Effect of Pads and Thickness of Paddy on Moisture Removal under Sun Drying

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**ABSTRACT**

**Background:** Sun drying is a popular post-harvest operation to maintain rice quality during the storage period. Farmers use different pads and thicknesses for sun drying of paddy in Ampara district, Sri Lanka. A study was conducted to evaluate the suitability and effectiveness of the drying pad and thickness as practiced by local paddy farmers during the sun drying process.

**Methods:** The grain with an initial moisture content of 28% (dry basis) was sun dried with four types of drying pads and five levels of thickness of grain. This experiment was conducted between 8 am and 4 pm at the South Eastern University of Sri Lanka in August 2020. The moisture contents of the grain were measured at regular time intervals.

**Result:** It was found that the duration of drying of paddy from 28% to 13% moisture content on a dry basis was 300 to 540 minutes depending upon the drying pad and thickness. The tarpaulin is reasonable at shallow thickness with less time to reach the necessary moisture level than other drying pads. Black polythene and fertilizer bag can be utilized for sun drying of paddy at 4 cm thickness with 130 minutes. It was found that with an increase in the thickness of paddy from 0.5 cm to 4 cm, the drying time increases. A statistically significant interaction was obtained between drying pads and thickness level on moisture removal of paddy. Therefore, the moisture removal rate differs with the drying pad and thickness of the paddy under open sun drying.

**Key words:** Drying pad, Drying time, Paddy, Sun drying, Thickness.

**INTRODUCTION**

Open sun drying is one of the cost-effective and popular methods to remove paddy moisture content compared to mechanical drying in South Asian countries. Paddy drying is a highly energy consuming process and significantly affects the milled rice quality, such as head rice yield (Prahayawakon et al., 2005). Furthermore, drying is a critical step during post-harvest practices and inadequate drying contributes to increased post-harvest loss (Kumar and Kalita, 2017). Moreover, poor drying practices may cause 3-5% post-harvest losses of paddy (FAO, 2013). It is also essential to dry the paddy as soon as possible after harvesting, ideally within 24 hours (Wilfred, 2006). Acceptable drying practices are crucial that directly influence safe storage to minimize post-harvest losses (Masood et al., 2018). Therefore, an understanding of the different parameters that farmers can control on drying performance and on the final quality of the dried grain is fundamental, as it can optimize the drying process and maximize the quality and hence the value of the grain (Imoudu and Olufayo, 2000).

The effectiveness of drying varies due to several factors such as variety, harvesting methods, initial and final moisture content and drying methods (Iguaz et al., 2003 and Torki-Harchegani et al., 2014). Sun drying increases the broken rice rate in milling if the grain temperature gets excessively high (Truong et al., 2012). Among these factors, the final moisture content is a critical factor determining rice's self-life during storage and other post-harvest practices. Because respiration in the grain at high grain wetness causes deterioration. High moisture content promotes the pest and disease attack in the grain. In contrast, if the paddy's moisture content is too low, the grains are so fragile when being milled. This can lead to a higher fraction of broken kernels. Keeping the paddy at acceptable moisture content can prolong storage time and prevent mould growth (Cheenkachorn, 2007). Therefore, the required moisture content is 13 to 14% for storage and 10 to 13% for milling (Babamiri et al., 2013).

The drying pad is one of the critical factors determining the drying rate of paddy. Drying pads have been used for sun drying by farmers for easy unloading, loading and least losses. Imoudu and Olufayo (2000) found that sun drying on a concrete floor took a high drawn-out time than on a mat surface even though it produced higher head rice recovery. A similar sun drying experiment was conducted between 8 am to 4 pm in Cambodia to assess the effects of different drying pads (tarpaulin, nylon net, nylon net on husk layer and mat made of sugar palm leaves) and two levels of
bed depth on moisture removal by open sun drying (Meas et al., 2011). Therefore, the drying pad influences the moisture removal rate from the paddy during the sun drying operation.

The thickness of paddy on the drying surface is another crucial factor determining the moisture removal of paddy. Most of the farmers are practicing different thickness levels according to the quantity of paddy, condition of weather and labor availability without an understanding of the drying performances. Too thin layers tend to heat up very quickly, negatively affecting the head rice recovery. On the other hand, deep layers create dry grains on the top and wet grains on the base, which re-adsorbs moisture on subsequent stirring leads to high broken grains (IRRI, 2013). Thus, the paddy has to be dried in optimum thickness during the sun drying operation.

Paddy is dried in an open environment with different conditions in the Ampara district, one of the areas with higher paddy production in Sri Lanka. Different drying pads and thicknesses have been used traditionally depending on the quantity, labor availability and surface area. However, the performance of drying under these conditions has not been studied. Therefore, the objectives of this study were to determine the suitable drying pad and the optimum drying depth during sun drying methods practiced by local paddy farmers in the Ampara District.

MATERIALS AND METHODS
Sample collection and experimental site
Freshly harvested long grain paddy variety (AT 362) that is commonly grown in the region was used in this study. Paddy harvested by combine harvester was procured from the paddy field at Nithavur, Ampara District, Sri Lanka, during the Yala season. The grain sample was transported immediately from the paddy field to the experimental site. The sun drying experiment was conducted between 8.30 am to 4.30 pm in August 2020 at the South Eastern University of Sri Lanka (7°18’00.3"N and 81°51’41.8"E).

Experimental design
The different drying treatments were identified based on the traditional methods used by local farmers. This experiment was designed as a Factorial Randomized Complete Block Design with two factors, different drying pad (4 types) and different bed depth (5 levels) with three (03) replications (Fig 1). Table 1 shows the characteristics of the four drying pads used in this study. Five levels of grain thicknesses, 0.5 cm, 1 cm, 2 cm, 3 cm and 4 cm, were prepared within one-meter square (1m²) wooden frames.

Measurement
The grain’s moisture content was measured hourly using a digital grain moisture meter (Model: LDS-1H) and the paddy was stirred hourly by hand raking. The moisture meter was calibrated by standard hot air oven method using collected paddy sample (ASAE Standards, 1998). The atmospheric temperature and relative humidity were recorded at one hour interval during the drying. All the drying experiments were carried out in triplicate.

Data analysis
All data were subjected to analyze the variance and significant differences among the treatments using SAS, SPSS Version 26 for Windows and OriginLab (2019b).

RESULTS AND DISCUSSION
Effect of different drying pads on moisture removal
The changes in paddy moisture content under the tarpaulin, black polythene, fertilizer bag and hemp sack with day time are shown in Fig 2. Moisture content reduces during the drying period in all drying pads with different thickness levels.

Table 1: Characteristics of drying pads.

| Drying Pads      | Composition                                           | Thickness (mm) |
|------------------|-------------------------------------------------------|----------------|
| Tarpaulin        | Polyester coated with PVC film on either side.        | 1.00           |
| Black polythene  | Low-density polyethylene                              | 0.50           |
| Fertilizer bag   | High-Density Polyethylene/Polypropylene (Binary blend)| 0.40           |
| Hemp sack        | Burlap / hessian fabric                               | 1.50           |

Fig 1: Experimental design.
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Around 12% of moisture content was removed from the paddy between 8.30 am to 12.30 pm in all the treatments and there are no significant differences in moisture removal were observed in all four drying pads after 1.30 pm. Candia et al. (2013) also conducted a similar experiment at the initial moisture content of 22 - 28%. The required moisture content of 14% (dry basis) was obtained in 5 to 9 hours from 28% initial moisture content depending on the type of drying pads used. Kumoro et al. (2019) conducted another similar experiment from 7.00 am to 12.00 noon by evenly spreading rough paddy onto a concrete floor and tarpaulin (white and black) with the rice layer thickness 2 to 5 cm. Hellevang (2004) reported that plastic sheets could result in condensed water and tend to hold them in low places; thus, not suitable for drying pads. In this study, tarpaulin and hemp sack were found suitable at shallow thickness with less time to attain the required moisture level than other drying pads. Black polythene and fertilizer bag are ideal for sun drying with an increased thickness level of paddy.

**Effect of different thickness level on moisture removal**

Fig 3 shows changes in moisture content with day time at different thicknesses of paddy. The moisture removal trend was similar in 0.5 cm and 1 cm thickness in all treatments. Similarly, 3 cm and 4 cm thickness of paddy were shown a similar trend during this experiment. Furthermore, all the drying pads in 1 cm thickness indicated no variation in grain moisture removal in the investigation. Initial moisture removal from 8.30 to 10.30 am under the tarpaulin and black polythene show a significant difference in 3 cm and 4 cm thickness of paddy. Since all paddy depths received the same quantity of solar radiation per unit area and at the same time, the deeper depths needed much more time to reach the recommended milling moisture content. Candia et al. (2013) reported that 7 to 8 days of drying is required for 7 cm thickness.

A similar study conducted in the Philippines reported that the recommended paddy drying depth using the open sun drying method is 2 to 4 cm (IRRI, 2009). Therefore, a suitable thickness of paddy and efficient drying rate in open sun drying depends on the drying pad used.

**Time requirement on required moisture content for storage**

Fig 4 and Table 2 illustrate the time required to obtain the recommended moisture content (14%) of paddy grains with four types of drying pads and five thickness levels. Overall, the time requirement is gradually increasing with the increased level of thickness from 0.5 cm to 4.0 cm in every treatment. The least time required to reach 14% moisture level is at 0.5 cm thickness using four different drying pads, whereas the highest time requirement is at 4 cm thickness. At 0.5 cm thickness, tarpaulin recorded the lowest time (98 minutes), while fertilizer bag required the highest time (156 minutes). Tarpaulin and hemp sack are not suitable with 4 cm thickness in terms of drying time.

Moreover, there was no significant difference observed among the four different drying pads using 1 cm thickness. Black polythene and fertilizer bag showed the lowest time at 2 cm, 3 cm and 4 cm of drying thickness. However, the
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**Fig 4:** Time requirement to obtain the recommended MC.

**Table 2:** Time required to reach 14% moisture content.

| Thickness (cm) | Tarpaulin | Black polythene | Fertilizer bag | Hemp sack |
|----------------|-----------|------------------|----------------|-----------|
| 0.5            | 98        | 126              | 156            | 142       |
| 1              | 139       | 162              | 182            | 148       |
| 2              | 226       | 115              | 120            | 196       |
| 3              | 310       | 134              | 124            | 270       |
| 4              | 351       | 156              | 168            | 420       |
tarpaulin showed less time to reach the target moisture level than the hemp sack drying pad. International Rice Research Institute (2013) reported that the optimum paddy layer thickness is between 2 to 4 cm for open sun drying.

Black polythene and fertilizer bag can be used in paddy drying when the farmers need to dry the paddy with a high thickness level. In contrast, the increased thickness level of paddy under the tarpaulin is not suitable for sun drying. But tarpaulin is the right drying pad when the farmers want to dry the paddy in a shallow thickness level because it will take less time to attain the required moisture level than other drying pads. An increasing trend was observed in tarpaulin and hemp sack from a low level to a high level of paddy thickness, but no significant trend has been kept in black polythene and fertilizer bag.

Interaction effect of drying pad, thickness and time on moisture removal

Interaction between drying pad and thickness on moisture removal was found to be significant (p<0.001) and the relationship between thickness and moisture content also showed a significant (p<0.001) interaction with moisture removal. Similarly, the relationship between drying pad and moisture content also showed a significant (p=0.001) interaction with paddy moisture removal in this experiment. The posthoc test using Duncan’s Multiple Range (α= 0.05) results indicated no significant variation in the moisture removal by using a hemp sack and tarpaulin. Similarly, there is no significant variation in paddy moisture content by using fertilizer bag and black polythene in all the thickness level. Therefore, different drying pads and thickness levels showed moisture removal’s influence under open sun drying.

Effect of atmospheric temperature and relative humidity

Fig 5 shows the variation of atmospheric temperature and relative humidity in the experimental site. Accordingly, weather and high relative humidity range between 29°C - 30°C and 72% - 78%, respectively. Around 12% of moisture content was removed from the paddy between 8.30 am to 12.30 pm in all the treatments. However, there are no significant differences in moisture removal observed in all four drying pads after 1.30 pm. The main reason for fast initial moisture removal before noon is due to high atmospheric temperature and low relative humidity in the experimental site (Fig 5). This is supported by Candia et al. (2013) as external wetness will readily evaporate when the paddy is open to hot air. Still, interior moisture evaporates gently as it has to transfer away from the kernel to the exterior due to surface forces. According to Mujumdar (2004), the mechanism of water evaporation in the material occurs through heat and mass processes simultaneously. The time taken to reach the required moisture content of paddy is ranged from 5 to 9 hours, depending on the air temperature and relative humidity in the experimental site.

CONCLUSION

Drying performance significantly varies with the drying pad and thickness of the paddy. The time requirements to reach the required moisture content with black polythene and fertilizer bag were 120 to 156 minutes, respectively, from 28% initial moisture content (dry basis). Tarpaulin was found suitable at shallow thickness with a less amount of time compared to other drying pads. In contrast, the tarpaulin drying pad is not ideal for sun drying for paddy’s high thickness. The time required to reach the required moisture content has increased with the increasing thickness level in tarpaulin and hemp sack. There is no significant trend observed in black polythene and fertilizer bag with thickness. Black polythene and fertilizer bag can be used for sun drying of paddy at 4 cm thickness with 130 minutes duration under a sunny day. A statistically significant interaction was obtained between drying pads and thickness level on moisture removal of paddy.

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