

Drying of paddy seed using flat bed drier

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Abstract

This study was conducted to evaluate the field level performance of a flat bed drier. The flat bed drier installed at Agriculture farm, Bangladesh Agricultural University, Mymensingh, was used to investigate the performance of the dryer for drying of paddy seed. The drier consists of an axial fan, a biomass furnace and a drying bin with perforated floor. Two sets of full scale experimental runs on drying of paddy seed were carried out in the month of May, 2007 and 2008. During drying ambient temperature, relative humidity, inlet air temperature and air flow rate were measured at fifteen minutes interval and three samples were collected to measure the moisture content at one hour interval. The performance of the dryer was evaluated in terms of the drying rate, specific energy utilization, drying efficiency and operational cost, pay back period and quality of dried paddy seed. The paddy seed was dried from 23.3 to 15% moisture content (wb) within 8 hours using inlet air temperature in the range of 37 - 42°C and air flow rate in range of 0.18 - 0.23 m/s. The specific energy utilization, drying efficiency and operational cost were 454 kJ/kg, 74% and Tk. 0.41/kg respectively. Pay back period of the drier is about three months for drying seed paddy and about 14 months for drying paddy for consumption. The germination percentage and viability of dried paddy seed were 71% and 96.6% respectively. The drier was found suitable for drying of paddy seed in Bangladesh especially during rainy season.

Key words: Flat bed drier, Paddy seed, Drying efficiency, Biomass fuel, Germination

1. Introduction

The quality of seed is important for increased agricultural production. Good seed means good harvest. There is a lack of quality seed in Bangladesh. Only 15% of total paddy seed used in Bangladesh is of quality seed. Bangladesh Agricultural Development Corporation (BADC), various NGOs and private sectors produce quality seed of high price. Drying is an important post harvest operation for production of quality seed and a package of drying technology is essential for production of high quality seed at reasonable cost.

One of the important factors affecting the quality of seed is the moisture content and it must be in the suitable range (14% wb or less) for long-term storage. Too high moisture leads to deterioration in seed quality as a result of the growth of microorganisms and premature germination. In contrast, too low moisture can cause unnecessary energy consumption and seed cracks during the drying process.

Inappropriate drying condition may cause seed injury. A number of researchers have tried to determine the optimum drying condition for production of good quality seeds. Different kinds of seeds may have dissimilar optimum

drying conditions. Hebblethwaite (1980) pointed out that the response of seed grain to hot air drying depends on species and variety, moisture content, exposure time and the drying technology. McDonald and Copeland (1997) suggested that a drying air temperature of 43°C is accepted as the safe upper limit for drying of most of the seeds without damage. According to Soponronnarit (1997), the temperature of drying air for seeds should not be over 43°C. Arora *et al.* (1973) investigated the effect of drying air temperature on the viability of shelled maize seeds. They established that maize in the moisture content range of 17-25 % is subjected to 30 minutes of drying by air at temperature below 60°C; the germination does not decrease below 90%. McDonald and Copeland (1997) recommended that the drying temperature for rice seed should not exceed 35°C. Likewise, Madamba and Yabes (2005) studied the effect of drying air temperature in the range of 35 - 55°C on the germination percentage of rice seeds. They found that the germination percentage of the dried seeds tended to increase when using lower drying air temperatures, with the highest value of 92% in the case of 35 °C drying air temperature. However, Wong (2004) affirmed that drying rice seeds from 18 % (wb) to final moisture content of 13, 12 and 10 % (wb) with

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40°C air temperature by heat pump dryer gave quality rice seeds. Furthermore, Owuor (2002) postulated that although lower temperature and moderate time of heat treatment generally resulted in higher seed viability than high temperature. They observed that the heat treatment at 50°C for 45 minutes led to the highest value of rice seed germination. Jittanit (2007) reported that the drying air temperature of 40°C is safe for corn and rice in fluidised bed drier while 60°C is acceptable for wheat and also 40°C is the maximum drying temperature for rice and wheat without quality deterioration in spouted bed drier. Drying of seeds should be performed at low temperature to save germination capability of the seeds (Imre *et al.*, 1990). High quality seed production requires proper drying and storage of the seed.

Rice, wheat and maize are the major cereal grains in Bangladesh. At present, the low quality of the seeds of these crops is an important problem facing by a large number of farmers. Some varieties of rice are harvested in rainy season, leading to high moisture content and risk of spoilage. A large number of farmers in Bangladesh experience seed quality losses due to delayed or improper drying caused by the lack of knowledge and adequate drying facilities. Hien *et al.* (1997) found that 85% germination for rice seed dried in the dryer, compared with 70% for that produced by sun drying. So adoption and application of mechanical dryers for drying of paddy seed is important.

The purpose of this study was to investigate the performance of a flat bed drier for drying of paddy seed using biomass fuel (wood, rice husk etc.) and to determine the viability and germination percentage of paddy seed dried by the drier and to assess the drying efficiency and economics of energy utilization.

2. Materials and Methods

A 4 ton flat bed drier installed at the Agriculture farm of Bangladesh Agricultural University, Mymensingh was used to investigate the performance of the dryer for drying of paddy seed. Dimension of the grain bed was 8m x 3m. Two sets of full scale experimental runs on drying of paddy for seed were carried out in the month of May, 2007 and 2008. This farm produced seeds for Bangladesh Agricultural Development Corporation

(BADC). The variety of the paddy was BR-29. In first year test, the paddy for seed was dried from a moisture content of 23.3 to 15% (wb) while during second year test that was dried from 23.0 to 13% (wb).

The schematic diagram of the flat bed dryer is shown Fig 1. The flat bed drier consists of an axial flow fan; a biomass furnace and a drying bin with perforated floor. The axial flow fan of 750 mm rotor diameter can be used to provide required air flow using either a 12 hp diesel engine or by an electric motor of capacity 7.5 kW. This fan can provide an air flow of 4 m³/s against 30 mm WG of static pressure. The biomass furnace has a cylindrical combustion chamber and it requires 20 kg of rice husk per hour to provide the heat for the required drying air temperature. The drying bin has a perforated floor with a side main air duct. This drier can be used to dry four tons of paddy seed per batch from 26% MC (wb) down to 14-15% in 7-8 hours.

2.1 Seed drying test

Important parameters affecting the performance of the drier were measured. The k-type thermocouple was used to measure the drying air temperature at the inlet of the drier and in different layers of the grain bed. The ambient temperature and relative humidity of air were measured with a digital thermometer and relative humidity meter respectively. The air flow rate was measured with an anemometer at the exit from the grain surface. During experiment ambient temperature, relative humidity, inlet air temperature and air flow rate were measured at fifteen minutes interval and three samples of dried paddy seed were collected from three layers (surface, middle and bottom) of the grain bed to measure the moisture content at one hour interval. To measure the initial moisture content of the paddy seed samples were collected in similar way. Then the moisture content of each sample was determined by air oven method at 130°C for 16 hours (Bala, 1997). In each sample 20g paddy seed was used. The samples were weighed using a digital electronic balance.

2.2 Seed quality test

The seeds collected from each experimental runs were tested to determine their viability and germination percentage. Tetrazolium test and standard germination test were carried out to determine viability and germination percentage respectively.

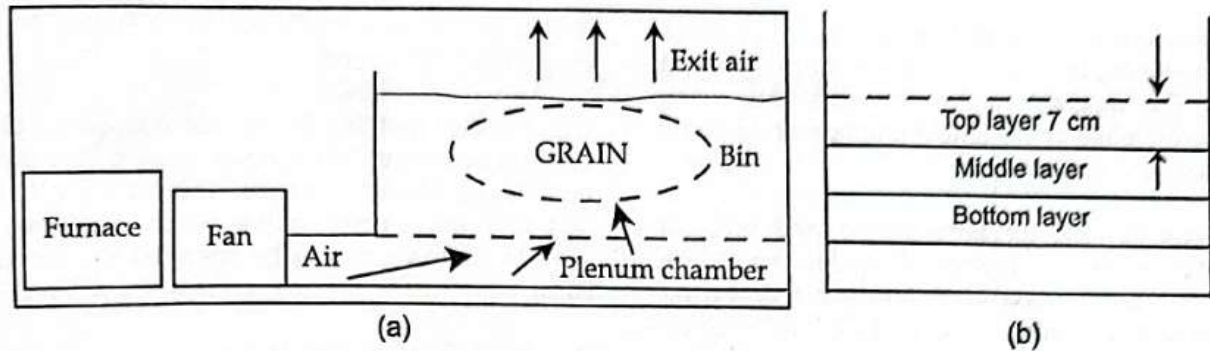


Fig. 1. Schematic of the (a) flat bed dryer and (b) gain bed layers

In tetrazolium test viability of paddy seed was determined by using 0.1-0.5% tetrazolium solution. For this test at first the paddy seeds were soaked in water for overnight to allow absorption of water to soften the embryo and endosperm and active the enzyme system. Seeds coats were then removed to expose the embryo and to facilitate the contact of the embryo with tetrazolium solution. The seeds were then put in tetrazolium salt solution and left for 2 hours. After 2 hours the seeds were examined under magnifying glass. Red color or purple color of the embryo indicates the living seed and colour less embryo indicates dead seed.

In standard germination test the seed samples were kept in aluminum dishes under ambient condition overnight in order to equilibrate with the ambient temperature and reduce the stress within the seed. The standard germination test was conducted by placing seed samples on moist sand trays. Three replications of 100 seeds were taken for each sample. The trays with samples were left under room temperature to germinate. The seeds that had root or shoot longer than 2 mm were considered as germinated seeds. Germinated seeds were counted after 3, 7, 10 and 12 days.

2.3 Specific energy utilization

Specific energy utilization for drying is defined as the sum of electrical and fuel energy used per unit mass of dried paddy seed and this can be expressed as

$$SEU = (m_f HV_f + E) / m_p \dots \dots \dots (1)$$

where

- SEU = specific energy utilization, MJ/kg dried paddy
- m_f = mass of fuel used, kg
- HV_f = heat value of fuel, MJ/kg.
- E = electrical energy used, MJ
- m_p = mass of dried paddy, kg

2.4 Drying efficiency

Drying efficiency is defined as the heat used to evaporate moisture from the grain divided by the heat input and this can be expressed as

$$\eta = m_w \times L / (m_f HV_f + E) \dots \dots \dots (2)$$

- where, η = drying efficiency, %
- m_w = mass of water removed, kg
- L = latent heat of evaporation (J/kg)

2.5 Economics of the drier

2.5.1 Cost index

The cost index is the operating cost divided by weight of dried paddy seed operating cost includes fuel, electricity and labour costs.

$$\text{Cost index, } I = C / m_p$$

Where, (3)

- I = cost index, Tk./kg dried paddy
- C = operating cost (i.e. sum of fuel, electricity and labour costs)

2.5.2 Pay back period

Pay back period of the flat bed dryer is the time required to get back the fund utilized to purchase the drier and this can be expressed as

$$\text{Pay back period} = \text{Initial investment} / \text{Annual net undiscounted benefits}$$

Depreciation was calculated using Straight- Line method

3. Results and Discussions

Two field tests were conducted to study the performances of the flat bed drier for drying of paddy seed. The performances of the dryer were evaluated in terms of the drying rate, drying efficiency, specific energy utilization, operational cost, pay back period and quality of dried paddy seed.

The variations of ambient temperature and relative humidity during drying of paddy seed are shown in Fig 2. The ambient relative humidity decreased with the increase in the ambient temperature and it is logical.

Variations of inlet air temperature and ambient temperature during drying of paddy seed are shown in Fig. 3. Maximum permissible drying air temperature for paddy seed is 43°C and inlet air temperature of the dryer was maintained within the range of 37-42°C, while the ambient temperature varied within the range of 25-32°C. As the inlet air temperature was maintained manually, there was a fluctuation in temperature in the different layers of the grain bed and these are shown in Fig. 4. There

is little difference in the temperature in the different layers in the grain bed.

Fig. 5 shows that the airflow rate through the grain bed (measured at the surface layer) during drying period was almost constant. This was due to the fact that the electric motor which was used to provide air flow can only be operated at a constant RPM.

During the first test, the paddy seed was dried from a moisture content of 23.3 to 15% (wb) while during second test the paddy seed was dried from 23.0 to 13% (wb). The variations of average moisture content with drying time are shown in Fig. 6. It takes 7 – 8 hours to reduce the moisture content to 13 % (wb).

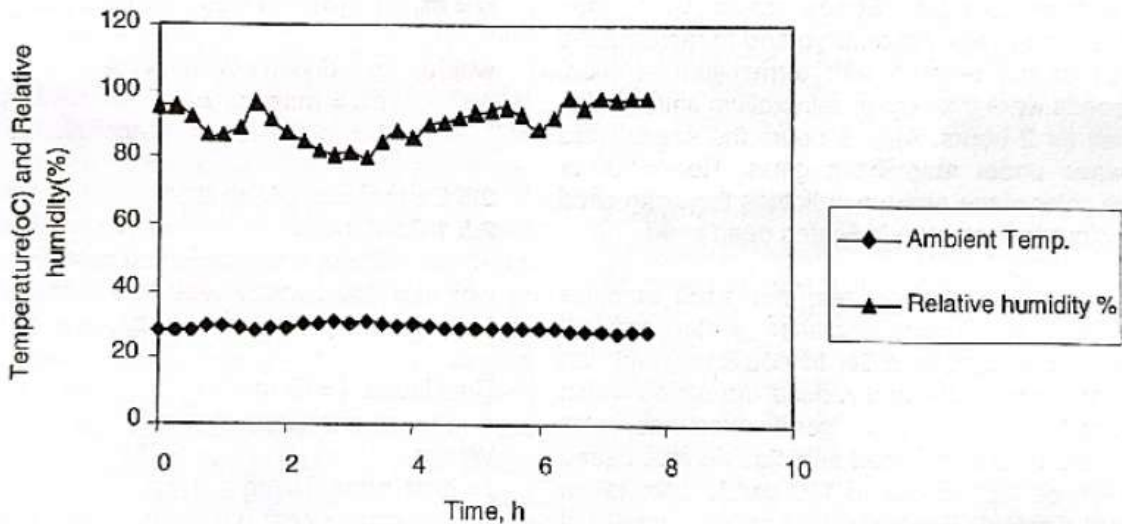


Fig. 2. Variations of ambient temperature and relative humidity during drying of paddy seed

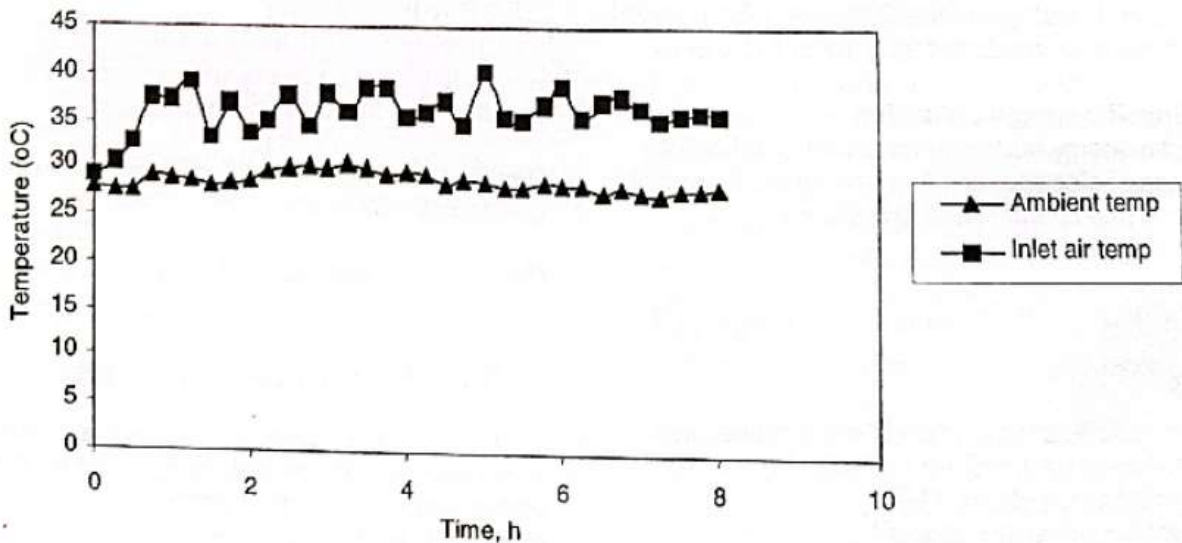


Fig. 3. Variations of drying air temperature in the drier and ambient temperature

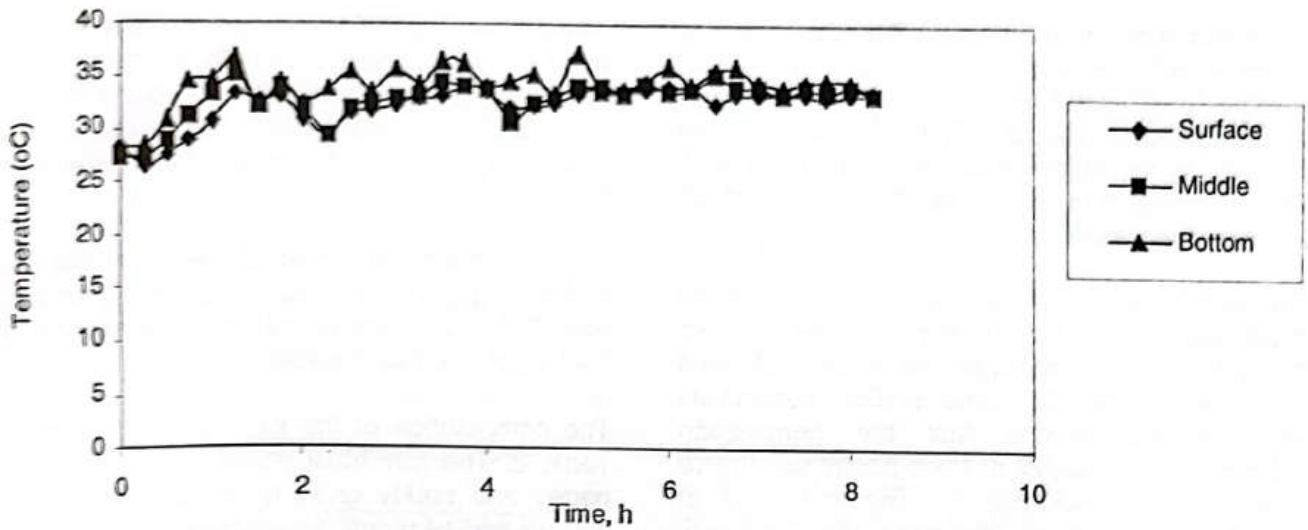


Fig. 4. Variations of temperature of the different layers of the grain bed

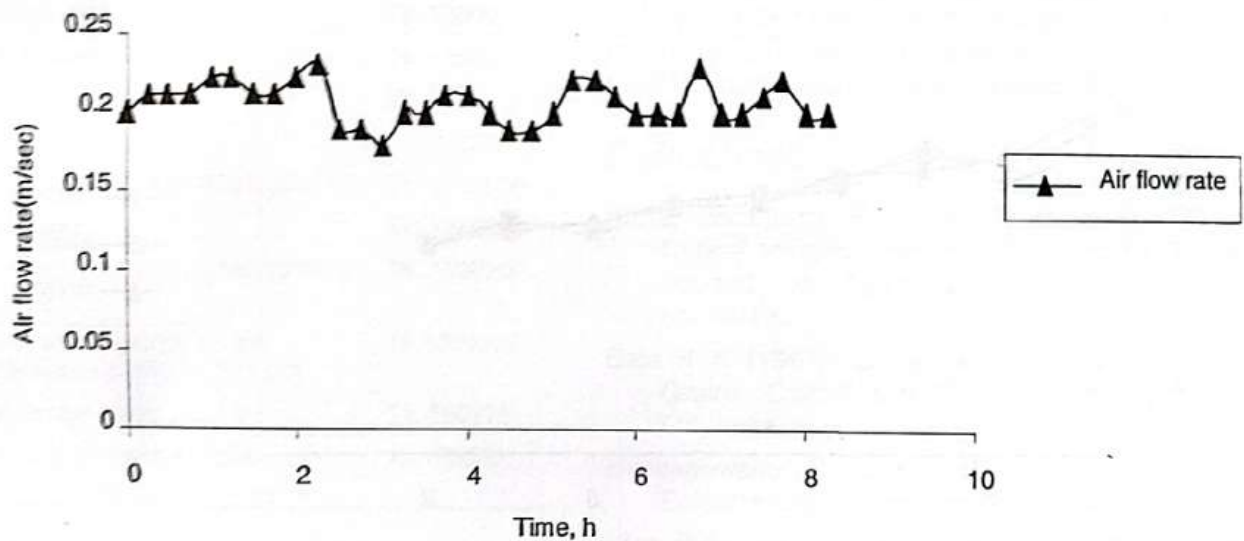


Fig. 5. Variations of air flow rate through the grain in the drier

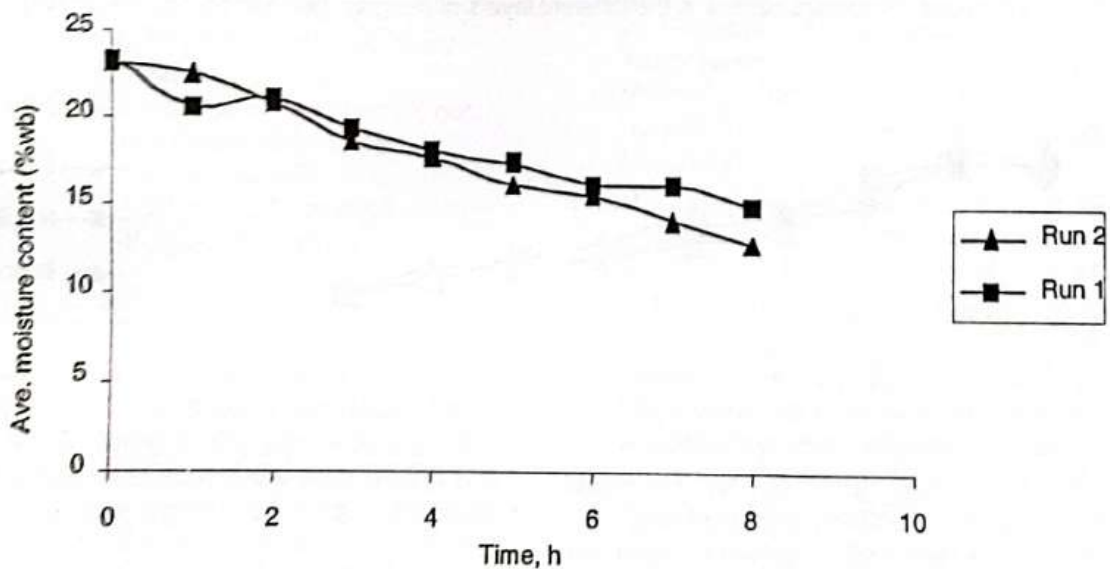


Fig. 6. Variations of moisture content with drying time.

Variations of moisture content in the different layers of the grain bed with drying time are shown in Fig. 7 and 8 for 1st and 2nd runs respectively and there is no significant difference between the moisture contents in the different layers of the grain bed. This is mainly due to mixing of the grain at an interval of two hours.

The germination percentage and viability of dried paddy seed are shown in table 1. In the first test the germination percentage and viability of dried paddy seed were 71% and 96.6% respectively while in the second test the germination percentage and viability of dried paddy seed were 77% and 100% respectively. The low value of germination percentage was due to the dormancy of dried seed. The dried seed was a mixture of

different varieties of paddy seed in the first case while it was a single variety in the second case. Moreover the wet paddy after threshing was piled up for 24 hours. These might be the causes in the difference of germination percentage between the two tests.

Specific energy utilization of the drier was found 454 kJ/ kg of dried paddy seed, drying efficiency was 74% and operational cost index was Tk. 0.41/kg of dried paddy seed.

The computation of the back period is shown in Table 2. The pay back period for drying of seed paddy and paddy grain for consumption were 3 months and 14 months respectively.

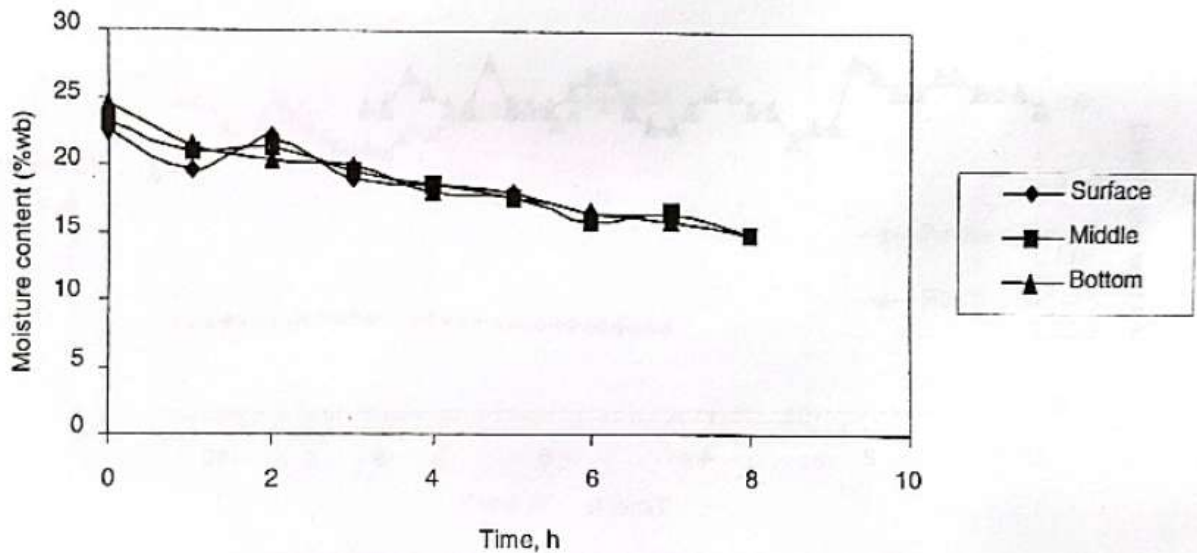


Fig. 7. Variations of moisture content in the different layers of the grain bed with drying time (1st run)

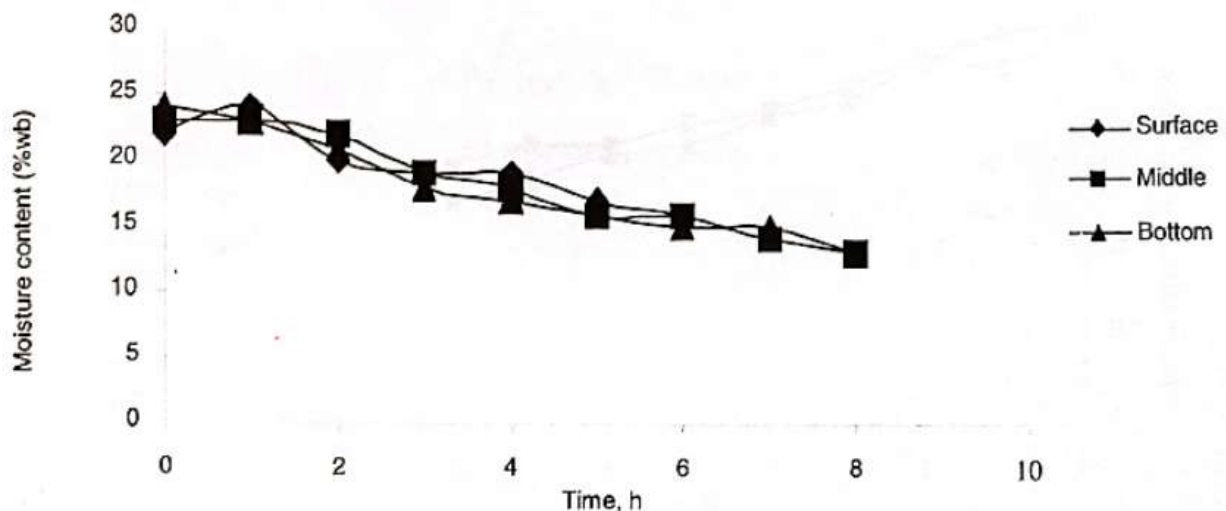


Fig. 8. Variations of moisture content in the different layers of the grain bed with drying time (2nd run)

Table 1. Germination percentage and viability of dried paddy seed

| Run | Germination percentage | | | Viability test | | |
|-----|------------------------|---------|--------------------|----------------|-------------|--------------------|
| | Value | Average | Standard deviation | Value | Average (%) | Standard deviation |
| 1 | 71 | 71 | 0.88 | 10 | 96.6 | 0.47 |
| | 70 | | | 10 | | |
| | 72 | | | 9 | | |
| 2 | 77 | 77 | 0.88 | 10 | 100 | 0 |
| | 78 | | | 10 | | |
| | 76 | | | 10 | | |
| | 76 | | | 10 | | |

Table 2. Computation of pay back period of the drier

| | | |
|----|---|--------------------|
| 1 | Drier cost | Tk. 150000 |
| 2 | Expected life | 10 year |
| 3 | Salvage value | Tk. 15000 |
| 4 | Depreciation | Tk. 13500 |
| 5 | Maintenance | Tk. 3000 |
| 6 | Operational cost | Tk. 31930 |
| 7 | Cost of raw paddy (4000 x 20 x 15) | Tk. 1200000 |
| 8 | Total cost | Tk. 1248430 |
| 9 | Total income (seed paddy) (3460 x 20 x 26) | Tk. 1799200 |
| 10 | Total income (paddy of rice consumption) (3460 x 20 x 20) | Tk. 1384000 |
| 11 | Net income (seed paddy) | Tk. 550770 |
| 12 | Net income (paddy of rice consumption) | Tk. 135570 |

Pay back period = Initial investment/ Annual net undiscounted benefits
 = 150000/ 550770
 = 0.27 year \approx 3 months (seed paddy)

Pay back period = Initial investment/ Annual net undiscounted benefits
 = 150000/135570
 = 1.10 year \approx 14 months (paddy of rice consumption)

4. Conclusions

Two full scale field level drying tests for paddy seed were conducted. The inlet air temperature varied from 37 to 42 °C during drying period and air flow rate was maintained at almost 0.2 m/s. During first test, the paddy seed was dried from a moisture content of 23.3 to 15% (wb) while during second test, the paddy seed was dried from 23.0 to 13% (wb). Total drying time was about 8 hours. Specific energy utilization was 454 kJ/ kg of dried paddy,

drying efficiency was 74% and operational cost was Tk. 0.41/kg of dried paddy. The pay back period of the dryer for seed paddy and paddy for rice consumption were 3 months and 14 months respectively. The germination percentage and viability of dried paddy seed were 88 % and 100 % respectively. This drier is suitable for drying paddy seed in Bangladesh especially during rainy season.

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