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COMPARISON BETWEEN THE EXPERIMENTAL DESIGNS WITH THE RESPONSE SURFACE METHODOLOGY IN THE RICE HUSKING PROCESS

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Abstract
This research was to compare the experimental design by the yield response surface method in three rubbers and six rubbers. In the process of cracking the paddy. The objective is to find the optimal value. This research has identified the variables, two variables and three variables, respectively, were analyzed of variance and found that the p-value was less, at alpha 0.005, confidence level at 95 percent. The adjustment of the judgment coefficient was equal to 97.35 percentage, and 96.55 percentage respectively. Test between six rubbers, and three rubbers, the use of six rubbers have the best efficiency and optimization. The design of six rubbers in paddy cracking, it is most likely to expand the market, or community enterprise. Throughout the community who are interested in the production process of rice husking of six rubbers. But there is a cost higher than the three rubbers type.

Keywords: comparison, response surface methodology, rice husking, analysis of variance, analysis of coefficient, significant

INTRODUCTION

The quality of peeled rice are depends on many factors such as rice strain, the rate of feeding, clearance between a rubber to rubber cylinder, paddy moisture content which usually are controlled not to be exceed 14% etc. But the most important factor is the type of the abrasives (S. Bangphan, S. Lee, 2006), (S. Bangphan, S. Lee and S. Jomjunyong, 2007). Nutritional Implications of Rice Milling: In rice milling, the bran layers and germ removed during polishing are high in fiber, vitamins and minerals as well as protein. Their removal results in loss of nutrients, especially in substantial losses of B vitamins.

Polishing rice reduces the thiamin content of rice by over 80%. Parboiling results in substantial losses of B vitamins. Polishing rice reduces the thiamin content of rice by over 80%. Parboiling results in gelatinization of the starch and disintegration of the protein in the endosperm resulting in inward shift of water-soluble vitamins to the endosperm. Parboiled rice is therefore higher in B vitamins (Oh, C.H. and S.H. Oh, 2004), and shown in Table 1. Brown Rice Is Superior to Polished Rice: Brown rice has high dietary fiber (a gentle laxative, prevents gastro-intestinal diseases and good for diabetes sufferers); rich in B vitamins and minerals (prevents beriberi); and high in fat (energy source), (Oh, C.H. and S.H. Oh, 2004).

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Table 1 Nutrient Content of Rice (Oh, C.H. and S.H. Oh, 2004)

Mg/10g	Brown rice	Polished rice
Thiamine	0.34	0.07
Riboflavin	0.05	0.03
Niacin	4.7	1.6
Iron	1.9	0.5
Magnesium	187.0	13.0

Table 1 shows the comparison between white rice and brown rice. Brown rice is more nutritious than white rice.

The enhancement of rice supply is another advantage of brown rice relative to polished or white rice. Post-harvest researchers say that the milling recovery in brown rice is 10% higher than polished rice (Garrow, J.S. et al, 2000). There is the other benefit of brown rice – economics the fuel savings in milling is 50-60% because the polishing and whitening steps are eliminated. It follows that the milling time is also shortened; labor is less; and the cost of equipment (if the mill is dedicated to brown rice) is much lower because the miller doesn’t have to install polishers and whiteners. The enhancement in output volume and the economy in milling constitute the business opportunity in brown rice (Rogelio V. Cuyno, 2003).

Figure 1 shows the difference between white rice and brown rice. White rice has less nutritional value than brown rice. Nowadays, in Thailand, Thai people have turned to prefer brown rice over white rice. And brown rice has a higher price than brown rice.

(A) Brown rice

(B) White rice

Figure 1 (A) Brown rice versus (B) white rice

(googlegroups.com,2021), (wordpress.com,2021)

The process of producing brown rice in Thailand has many companies, including government agencies, universities, technical colleges. It depends on the manufacturer what size, capacity, and performance of the machine are required. Most of them are small and medium-sized, suitable for groups of farmers. Community enterprise group.

In this research, the experimental design consisted of two rubber balls, three rubber balls, four rubber balls, and six rubber balls for hulling paddy into brown rice. To compare the machine, and the difference between rubber balls. Factors of interest such as speed of rotation, the clearance between rubber balls in hulling time, paddy weight were studied. Paddy moisture, and relative humidity as well as the operator to test the performance.

LITERATURE REVIEW

Milling is the primary difference between brown and white rice. The varieties may be identical, but it is in the milling process where brown rice becomes white rice. Milling, often called "whitening", removes the outer bran layer of the rice grain. Milling affects the nutritional quality of the rice. Milling strips off the bran layer, leaving a core comprised of mostly carbohydrates. In this bran layer resides nutrients of vital importance in the diet, making white rice a poor competitor in the nutrition game. The following chart shows the nutritional differences between brown and white rice. Fiber is dramatically lower in white rice, as are the oils, most of the B vitamins and important minerals. Unknown to many, the bran layer contains very important nutrient such as thiamine, an important component in mother’s milk (Wood, Rebecca,1988). Brown rice (hulled rice) is composed of surface bran (6–7% by weight), endosperm (E90%) and embryo (2–3%) [8] White rice is referred to a milled, polished or whitened rice when 8–10% of mass (mainly bran) has been removed from brown rice [8]. During milling, brown rice is subjected to abrasive or friction pressure to remove bran layers resulting in high, medium or low degrees of milling depending on the amount of bran removed (Chen, H., Siebenmorgen,

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T.J,1997),(Kennedy, G., Burlingame, B., Nguyen, N.,2002). Milling brings about considerable loss of nutrients and affects the edible properties of milled rice (Chen, H., Siebenmorgen, T.J,1997),(Kennedy, G., Burlingame, B., Nguyen, N.,2002). As most cereals, rice does not show a homogeneous structure from its outer (surface) to inner (central) (Kennedy, G., Burlingame, B., Nguyen, N, 2002). As a consequence, information on the distribution of nutrients will greatly help in understanding the effect of milling and aid in improving sensory properties of rice while retaining its essential nutrients as much as possible (Jianfen Liang et al,2008). Therefore, the aim of this study is to generate between rice of varieties and rice of moisture using Design of Experiment(DOE) by full factorial design in order to generate the suitable factors.

This research was compared with the research that the researcher has done before between paddy shellers and rubber balls. as well as different control factors such as rotation speed, paddy moisture, humidity, the gap between the paddy crackers, and number of rubber balls used in the experiment including the paddy cultivars that were tested for efficiency in the paddy sheller as well as operators It is necessary to keep the controls within the scope of the experiment.

EXPERIMENTAL PROCEDURE

Material and Method

The most outer rough shell of paddy is removed. Rubber roll sheller Figure 2 is the most common machine that is used for paddy shelling, however friction type browner is sometimes used as a sheller. Paddy goes between six rubber rollers that are rotating in opposite direction with different velocities. There is a small clearance between the rollers so that when paddy passes through, it is subjected to some shear forces and husk is removed from production process of rice peeled (S. Bangphan, S. Lee and S. Jomjunyong, 2007),Oh, (C.H. and S.H. Oh, 2004), (S. Bangphan, P. Bangphan., and T.Boonkang, 2013). Picture 2, and 3 shows the design of (S. Bangphan, P. Bangphan., and T.Boonkang, 2013) paddy Sheller three rubber balls vs. (S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016) six balls to show the difference in results after the experiment.

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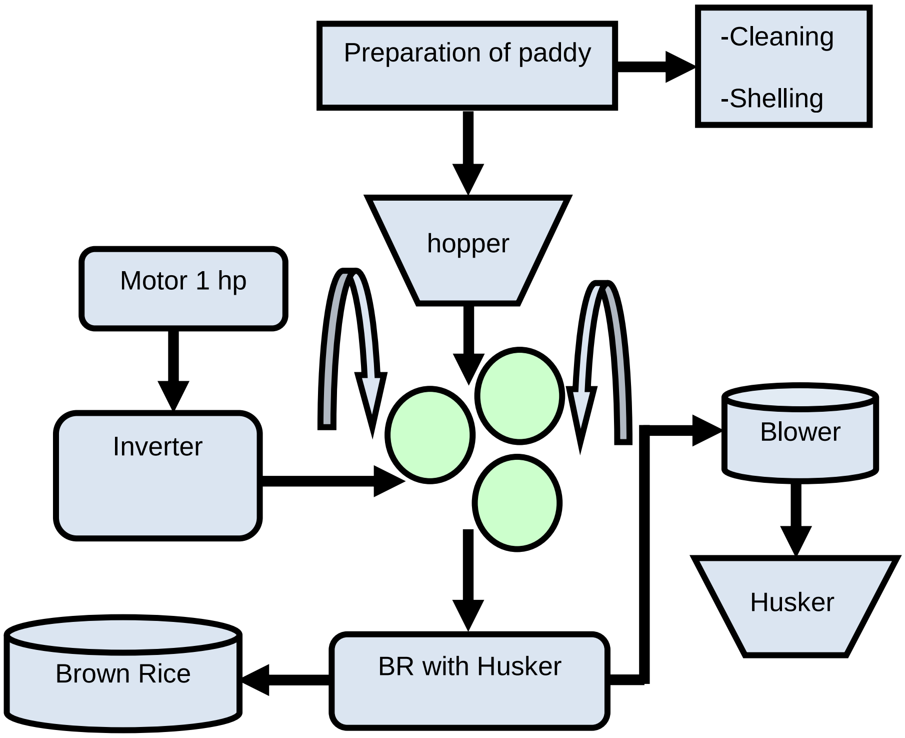

Figure 2 Diagram of brown rice peeling machine

(S. Bangphan, P. Bangphan., and T.Boonkang, 2013)

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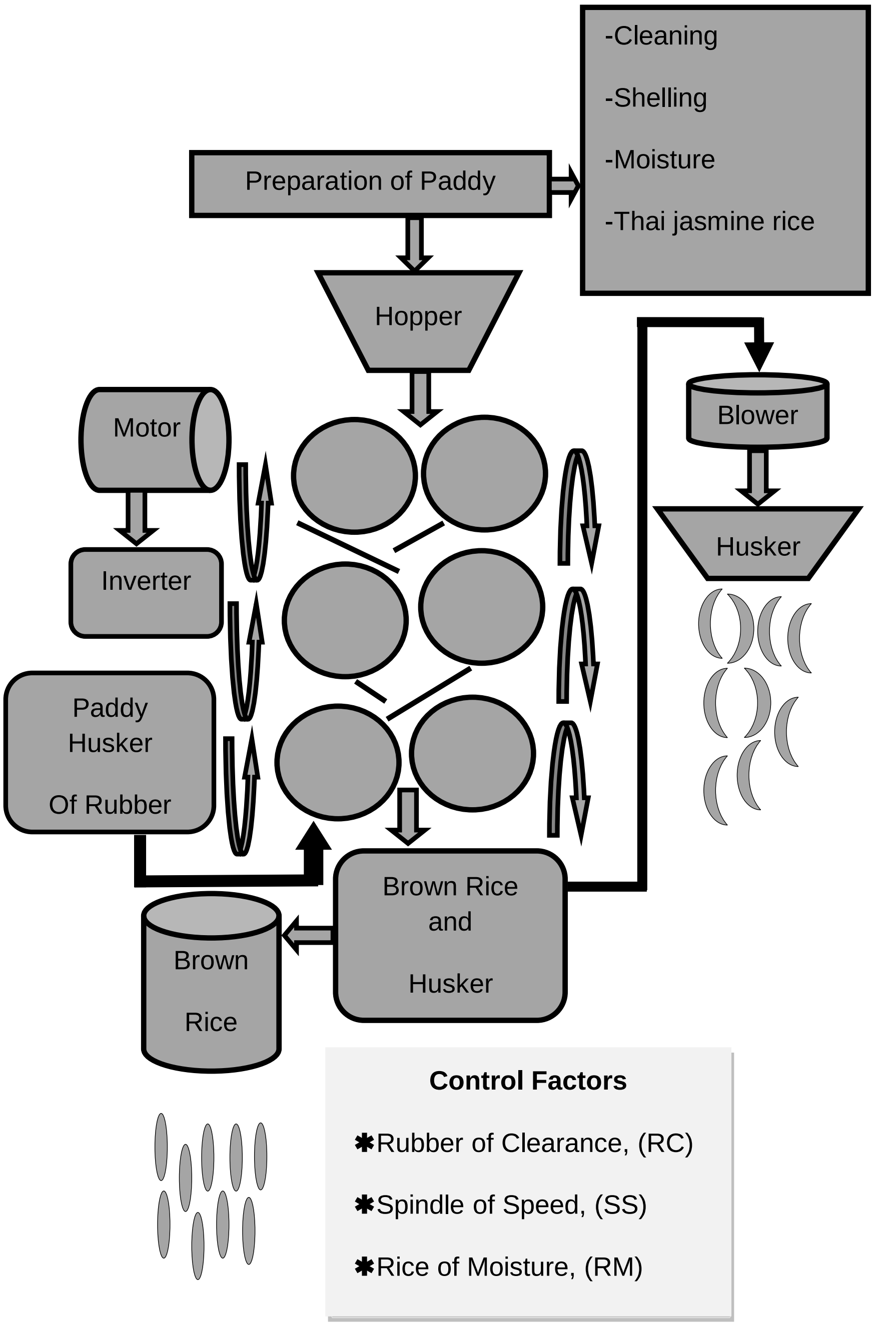

Figure 3 Diagram of paddy husker production process

(S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016)

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Method

Design of experiments (DOE) and Response Surface Methodology (RSM) is a collection of statistical and mathematical techniques useful for developing, improving and optimizing process and new products, as well as in the improvement of existing product designs. RSM can take unknown response function and approximate it by coded variables where these coded variables are usually defined to be dimensionless with zero mean and the same spread or standard deviation. Usually a low order polynomial in some relatively small region of the independent variable space is generated. The approach presented in this paper is a statistically based method which combines design of experiments (DOE) and response surface methodology (RSM) (Myers R. H., Montgomery D. C.,1995). RSM is generally conducted in three phases, as emphasized according to research conducted Myers and Montgomery (Myers R.H., Montgomery D.C, 2002). The fundamentals of RSM are set out in the semina papers of (Myers R.H., Montgomery D.C, 2002),(Khuri A.I., Cornell J.A, 1987). Further developments are drawn together in three key review articles, namely those of designs taken from the RSM paradigm can be used to good effect in a traditional agricultural setting and this point is further underscored by the work of (Khuri A.I., Cornell J.A, 1987), (Edmondson R.N. ,1991). And according to Hill and Hunter, RSM method was introduced by (Box G.E.P., Wilson K.B, 1951),(Box G.E.P., Draper N.R, 1959), (Box G.E.P., Draper N.R, 1987) suggested to use a first-degree polynomial model to approximate the response variable. They acknowledged that this model is only an approximation, not accurate, but such a model is easy to estimate and apply, even when little is known about the process (http://en.wikipedia.org/wiki/, 2021). The resulting surfaces, usually linear or quadratic, are fitted to these points. Often statistical methods such as design of experiments are used to determine where in the design space these points should be located in order to obtain best possible fit. In this paper we use linear polynomials to create the response surface. The creation of such response surface models to approximate detailed computer analysis codes is particularly appropriate in the preliminary design stages when comprehensive trade-offs of multiple performance and economic objectives is critical. In many cases, either a second-order model is used. For the case of three independent variables, the second-order model is:

$$y_k = \beta_0 + \sum_{i=1}^{n} \beta_i x_i + \sum_{i=1}^{n} \beta_{ii} x_1^2 + \sum_{i=1}^{n-1} \sum_{j=1}^{n-1} \beta_{ij} x_i x_j \qquad (1)$$

Where β are the coefficients which have calculated using an appropriate method such as the least square method. When the result estimated surface is an adequate approximation of the true response function, the results will be approximately equivalent to analysis of the actual system. The model parameters can be

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approximated whenever proper experimental designs are used to collect the data. The DOE simulation was accomplished with three parameters: between rubber of clearance, spindle of speed and rice of moisture respectively. It was performed according (see Table 2, and 3), and Diagram of paddy husker production process shown in Figure 2, and 3 respectively. A model fitting was accomplished for the first 2^3-CCD,and 2^2 CCD shown in Table 2, and 3 respectively. According to the research of (S. Bangphan, P. Bangphan., and T.Boonkang, 2013), (S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016).

Table 2 DOE Parameters (S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016)

Parameter	Variable	Lower Limit	Variable
Rubber of Clearance, RC (mm.)	X1	1.0	1.40
Spindle of Speed, SS, (RPM)	X_2	1,440	1,480
Rice of Moisture , RM, (percent)	X_3	10	14

Table 3 DOE Parameters (S. Bangphan, P. Bangphan., and T.Boonkang, 2013)

Parameter	Variable	Lower Limit	Variable
Rubber of Clearance, RC (mm.)	X1	1.2	1.5
Spindle of Speed, SS, (RPM) Round Per Minute	X_2	1,440	1,500

Table 4 DOE Set and Results (S. Bangphan, P. Bangphan., and T.Boonkang, 2013)

Std Order	Run Order	Pt Type	Block	clearance	rpm	brokens
2	1	1	1	1.65000	1440.00	25.0
3	2	1	1	1.25000	1600.00	35.0
35	3	0	1	1.45000	1520.00	20.0
30	4	1	1	1.65000	1440.00	25.8
15	5	1	1	1.25000	1440.00	25.8
4	6	1	1	1.65000	1600.00	32.1
17	7	1	1	1.25000	1600.00	35.4
31	8	1	1	1.25000	1600.00	35.1
19	9	0	1	1.45000	1520.00	20.6
32	10	1	1	1.65000	1600.00	31.8
20	11	0	1	1.45000	1520.00	19.7
29	12	1	1	1.25000	1440.00	25.5

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18	13	1	1	1.65000	1600.00	32.4
21	14	0	1	1.45000	1520.00	20.5
1	15	1	1	1.25000	1440.00	25.8
6	16	0	1	1.45000	1520.00	20.5
16	17	1	1	1.65000	1440.00	25.9
5	18	0	1	1.45000	1520.00	19.8
7	19	0	1	1.45000	1520.00	19.9

Table 4 (Cont.) DOE Set and Results (S. Bangphan, P. Bangphan., and T.Boonkang, 2013)

Std Order	Run Order	Pt Type	Block	clearance	rpm	brokens
34	20	0	1	1.45000	1520.00	20.1
33	21	0	1	1.45000	1520.00	20.2
40	22	0	2	1.45000	1520.00	20.4
23	23	-1	2	1.73284	1520.00	31.1
13	24	0	2	1.45000	1520.00	20.1
9	25	-1	2	1.73284	1520.00	31.8
39	26	-1	2	1.45000	1633.14	38.1
27	27	0	2	1.45000	1520.00	20.2
25	28	-1	2	1.45000	1633.14	38.4
42	29	0	2	1.45000	1520.00	20.4
10	30	-1	2	1.45000	1406.86	22.4
26	31	0	2	1.45000	1520.00	20.8
8	32	-1	2	1.16716	1520.00	35.5
28	33	0	2	1.45000	1520.00	20.2
22	34	-1	2	1.16716	1520.00	35.7
41	**35**	**0**	**2**	**1.45000**	**1520.00**	**19.8**
38	36	-1	2	1.45000	1406.86	22.4
37	37	-1	2	1.73284	1520.00	33.4
14	38	0	2	1.45000	1520.00	20.4
24	39	-1	2	1.45000	1406.86	25.5
11	40	-1	2	1.45000	1633.14	38.8
36	41	-1	2	1.16716	1520.00	35.8
12	**42**	**0**	**2**	**1.45000**	**1520.00**	**19.8**

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Table 5 Central Composite Design for Optimization Parameters (S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016)

A	B	C	D	E	F	G	H
39	1	0	1	1.30	1,460	12.0	75
19	2	0	1	1.30	1,460	12.0	74
28	3	1	1	1.40	1,480	14.0	70
17	4	0	1	1.30	1,460	12.0	73
22	5	1	1	1.40	1,440	10.0	70
11	6	-1	1	1.30	1,426	12.0	74
56	7	0	1	1.30	1,460	12.0	75
51	8	-1	1	1.30	1,426	12.0	74
54	9	-1	1	1.30	1,460	15.4	75
60	10	0	1	1.30	1,460	12.0	75
44	11	1	1	1.40	1,480	10.0	77
34	12	-1	1	1.30	1,460	15.4	75
20	13	0	1	1.30	1,460	12.0	76
41	14	1	1	1.20	1,440	10.0	80
16	15	0	1	1.30	1,460	12.0	75
52	16	-1	1	1.30	1,494	12.0	76
21	17	1	1	1.20	1,440	10.0	80
13	18	-1	1	1.30	1,460	8.64	76
2	19	1	1	1.40	1,440	10.0	70
14	20	-1	1	1.30	1,460	15. 6	76
30	34	-1	1	1.47	1,460	12.0	72
29	**35**	**-1**	**1**	**1.13**	**1,460**	**12.0**	**91**
31	36	-1	1	1.30	1,426	12.0	76
3	37	1	1	1.20	1,480	10.0	87
57	38	0	1	1.30	1,460	12.0	75
36	39	0	1	1.30	1,460	12.0	76
9	40	-1	1	1.13	1,460	12.0	90
42	41	1	1	1.40	1,440	10.0	71
45	42	1	1	1.20	1,440	14.0	86
27	43	1	1	1.20	1,480	14.0	85
33	44	-1	1	1.30	1,460	8.64	76
47	45	1	1	1.20	1,480	14.0	84
10	46	-1	1	1.47	1,460	12.0	70
38	47	0	1	1.30	1,460	12.0	76
23	48	1	1	1.20	1,480	10.0	86
50	49	-1	1	1.47	1,460	12.0	69
4	50	1	1	1.40	1,480	10.0	77
7	51	1	1	1.20	1,480	14.0	82

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53	52	-1	1	1.30	1,460	8.64	76
46	53	1	1	1.40	1,440	14.0	73

Table 5 (Cont.) Central Composite Design for Optimization Parameters (S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016)

A	B	C	D	E	F	G	H
37	54	0	1	1.30	1,460	12.0	75
6	55	1	1	1.40	1,440	14.0	73
40	56	0	1	1.30	1,460	12.0	76
43	57	1	1	1.20	1,480	10.0	88
15	58	0	1	1.30	1,460	12.0	75
35	59	0	1	1.30	1,460	12.0	74
55	60	0	1	1.30	1,460	12.0	73

Research Results

DOE and Surface Response Methodology

The DOE simulation was accomplished with two parameters: between rubber clearance and round per minute. It was performed according (see Table 2,3,4, and 5 respectively), and brown rice peeling machine shown in Figure 2, and 3. A model fitting was accomplished for the first 2^2-CCD,and 2^3 CCD shown in Table 2,3,4, and 5 respectively. The independent (rubber clearance with RPM) and the dependent variables were fitted to the second-order model equation and examined in terms of the goodness of fit. The analysis of variance (ANOVA) was used to evaluate the adequacy of the fitted model. The R-square value (determination coefficient) provided a measure of how much of the variability in the observed response values could be explained by the experiment factors and their interactions.

DOE order defines the sequence that variables should be introduced in response surface analysis. See Table 4, and 5 shows the results according to simulated analysis performed in MINITAB Release 19.00 used for simultaneous optimization of the multiple responses. The desired goals for each variable and response were chosen. All the independent variables were kept within range while the responses were either maximized or minimized. The significant terms in different models were found by analysis of variance (ANOVA) for each response. Significance was judged by determining the probability level that the F-statistic calculated from the data is less than 5%. The model adequacies were checked by R2, adjusted-R2 (adj-R2).The coefficient of determination, R2, is defined as the ratio of the explained variation to the total variation according to its magnitude. It is also the proportion of the variation in the response variable attributed to the model and was suggested that for a good fitting model, R2 should not be more than 75 %. A good model should have a large R2, adj-R2. Response surface plots were generated with MINITAB Release 19.00. According to the research of (S. Bangphan, P. Bangphan., and T.Boonkang, 2013), (S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016).

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Response surfaces equations were obtained from design of experiments. Using all values (tests 1 to 42, and 1 to 60) to the system analysis, the following polynomial equations were generated: (S. Bangphan, P. Bangphan., and T.Boonkang, 2013), (S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016).

The Estimated Regression Coefficients for brokens, and percentage of good rice using data in uncoded units:

$$\hat{y} = 1850.63 + (-0.811905) + (-381.613x_1) + (-2.09767x_2) + (153.837x_1x_1) + (0.000731611x_2x_2) + (-0.0458333x_1x_2) \quad (2)$$

$$\hat{y} = 1761.60 + (-450)(RC_1) + (-2.58525)(SS_2) + (83.6989)(RM_2) + (205.283)(RC_1RC_1) + (0.00115460)(SS_2SS_2) + (0.100729RM_3RM_3) + (-0.0625000)(RC_1SS_2) + (-4.37500)(RC_1RM_3) + (-0.0552083)(SS_2RM_3) \quad (3)$$

Equation (2) is generate the graphic shown in Figure 4 shows optimal solutions considering Rubber Clearance and Round per minute. Main solutions are positioned at 1440 and 1500 RPM distance and there is a range between 1.2 and 1.5 mm of rubber clearance where it is allowable to use other distances (see Table 2. DOE parameter). Result of the analysis of variance is given in Table 6. The test statistic F0= 26.78 is bigger than the critical F.05,3,32 =3.52635 value. There is significant evidence of lack of fit at a = 0.05. Therefore, this study can conclude that the true response surface is explained by the linear model. To study the effects of two factors, 22 = 14 runs are required. Due to space limitations, the treatments, factor values, and the corresponding responses are not shown. Analysis of variance method (ANOVA) is used to find factors with significant effects. Effects X1, X2, X1X1, X2X2,X1X2 and DF are found to be significant ,that is the most significant effect, has significant interactions with all other factors. Alternatively, these results can be obtained visually from the residual versus fits probability plot of effects method shown in Figure 8 plot the range of the residuals looks essentially constant across the levels of the predictor variable, round per minute and rubber clearance. The scatter in the residuals at RPM between 1440 and 1500 RPM with rubber clearance at between 1.2 and 1.5 millimeters that the standard deviation of the random errors is the same for the responses observed at each round per minute and rubber clearance. (S. Bangphan, P. Bangphan., and T.Boonkang, 2013)

Equation (3) is generate the graphic shown in Figure 5 shows optimal solutions considering rubber of clearance , spindle of speed and rice of moisture respectively. Main solutions are positioned at 1,440 and 1,480 RPM distance , there is a range between 1.00 and 1.40 mm of rubber clearance where it is allowable to use other

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distances and there is a range between 10.00 and 14.00 percent of rice moisture where it is allowable to use other distances (see Table 3. DOE parameter). Result of the analysis of variance is given in Table 7. The test statistic F0= 1.49 is less than the critical F.05,5,45 =2.42 value. There is no significant evidence of lack of fit at a = 0.05. Therefore, this study can conclude that the true response surface is explained by the linear model. To study the effects of three factors, 32 = 20 runs and three replicate are required. Due to space limitations, the treatments, factor values, and the corresponding responses are not shown. Analysis of variance method (ANOVA) is used to find factors with significant effects. EffectsX1,X2,X3,X1X1,X2X2,X3X3 ,X1X2 X2X3,X1,X2,X3and DF are found to be significant ,that is the most significant effect, has significant interactions with all other factors. Alternatively, these results can be obtained visually from the residual versus fits probability plot of effects method shown in Figure 5 plot the range of the residuals looks essentially constant across the levels of the predictor variable, rubber of clearance , spindle of speed and rice of moisture. The scatter in the residuals at SS between 1,440 and 1,480 RPM with RC at between 1.00,and 1.40 millimeters and rice of moisture between 10.00 to 14.00 percent that the standard deviation of the random errors is the same for the responses observed at each spindle of speed, rubber of clearance and rice of moisture. (S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016).

Result of Estimated regression coefficients for the response (percentage of good rice) function as surface paddy husker. This analysis is carried out for a significance level of 5%, i.e., for a confidence level of 95%. The model adequacies was checked by adjusted-R2 (adj-R2) of 96.55%, (S. Bangphan, P. Bangphan., and T.Boonkang, 2013).

The response taken from Table 8 revealed that the square coefficients of rubber clearance (X_1), and round per minute (X_2), have a remarkable effect on the BROKENS yield. Moreover, all the linear and interaction terms of two factor presented in significant effects on the BROKENS yield at 5% probability level. Since all coefficients of the above Equation (2) are all negative, the response surface is suggested t have a maximum point in Figure 5. A significantly brown rice peel was observed as moisture and temperature addition increased ($P < 0.05$, Figure 5). This can be partly attributed to the higher RPM and less rubber clearance of these brown rice. Using low brokens yielded smaller specific volumes, rubber clearance, and subsequently higher RPM values. In Figure.8 presents a graphical representation of one of the response surfaces generated through RSM using a full quadratic model of rubber clearance (X_1), and round per minute (X_2) to predict the BROKENS. As depicted, the normalized search direction to minimize the brown rice is (-1, +1), (S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016).

Figure 9 shows the optimal response surface between X_1, and X_3 affects the desired response.

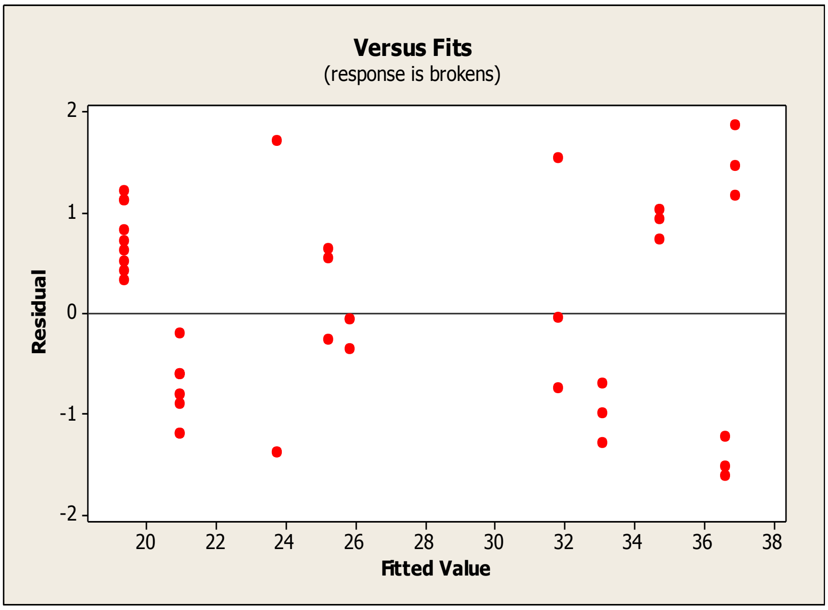

Figure 4 Residual of Rubber Clearance and RPM
(S. Bangphan, P. Bangphan., and T.Boonkang, 2013)

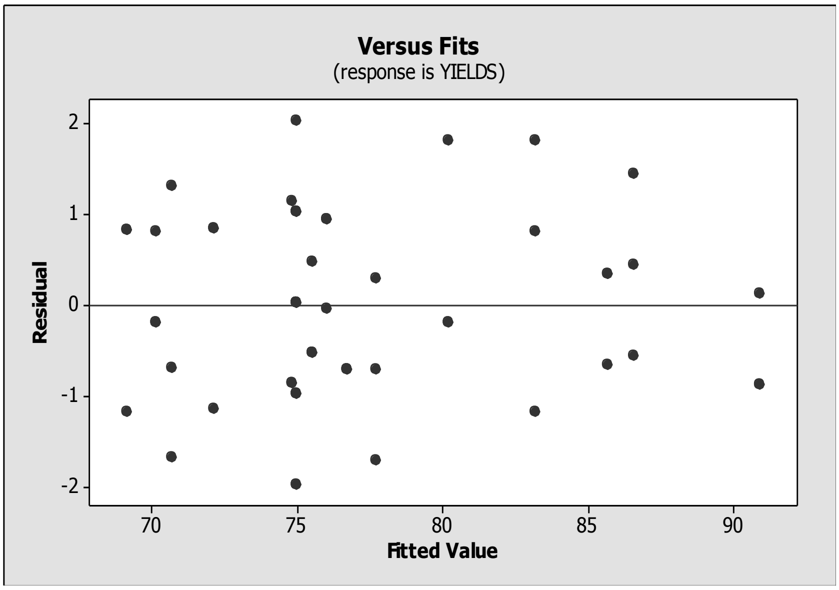

Figure 5 Residual of Rubber Clearance and RPM
(S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016)

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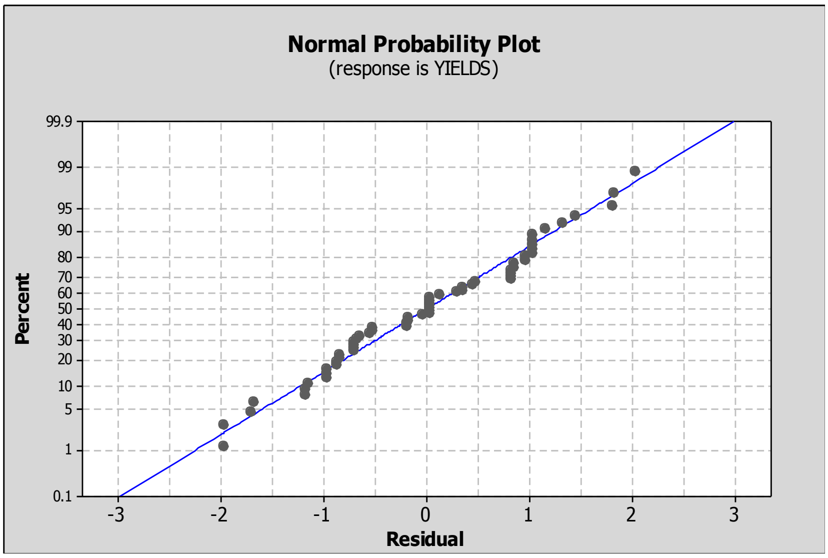

Figure 6 Normal probability plot of yields

(S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016)

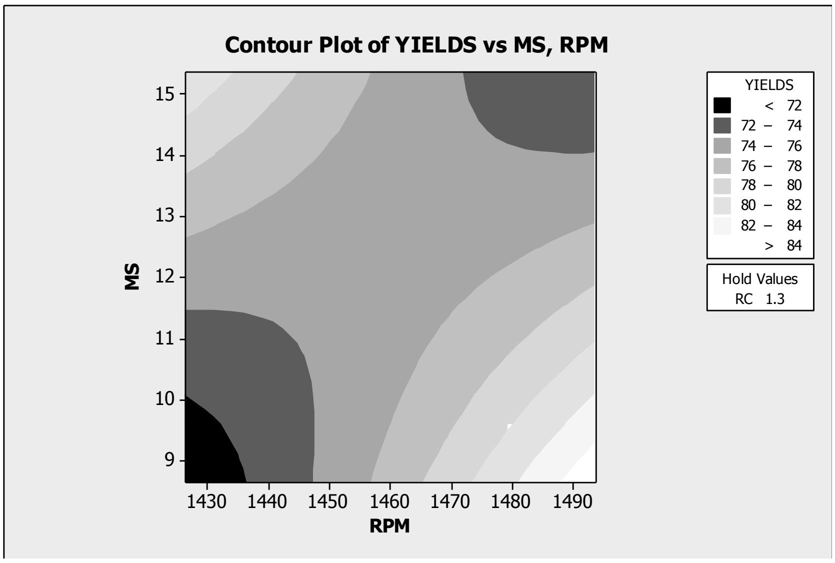

Figure 7 Contour plot of yields

(S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016)

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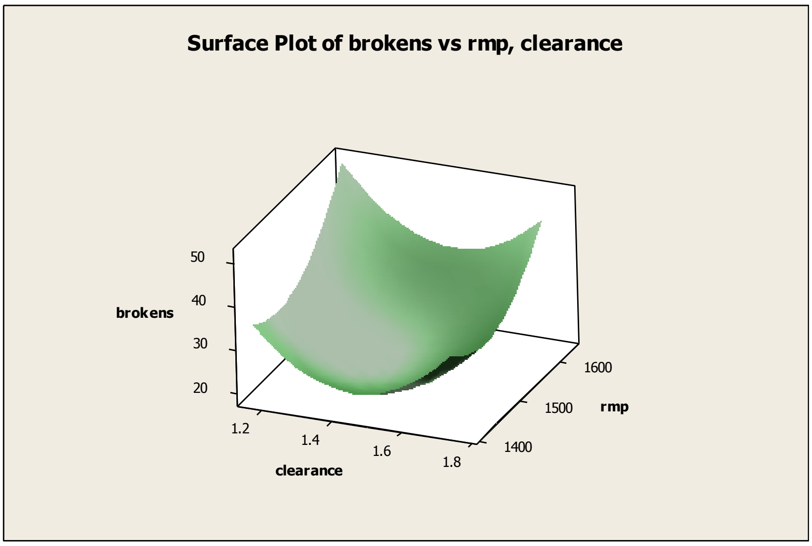

Figure 8 Response surfaces for the rubber clearance of 1.45 mm. and round per minute of 1480 RPM (S. Bangphan, P. Bangphan., and T.Boonkang, 2013)

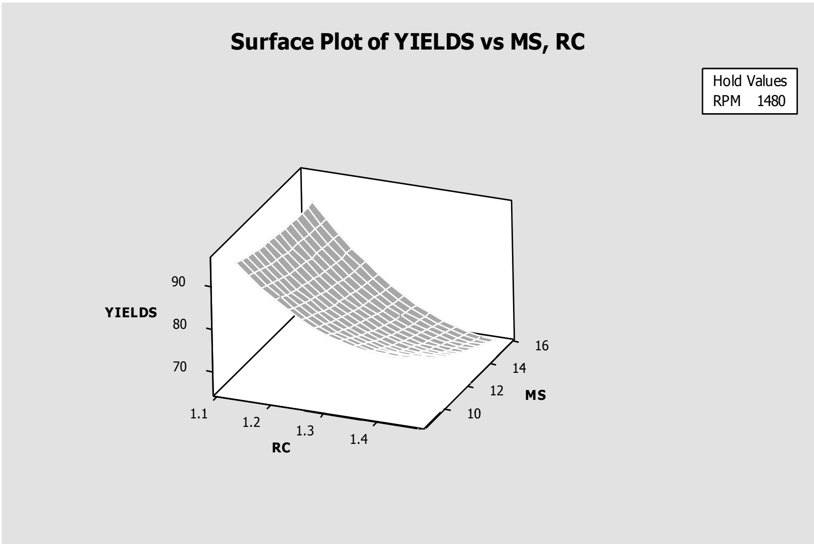

Figure 9 Response surfaces for the RC of 1.3 mm., SS of 1,480 RPM and RM of 14 percentage (S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016)

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Table 6 Analysis of Variance for the Experimental Results of the Central Composite Design (S. Bangphan, P. Bangphan., and T.Boonkang, 2013)

Source	DF	SS	MS	F	P
Blocks	1	27.69	27.686	23.09	0.000
Regression	5	1784.19	356.838	297.54	0.000
Linear	2	544.79	272.397	227.13	0.000
Square	2	1232.94	616.470	514.02	0.000
Interaction	1	6.45	6.453	5.38	0.026
Residual Error	35	41.98	1.199		
Lack-of-Fit	3	30.02	10.007	26.78	0.000
Pure Error	32	11.96	0.374		
Total	41	1853.85			

Table 7 Analysis of Variance for the Experimental Results of the Central Composite Design (S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016)

Source	DF	SS	MS	F	P
Regression	9	1,832.75	203.64	184.51	0.000
Linear	3	1,510.50	503.50	456.20	0.000
RC	1	1,475.95	1,475.95	1,337.30	0.000
SS	1	29.51	29.51	26.74	0.000
RM	1	5.04	5.04	4.56	0.038
Square	3	186.46	62.15	56.31	0.000
RC*RC	1	171.67	182.19	165.08	0.000
SS*SS	1	7.77	9.22	8.36	0.006
RM*RM	1	7.02	7.02	6.36	0.015
Interaction	3	135.79	45.26	41.01	0.000
RC*SS	1	0.38	0.38	0.34	0.563
RC*RM	1	18.38	18.38	16.65	0.000
SS*RM	1	117.04	117.04	106.05	0.000
Residual Error	50	55.18	55.18	1.10	
Lack-of-Fit	5	7.85	1.57	1.49	0.211
Pure Error	45	47.33	1.05		
Total	59	1,887.93			

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Table 8 Estimated Regression Coefficients for Yields (S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016)

Term	Coef	SE Coef	T	P
Constant	74.9744	0.2474	303.078	0.000
RC	-6.0021	0.1641	-36.569	0.000
SS	0.8487	0.1641	5.171	0.000
RM	-0.3506	0.1641	-2.136	0.038
RC*RC	2.0528	0.1598	12.848	0.000
SS*SS	0.4618	0.1598	2.891	0.006
RM*RM	0.4029	0.1598	2.522	0.015
RC*SS	-0.1250	0.2144	-0.583	0.563
RC*RM	-0.8750	0.2144	-4.080	0.000
SS*RM	-2.2083	0.2144	-10.298	0.000
S = 1.05056 PRESS = 79.4349				
R-Sq = 97.08%	R-Sq(pred) = 95.79%		R-Sq(adj) = 96.55%	

The check of the normality assumptions of the data is then conducted, it can be seen in Figure 6 that all the points on the normal plot come close to forming a straight line. This implies that the data are fairly normal and there is no deviation from the normality. This shows the effectiveness of the developed model. The effect of RM and SS is on the estimated response surface of good rice is depicted in the Figure 7 the spindle speed remains constant in its maximum level of 1,480 RPM. It can be noted that the good rice increases when the RM increases, the explanation is same, as stated earlier, however with the increase in SS, good rice decreases, this is because when SS increases, there will be an undesirable heat loss which does not contribute to good rice (S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016).

CONCLUSION

The results of this study have clearly indicated RSM is an effective method for optimization of Brokens. Response surface methodology was successfully applied to optimize rubber clearance and round per minute in brown rice that was not paddy. When productions into the formulation, the optimized levels of R-Squire (adjust) was 97.35 % and standard deviation was 1.09513 yielded good quality peeling. This study clearly showed that RSM was one of the suitable methods to optimize the best operating conditions to maximize the peel removing. Graphical response surface and contour plot were used to locate the optimum point. The statistical fitted models and the contour plot of responses, can be used to predict values of responses at any point inside the experimental space and can be successfully used to optimize the brown rice peeling machine. Also, the size and amount of this surface degradation was noticeably increased as a function of exposure time. The surface methodology was used. The optimal composition of the brown rice established by a central composite design (run order 42) was: rubber clearance 1.45 mm. and round per minute 1480 rpm. The optimal values for the brown rice peeling parameters were brokens rice of 19.02 % (S. Bangphan, P. Bangphan., and T.Boonkang, 2013).

The results of this study have clearly indicated RSM is an effective method for optimization of good rice. Response surface methodology was successfully applied to optimize rubber clearance, spindle of speed and rice of moisture in brown rice that was not paddy. When productions into the formulation, the optimized levels of R-Squire(adjust) was 96.55 % and standard deviation was 1.05056 yielded good quality peeling. This study clearly showed that RSM was one of the suitable methods to optimize the best operating conditions to maximize the peel removing. Graphical response surface and contour plot were used to locate the optimum point. The statistical fitted models and the contour plot of responses, can be used to predict values of responses at any point inside the experimental space and can be successfully used to optimize the brown rice peeling machine. Also, the size and amount of this surface degradation was noticeably increased as a function of exposure time. The surface methodology was used. The optimal composition of the brown rice established by a central composite design (run order 60) was: rubber clearance 1.13 mm., spindle of speed 1,426 rpm and rice of moisture 15.36 percent. The optimal values for the brown rice peeling parameters were good rice of 99.67 % (S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016).

The guideline for this research was to compare between the previous research which was the research using three rubbers using the experimental design to find the answer area in the paddy cracking process and the research on finding the value of The best method for cracking paddy by surface determination was to use six rubbers to crack paddy.

Research of (S. Bangphan, P. Bangphan., and T.Boonkang, 2013)

The study was conducted to determine the most suitable percentage of broken rice yielded the lowest percentage of broken rice. Found that 19.02 % where the optimal control factor is x_1 1.45 millimeters and the X_2 is 1,480 rpm. The confidence coefficient was adjusted at 97.35 %.

Research of (S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016)

The study was conducted to determine the most suitable percentage of good rice yielded a percentage of good rice equal to 99.67 %. The most optimal control factor was x_1 equal to 1.33 millimeters, x_2 equal 1,426 rpm, and x_3 equal 15.36 % respectively.

Research of (S. Bangphan, P. Bangphan., and T.Boonkang, 2013)

Study two factors and determine three rubbers by determining the power source, one horsepower.

Research section of (S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016) Study the three factors and determine the six rubbers by determining the power to use three horsepower and control the operation by the inverter.

If comparing the percentage of broken rice to the percentage of good rice, the research of (S. Bangphan, P. Bangphan., and T.Boonkang, 2013) found that 80.98 percent and research of (S. Bangphan, P. Bangphan , C. Ketsombun and T. Sammana, 2016). The percentage of broken rice is equal to 0.33.

Test between six rubbers, and three rubbers, the use of six rubbers have the best efficiency and optimization.

The design of six rubbers in paddy cracking, it is most likely to expand the market, or community enterprise. Throughout the community who are interested in the production process of rice husking of six rubbers. But there is a cost higher than the three rubbers type.

Therefore, the adoption of response surface methodology techniques in research can significantly increase the efficiency and reliability and be practical in the production of paddy Sheller's.

Assessment in Thailand in many provinces found that most of the rice huskers were manufacturing companies using no more than three rubber husks. And there are no reports of individual companies in Thailand doing experiments like this research.

The rice crackers that are currently in the machine are not much different. The capabilities and performance of the machines depend on each company as well as the price.

The researcher has studied the two, three, and six rubber paddy hulling systems, especially the six rubber balls. There is no report of any company in Thailand producing and the use of an inverter system to control the production process of paddy husking has not been reported in Thailand as well, which the researcher was the first to invent a working control system with an inverter system. Therefore, it can be regarded as the research that the researcher initiated as the first person to use such a system in the paddy cracking process in Thailand.

The factors affecting paddy husking consisted of paddy moisture rice cultivation area paddy varieties relative humidity experimental season rice cracker including the distance between the rubber Sheller's and the operator of the machine affects the conduct of the experiment.

In the experimental design, there have not been any reports in Thailand either, the company that produces rice crackers. Which the researcher initiated the experiment as the first. This is to find the appropriate factor, the best value and the most suitable rice varieties, the researchers reported the results shown above were significantly satisfactory.

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