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Drying Capacity Calculator Program for Paddy Using Sun Drying and Flatbed Drying Methods

Reina Joy L. Rome, Catherine S. Samson, and Nemesio A. Macabale, Jr.

College of Engineering, Central Luzon State University, 3120 Science City of Muñoz, Nueva Ecija, Philippines

Email for correspondence: rome.reinajoy@clsu2.edu.ph

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Abstract

Studies have been conducted on developing software programs and applications using C language to simulate drying methods particularly in paddy rice. However, these studies focused on the design and simulation of different drying parameters using specific drying methods. Therefore, this project developed a software program calculator as a simple tool on calculating the drying capacity using sun drying and flatbed drying methods.

The study used four target moisture content to calculate the drying capacity based on different input parameters on each drying method. Results revealed that the higher the desired moisture content of paddy, the higher the drying capacity obtained in both sun drying and flatbed drying methods. In terms of drying time, result showed that the longer the drying time, the lower the drying capacity of paddy in both drying methods. Furthermore, it was concluded that the program calculator was able to calculate the final weight, drying weight loss, drying time and drying capacity of paddy in both sun drying and flatbed drying methods.

Key Words: program calculator, drying capacity, sun drying, flatbed drying

Introduction

Rice production in the Philippines is an important aspect of the country's food supply and economy. The Philippines is the 8th largest rice producer in the world, accounting for 2.8% of global rice production (FAO, 2011). There have been various researches and studies that concern different aspects of rice production such as planting, cultivation, management, harvesting and even the post-harvest handling, aiming to improve the yield and also the quality of any variety. According to the International Rice Research Institute, of all post-harvest procedures of rice, drying is the most critical as it maintains the grain quality and lessens the losses. In drying, it is expected that the water that is loosely held will be removed most easily. Thus, it would be expected that drying rates would decrease as moisture content

decreases, with the remaining water being bound more strongly as its quantity decreases. Delays in drying, incomplete drying or ineffective drying will reduce grain quality and result in losses. Hence, reducing grain moisture to a safe level for storage has to be considered.

In today's scenario, there are lots of invented drying technologies used for drying rice, aside from the traditional sun drying, which will support them to be more efficient. There is no ideal dryer for drying rice since each drying method has its advantages and disadvantages. For that, they need to understand the basic concept and considerations such as moisture content, drying weight loss, drying time and drying capacity. On the other hand, ICT technologies are evidently transforming agricultural techniques and are now widely used and adopted in agricultural research. By using ICTs in the agriculture sector, the traditional ways have been reformed, thus significant improvement specifically in productivity and sustainability has been attained.

Therefore this study was undertaken to develop a simple program, with application of ICT, that calculates the drying capacity and drying time with the corresponding weight loss for both sun-drying and flatbed drying methods. Through this application, a simple calculator or tool that allows a user to estimate the drying capacity, drying weight loss and drying time needed to attain the desired moisture content of paddy rice was developed. The development of the drying capacity calculator program will provide local farmers a way to easily determine the drying capacity of both sun dryer and flat bed dryer given a specific volume/weight and moisture content of paddy and to estimate the drying weight loss and required time in drying rice paddy with their desired moisture content according to purpose.

Limitations of the Project/Program

The developed program was focused on the calculation of the drying capacity, operating time needed for the specific drying process of paddy rice and at the same time, to calculate the grain weight loss during the drying process based on the change in moisture content. Assumed values for initial moisture content at harvest time range from 20%-25% (based on IRRI data on paddy rice drying) and preferred final moisture content depends on the specific purpose, which is shown in the table below.

Table 1. Required Moisture Content for Safe Storage

Purpose	Required MC	Potential Problems
Weeks to a few months storage	14% or less	Molds, discoloration, respiration loss, insect damage, moisture adsorption
8 to 12 months storage	13% or less	Insect damage
Farmer's seeds	12% or less	Loss of germination
Storage for more than 1 year	9% or less	Loss of germination
For milling	14%	If the MC is too low, high grain breakage will occur resulting in low head rice recovery.

Materials and Methods

The design/plan of the project was developed to achieve the objectives considering all the provided limitations. The design and the program itself was developed to calculate and determine the drying capacity, drying weight loss and the appropriate drying time in attaining the desired moisture content of paddy rice using two methods of drying: sun drying and flatbed dryer.

Conceptual Framework of the Project

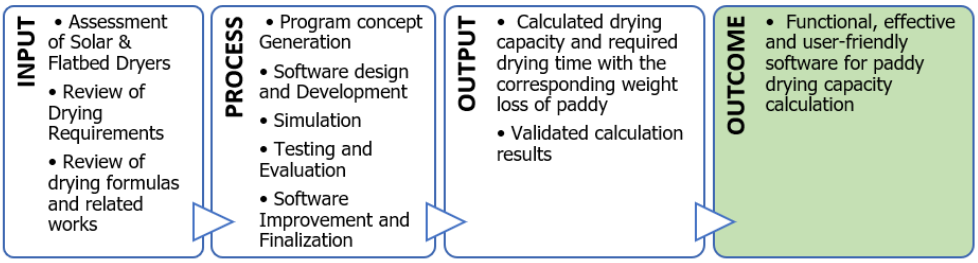


Figure 1. Conceptual Framework

Data Gathering

The project considered two different existing drying methods – sun drying and flatbed drying. Assessment of both drying methods was carried out to further investigate the required drying parameters and processes involved in the adoption of these drying methods. Further, all data gathered useful for the project including the drying formulas, standard values, drying requirements and other necessary data were consolidated for reference. These data were utilized in considering the drying requirements and were incorporated in the software development. Specific drying requirements necessary for the simulation were also identified based on previous studies conducted on the actual sun and flatbed drying. From thereon, drying formulas and parameters were established for each drying method.

Calculations

Below are the formulas consolidated from journals and studies of the International Rice Research Institute (IRRI) which were used and incorporated in the design of the software program. The same formulas were also used in the manual calculation for comparison of results. Tables 2 shows the various standard values used in the design and creation of the program. These data were gathered accordingly from reliable related works.

- Calculating Drying Weight Loss:

$$w_f = w_{i\,x}\,\frac{100 - MC_i}{100 - MC_f}$$

where

w_i = Initial Weight (kg)
w_f = Final Weight (kg)
MC_i = Initial moisture content (%)
MC_f = Final moisture content (%)

- Calculating moisture content from wet weight and dry weight:

$$MC_{wb} = \frac{w_i - w_f}{w_i} \; x \; 100$$

$$MC_{db} = \frac{w_i - w_f}{w_f} \; x \; 100$$

where

$MC_{wb} = Moisture\ content\ wet\ basis\ (\%)$
$MC_{db} = Moisture\ content\ dry\ basis\ (\%)$
w_i = Initial Weight (kg)
w_f = Final Weight (kg)

- Calculating Final Weight:

$$w_f = \frac{(w_i) x\ (100 - MC_i)}{(100 - MC_f)}$$

where

w_i = Initial Weight (kg)
w_f = Final Weight (kg)
MC_i = Initial moisture content (%)
MC_f = Final moisture content (%)

- Calculating Drying Time:

$$r_c = \frac{w_o - w_c}{t_c}$$

where

$r_c = constant\ drying\ rate$
$w_o = initial\ moisture\ content$
$w_i = final\ moisture\ content$
$t_c = drying\ time$

- Calculating Drying Capacity:

$$\frac{Initial\ Weight\ (kg)}{Drying\ Time\ (hr)}$$

Table 2. Standard Values for Sun drying and Flatbed Drying Method

Sun Drying			
MCi (%)	MCf (%)	Wi (kg)	Dr (%/hr)
25	14	6000	1
24	14	6000	1
23	14	6000	1
22	14	6000	1
21	14	6000	1
20	14	6000	1
25	13	6000	1
24	13	6000	1

Flatbed Drying			
MCi (%)	MCf (%)	Wi (kg)	Dr (%/hr)
25	14	6000	0.8
24	14	6000	0.8
23	14	6000	0.8
22	14	6000	0.8
21	14	6000	0.8
20	14	6000	0.8
25	13	6000	0.8
24	13	6000	0.8

23	13	6000	1	23	13	6000	0.8
22	13	6000	1	22	13	6000	0.8
21	13	6000	1	21	13	6000	0.8
20	13	6000	1	20	13	6000	0.8
25	12	6000	1	25	12	6000	0.8
24	12	6000	1	24	12	6000	0.8
23	12	6000	1	23	12	6000	0.8
22	12	6000	1	22	12	6000	0.8
21	12	6000	1	21	12	6000	0.8
20	12	6000	1	20	12	6000	0.8
25	9	6000	1	25	9	6000	0.8
24	9	6000	1	24	9	6000	0.8
23	9	6000	1	23	9	6000	0.8
22	9	6000	1	22	9	6000	0.8
21	9	6000	1	21	9	6000	0.8

MCi = Initial moisture content
MCf = Final moisture content
Wi = Initial Weight (maximum capacity of flatbed, same weight used in sundrying)
Dr = Drying Rate

Experimental Set-up and Methods of Evaluation

Experimental Set-up

The concept for the program was generated prior to software development. Software development includes the program coding using a C program language. For the process of development, program codes were created incorporating the data gathered necessary in the execution of the program.

The simulation process was then executed to initially process the data and improve the software. To ensure that the program is working and the simulation implementation is correct, the program was tested and its result was evaluated. Evaluation was done through comparison of program output to results of manual computation. The program was also finalized to address errors and malfunction during testing.

Sequence Diagram of the Program Calculator

As shown in Figure 2, the simulation process commenced by selecting the drying method which is either solar or flatbed drying. To calculate the drying time in each drying method, assumed values for specific drying parameters were entered. The calculator program then initialized to calculate drying time with the corresponding weight loss given the specific values entered.

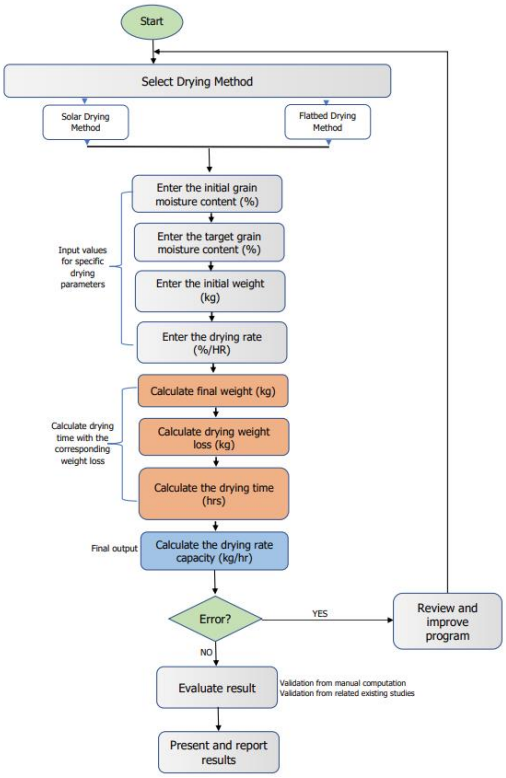


Figure 2. Sequence Diagram of the Simulation Program Calculator

C' Program Source Code for Drying Capacity Calculator

The codes for the program "Drying Capacity Calculator Program for Paddy Using Sun Drying and Flatbed Drying Methods" were established using different formula based on the related works cited and another relevant references.

```
/*Drying Capacity Calculator Program for Paddy Drying
 Using Solar and Flatbed Drying Methods */
//Dr. Nemecio Macabale Jr, Engr. Reina Joy L. Rome, Engr. Catherine S. Samson//
//Central Luzon State University//

#include <stdio.h>
#include<conio.h>
#include<math.h>

int main (){

float MCi, MCf, Wi,cdr;
float Wf, WL, DT, DC;

int choice;
printf("\n1:Calculate the drying capacity using sun dryer:");
printf("\n2:Calculate the drying capacity using flatbed dryer:");
printf("\nEnter your choice (1,2):");
scanf("%d", &choice);
```

```
if (choice == 1){
   printf("\nEnter the value of initial moisture content (in percent):");
   scanf("%f", &MCi);
   printf("Enter value of final moisture content(in percent): ");
   scanf("%f", &MCf);
   printf("Enter value of initial weight (kg): ");
   scanf("%f", &Wi);
   printf("Enter value of constant drying rate (percent/hr):");
   scanf("%f", &cdr);
   /*Final weight*/
   Wf=Wi*(100-MCi)/(100-MCf);
   printf("\n\t\t The final weight (kg) \Wf: %.2f",Wf);
   /*weight loss quantity*/
   WL=(Wi-Wf);
   printf ("\n\t\t The weight loss quantity (kg) \WL:%.2f",WL);
   /*Drying Time*/
   DT =(MCi-MCf)/cdr;
   printf ("\n\t\t The drying time (hrs) \DT:%.2f",DT);
  /*Drying capacity*/
   DC=(Wi/DT);
   printf ("\n\t\t\t The drying capacity (kg/hr) \DR: %.2f",DC);

}
else if (choice == 2){
   printf("\nEnter value of initial moisture content (in percent):");
   scanf("%f", &MCi);
   printf("Enter value of final moisture content(in percent): ");
   scanf("%f", &MCf);
   printf("Enter value of initial weight (kg): ");
   scanf("%f", &Wi);
   printf("Enter value of constant drying rate (percent/hr):");
   scanf("%f", &cdr);
   /*Final weight*/
   Wf=Wi*(100-MCi)/(100-MCf);
   printf("\n\t\tThe final weight (kg) \Wf: %.2f",Wf);
   /*weight loss quantity*/
   WL=(Wi-Wf);
   printf ("\n\t\tThe weight loss quantity (kg) \WL:%.2f",WL);
   /*Drying Time*/
   DT =(MCi-MCf)/cdr;
   printf ("\n\t\tThe drying time (hrs) \DT:%.2f",DT);
  /*Drying capacity*/
   DC=(Wi/DT);
   printf ("\n\t\t\tThe drying capacity (kg/hr) \DR: %.2f",DC);
}
else {
printf("You have entered an invalid input! Please select 1 or 2 only!\n");
```

```
}
return 0;
}
```

Testing and Evaluation

Testing and evaluation were done to assess if the program works and runs accordingly. Each process included was tested and evaluated from beginning to end. The following was done for the evaluation process:

1. Build and run the program to check on errors and inappropriate codes included.
2. Check and confirm all variables and formula included in the program.
3. Let the user run the program and perform calculation for both sun drying and flatbed drying methods following commands.
4. Allow the user to enter values from the keyboard for both methods.
5. Perform calculation using the values provided by the user.
6. Display the result for each calculation.
7. Perform a manual computation for both drying methods for comparison and of results.
8. Compare and state increment of results for total drying time and total weight loss from two calculation methods performed.

Data for Comparison

Input values included in the design of the program was also used to do the manual calculation. As part of the evaluation methods, comparison between program output and results of manual calculation was done for the assessment of reliability of the developed program. Table 3 showed the input values with the corresponding values attained from manual computation for sun-drying and flatbed drying methods, respectively. The focus of the comparison for both program and manual calculation output was on the total drying time and total weight loss during the whole duration of drying process.

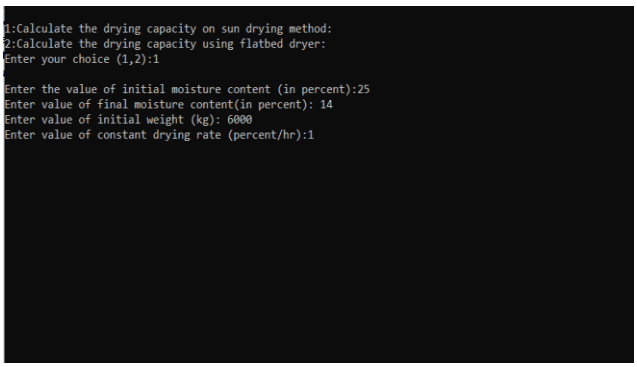
Table 3. Table of manual calculation results for sun drying and flatbed drying method

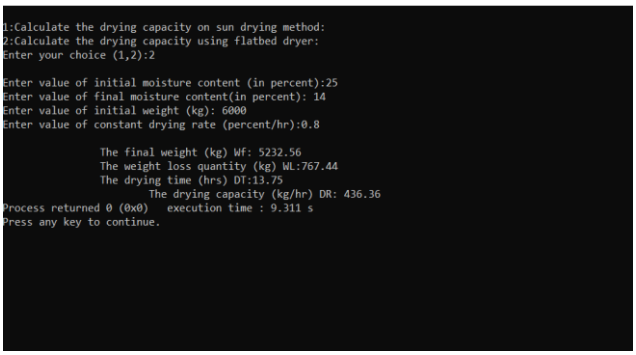
Input Values				**Manual Calculation Results**							
				Sun drying method				**Flatbed drying method**			
Mci (%)	MCf (%)	Wi (kg)	Dr (%/hr)	Wf (kg)	WL (kg)	DT (hrs)	DC (kg/hr)	Wf (kg)	WL (kg)	DT (hrs)	DC (kg/hr)
25	14	6000	1	5232.56	767.44	11	545.45	5232.56	767.44	13.75	436.36
24	14	6000	1	5302.33	697.67	10	600.00	5302.33	697.67	12.50	480.00
23	14	6000	1	5372.09	627.91	9	666.67	5372.09	627.91	11.25	533.33
22	14	6000	1	5441.86	558.14	8	750.00	5441.86	558.14	10.00	600.00
21	14	6000	1	5511.63	488.37	7	857.14	5511.63	488.37	8.75	685.71
20	14	6000	1	5581.40	418.60	6	1000.0	5581.40	418.60	7.50	800.00
25	13	6000	1	5172.41	827.59	12	500.00	5172.41	827.59	15.00	400.00
24	13	6000	1	5241.38	758.62	11	545.45	5241.38	758.62	13.75	436.36
23	13	6000	1	5310.34	689.66	10	600.00	5310.34	689.66	12.50	480.00
22	13	6000	1	5379.31	620.69	9	666.67	5379.31	620.69	11.25	533.33
21	13	6000	1	5448.28	551.72	8	750.00	5448.28	551.72	10.00	600.00

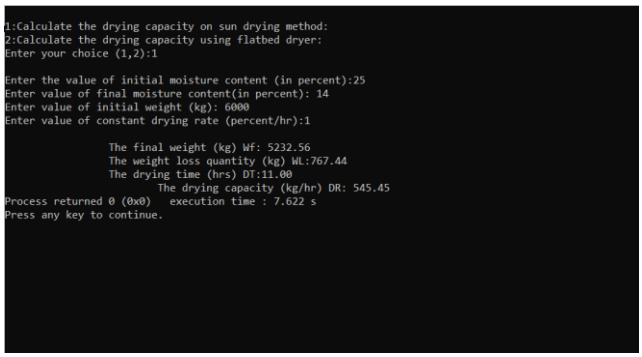
20	13	6000	1	5517.24	482.76	7	857.14	5517.24	482.76	8.75	685.71
25	12	6000	1	5113.64	886.36	13	461.54	5113.64	886.36	16.25	369.23
24	12	6000	1	5181.82	818.18	12	500.00	5181.82	818.18	15.00	400.00
23	12	6000	1	5250.00	750.00	11	545.45	5250.00	750.00	13.75	436.36
22	12	6000	1	5318.18	681.82	10	600.00	5318.18	681.82	12.50	480.00
21	12	6000	1	5386.36	613.64	9	666.67	5386.36	613.64	11.25	533.33
20	12	6000	1	5454.55	545.45	8	750.00	5454.55	545.45	10.00	600.00
25	9	6000	1	4945.05	1054.9	16	375.00	4945.05	1054.95	20.00	300.00
24	9	6000	1	5010.99	989.01	15	400.00	5010.99	989.01	18.75	320.00
23	9	6000	1	5076.92	923.08	14	428.57	5076.92	923.08	17.50	342.86
22	9	6000	1	5142.86	857.14	13	461.54	5142.86	857.14	16.25	369.23
21	9	6000	1	5208.79	791.21	12	500.00	5208.79	791.21	15.00	400.00

Results and Discussion

Using the program codes provided above, a calculator for drying capacity of paddy was developed. Shown below were the sample of actual program simulation run by a user wherein input values were based on Table 2. The developed program was able to calculate the drying capacity(kg/hr.), as well as final weight(kg), weight loss (kg), and drying time(hrs.), for each batch of drying process both in sun drying and flatbed drying methods. Values computed by the program was verified from the results of manual calculations shown in Table 3.







The developed program has used four target moisture content values to calculate the drying capacity based on the input parameters in sun drying and flatbed drying methods such as moisture content (initial and final), weight (initial and final), drying rate, drying weight loss

and drying time. Results show that the higher the desired moisture content of paddy given a specific initial moisture content value, the higher the drying capacity obtained in both sun drying and flatbed drying methods. However, the drying capacity decreases as the initial moisture content value increases in both drying methods as shown in Figures 3a and 3b. In terms of drying time, result shows that the longer the drying time, the lower the drying capacity of paddy in both drying methods. Figures 4a and 4b show the effects of drying time to the drying capacity in both drying methods test.

Figure 3a. Drying Capacity at Different Target Moisture Content using Sun Drying Method

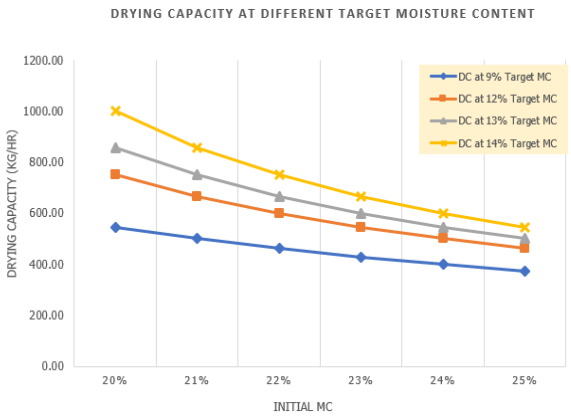


Figure 3b. Drying Capacity at Different Target Moisture Content using Flatbed Drying Method

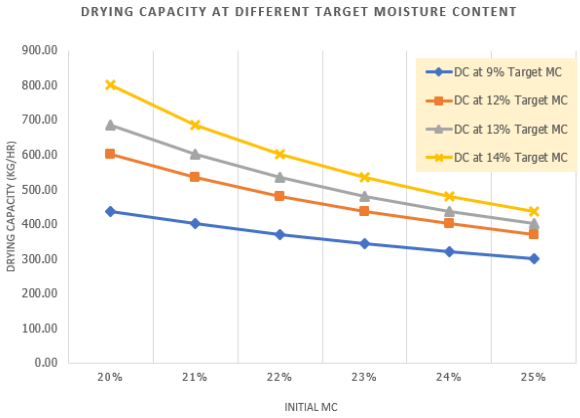


Figure 4a. Effects of Drying Time to the Drying Capacity using Sun Drying Method

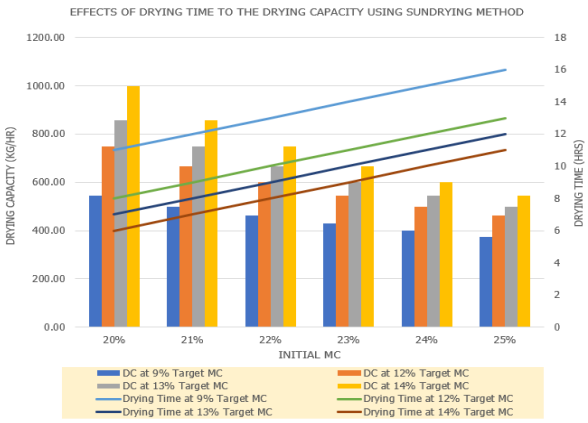
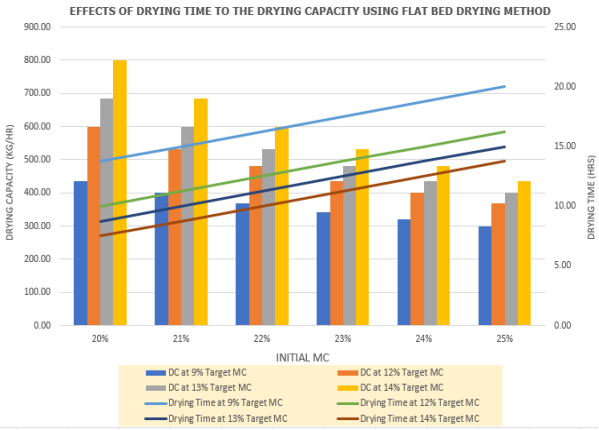


Figure 4b. Effects of Drying Time to the Drying Capacity using Flatbed Drying Method



Conclusion

The study concluded that the developed program calculator was able to calculate the final weight, drying weight loss, drying time and drying capacity of paddy in both sun drying and flatbed drying methods based on various drying input parameters. The simulation method presents an option in estimating drying parameters. Moreover, this can be used by

researchers for evaluation of studies related to paddy drying and for further relevant studies and improvements.

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