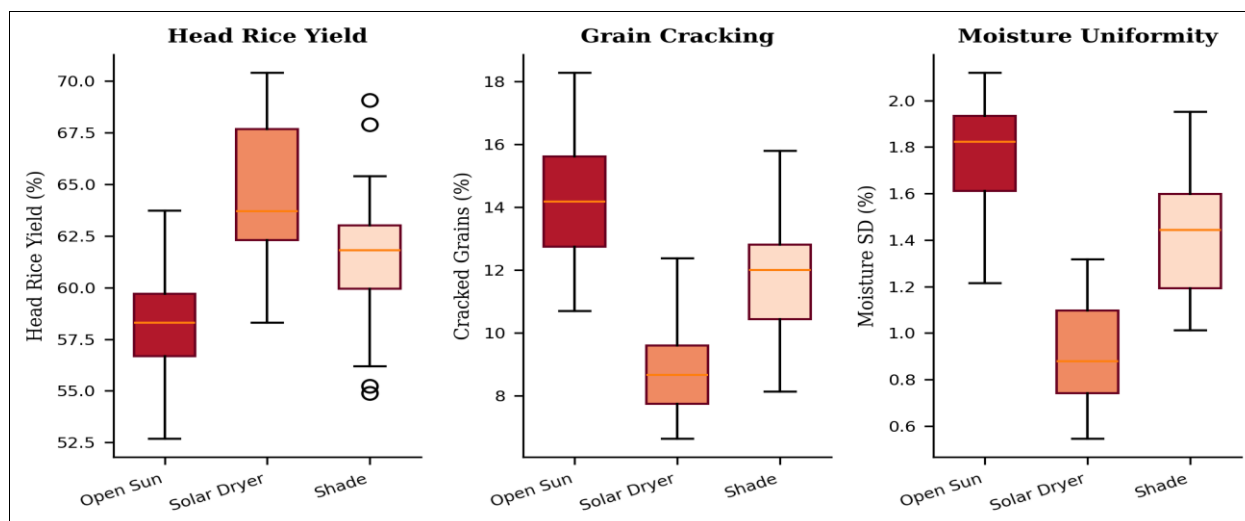


Fig 2: Box plots of head rice yield, grain cracking, and moisture uniformity across three drying methods

Both drying rate and solar radiation showed a strong linear relationship (Figure 1), with the solar dryer achieving consistently higher rates at every radiation level. Box plot distributions (Figure 2) confirm tighter, more favorable quality outcomes for solar-dried paddy across all three indicators.

Discussion

The 46% faster drying rate of the solar cabinet over open sun agrees with findings from similar trials in India and Southeast Asia. Sreekumar *et al.* [4] recorded drying rate improvements of 38-52% for a comparable solar dryer design in Kerala, while Bala and Mondol [11] documented a 41% reduction in drying time for paddy in Mymensingh using a tunnel-type solar dryer. The enclosed environment limits re-absorption of moisture during cloudy spells, which was a recurring issue during open sun trials.

The higher head rice yield (64.7% vs 58.3%) is the most economically meaningful result. In Bangladesh, milled rice price drops by roughly 8-12% for each 5-percentage-point decrease in head rice recovery [12]. The lower cracking rate in solar-dried samples (8.3% vs 14.7%) directly explains this improvement more uniform heat distribution inside the cabinet reduces thermal stress that causes fissures [13]. Shade drying produced intermediate quality, but it's extremely slow rate (31.6 hours to reach safe moisture) makes it impractical for the short drying windows available during Boro harvest season.

Conclusions

Solar cabinet drying proved superior to both open sun and shade drying for paddy rice in terms of drying speed, milling quality, and grain integrity. The technology reduced drying time by 34% compared to open sun methods and increased head rice yield by 6.4 percentage points a difference that translates directly into higher farmer income. Grain cracking was nearly halved, and moisture uniformity was markedly better. The cabinet dryer used in this research was fabricated from locally available materials at a cost accessible to farmer cooperatives, requiring no electricity. For Bangladeshi smallholders facing tight post-harvest windows during the Boro season, solar drying represents a realistic, affordable upgrade from traditional practices. Scaling up this technology through farmer training programs and cooperative-based ownership models could reduce national post-harvest rice losses measurably.

References

1. Kannan E, Kumar P, Vishnu K, Abraham H. Assessment of pre and post-harvest losses of rice and red gram in Karnataka. *Agricultural Economics Research Review*. 2013;26:63-70.
2. Bala BK. *Drying and storage of cereal grains*. 2nd ed. Chichester: John Wiley and Sons. 2017.
3. Gummert M, Quilty J, Hung NV, Vien NP. Engineering and management of rice harvesting. *Rice Production Worldwide*. 2019;387-406.
4. Sreekumar A, Manikantan PE, Vijayakumar KP. Performance of indirect solar cabinet dryer. *Energy Conversion and Management*. 2008;49(6):1388-1395.
5. Jain D, Tiwari GN. Effect of greenhouse on crop drying under natural and forced convection. *Energy Conversion and Management*. 2004;45(5):765-783.
6. Kunze OR. Effect of drying on grain quality. *Cereal Chemistry*. 2008;85(3):305-311.
7. Iguaz A, Rodriguez M, Virseda P. Moisture desorption isotherms of rough rice at high temperatures. *Journal of Food Engineering*. 2006;77(3):460-466.
8. IRRI. *Paddy drying manual*. Los Baños, Philippines: International Rice Research Institute. 2013.
9. Cnossen AG, Siebenmorgen TJ, Yang W. The glass transition temperature concept in rice drying and tempering. *Cereal Chemistry*. 2002;79(4):460-465.
10. Schluterman DA, Siebenmorgen TJ. Relating rough rice moisture content reduction and tempering duration to head rice yield reduction. *Transactions of the ASABE*. 2007;50(1):137-142.
11. Bala BK, Mondol MRA. Experimental investigation on solar drying of fish using solar tunnel dryer. *Drying Technology*. 2001;19(2):427-436.
12. Huda FA, Bose ML, Alam MA. Economic analysis of rice milling in Bangladesh. *Bangladesh Journal of Agricultural Economics*. 2012;35(1-2):59-74.
13. Siebenmorgen TJ, Grigg BC, Lanning SB. Impacts of preharvest factors during kernel development on rice quality and functionality. *Annual Review of Food Science and Technology*. 2013;4:101-115.
14. Fudholi A, Sopian K, Ruslan MH, Alghoul MA, Sulaiman MY. Review of solar dryers for agricultural and marine products. *Renewable and Sustainable Energy Reviews*. 2010;14(1):1-30.