ISSN: 2347-4688, Vol. 06, No.(1) 2018, pg. 20-29

Current Agriculture Research Journal

www.agriculturejournal.org/

Analysis of Physical Quality and Nutrition of Two Rice Varieties With the Implementation of Various Planting Systems

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Abstract

As an effort to overcome problems in rice cultivation system, it is necessary to use new technologies and innovations. This study aims to determine the physical and nutritional quality of grain and milled rice from 2 varieties of rice using several planting systems. The research was conducted using a Complete Randomized Block Design of factorial pattern, consisting of 2 factors with 3 replications. The factors were: a) Planting system (S1 = Cubic S2 = Double row 2: 1, and S3 = Twin seed) and b) Rice varieties (V1 = Ciherang; V2 = Inpari 10). The observation parameters include: physical quality of grain, rice milled quality, physical quality of rice and rice nutrition. The results showed that the cubic planting system produced a higher empty grains than the double row and twin seed planting system. The twin seed planting system, yielding lime green grains and yellow broken grains lower than other planting systems, both on rice varieties of Ciherang and Inpari 10. Grains from Ciherang variety had a thinner shell and a higher hardness level of rice compared to grain of Inpari 10 variety, resulting in higher milled rice and head rice, but lower in broken rice and rice groats contents. It can be concluded that: a) the physical quality of rice was not affected by the planting system, but it was significantly affected by the rice varieties; b) the planting system and rice varieties used in this study did not have significant effect on the nutritional quality of the rice produced.

Article History

Received: 19 February 2018
Accepted: 25 March 2018

Keywords:

Physical quality,
Planting system,
Nutrition,
Rice variety.

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To Link to this Article: http://dx.doi.org/10.12944/CARJ.6.1.03

Introduction

As an effort to secure the national food and to achieve the national production target, an appropriate way of cultivation is needed, such as through the arrangement of planting spacing. This spacing has an effect on the number of clumps per hectare, so it can increase the productivity of rice crops. In addition, the spacing will also affect the quality of growth of clumps of plants in the field[1]. This is in line with the results of Hatta's[2] study indicating that plant spacing has significant effect on the number of productive tillers, but has no significant effect on panicle length and yield per hectare. In addition, plant spacing with a 25 cm base significantly contributes to the number of more productive tillers compared to 21 cm-based spacing.

The low agricultural productivity in Indonesia is currently due to various factors, one of which is the use of improper plant spacing, i.e. the cubic planting system. Farmers tend to assume that the closer the spacing, the higher the yield, because it will cause more population of planted crops. Whereas, the 2:1 double row planting system is generally used by the local farmers.

It has been reported that using the double row planting system the plant population is 33% higher than the cubic planting system, so the yield potential is also higher[3]. Plant spacing is a pattern of arranging the distance between plants that include the distance between and within rows, resulting in solidification of clumps and a broad unified rice plant population[4]. Spacing will affect agricultural production as it relates to the availability of nutrients, sunlight and space for the plants[5,6].

The results of research by Pratiwi *et al.,*[7] found that the components of rice crops are strongly influenced by plant spacing, especially the number of grain and panicle length. This is in line with the results of Abdulrachman *et al.,*[8], which states that the double row planting system is one of the new technologies and innovations to overcome the problems in the cultivation system, especially in terms of increasing the productivity of rice crops. The combination of scientific considerations (to achieve the best/highest results), and technical considerations (easy, cheap and farmers' desires) leads to diversity of spacing application in the field. The spacing system used by farmers are in various sizes including a) the cubic planting system with a space ranging from 20 cm x 20 cm; 25 cm x 25 cm; 27.5 cm x 27.5 cm; 30 cm x 30 cm or b) the double row pattern of 2:1. The plant spacing should be adjusted to soil conditions and soil fertility based on the soil test. On a very fertile land the spacing use are 25 cm between rows, 12.5 cm within rows, and 50 cm between double row. In less fertile land spacing is wider, ie 30 cm between rows, 15 cm within rows, and 40 cm between double row, or it can also be 20 cm between rows, 20 cm within rows and 40 cm between double row.

Erythrina *et al.,*[9], explains that although the double row planting system technology has a higher grain yield compared to the cubic planting system, this technology is not easily adopted by farmers, as most of them are accustomed to using the cubic planting system, so it takes time to change the behavior of these farmers. Therefore, in addition to the introduction of the double row planting system, the Assessment Institute for Agricultural Technology (AIAT) of Lampung Province has currently introduced the twin seed planting system, which has been widely adopted by farmers in the Pesawaran and Central Lampung District. The twin seeds planting are also aimed at utilizing the effects neighbouring plants as in the double row planting system. Other advantages of the twin seeds system includes: number of seeds are fewer, planting and weeding are relatively easier, productivity are 5-10% higher compared to the double row system and 6.70% higher than the cubic planting system[10].

Two varieties of rice were used in this experiment, namely the Ciherang and Inpari 10 varieties. The Ciherang variety was released in 2000, it is a superior rice that is favored by farmers because, relatively resistant to pests, harvest age is at 116-125 days, with productivity potential of 5-7 tons/ha, suitable to be planted in the rainy season, and has a waxy taste. However, as the Ciherang variety has been planted continuously, for quite sometimes, so that it becomes susceptible to the pest attack, therefore it has been crossed back to some superior rice varieties and in 2009 the new rice yielded superior varieties named Inpari 10 is released.

The superiority of the Inpari 10 variety inculdes: a) relatively resistant to brown planthopper stems biotype 1 and 2, b) realtively resistant to bacterial leaf blight strains III, c) rather susceptible to the blight of bacteria strain IV leaves, d) can be planted during the rainy and dry seasons and well planted on paddy fields with 5-7 days irrigation system, e) the harvest age is at 112 days, f) productivity potential is 7 tons/ha, g) has a slender form of grain and h) the flavor of rice is waxy, so it is favored by consumers[11].

This reserach aims to investigate the physical and nutritional quality of grain and milled rice using two rice varieties (i.e. the Ciherang and Inpari 10), with three different planting systems (i.e. the cubic, double row and twin seed).

Materials and Methods

This research was conducted in Simbar Waringin Village, Trimurjo Sub-district, Central Lampung District, Lampung Province, Indonesia, from March 2015 until September 2015. The research was conducted using a Complete Randomized Block Design of factorial pattern, consisting of 2 factors with 3 replications. The factors of the research were: a) Planting system (S1 = Cubic, S2 = Double row 2:1, and S3 = Twin seed) and b) Rice varieties (V1 = Ciherang; V2 = Inpari 10).

Soil processing was conducted completely with two plows and one rake. The seeds used were 17 days old, numbers of seeds used were 2 stems per clump, and the planting spacings used were in accordance to the planting system applied as the treatments. The distance between plants in the cubic planting system was 25 cm x 25 cm and numbers of plants were 160,000 plants/ha (Figure 1). The plant spacing in the double row planting system was 25 cm x 12,5 cm x 50 cm and numbers of plants were 213,000 plants/ha (Figure 2). On the other hand, the planting distance in the twin seed system was 30 cm x 5 cm x 30 cm and numbers of plants were 211,000 plants/ha (Figure 3).

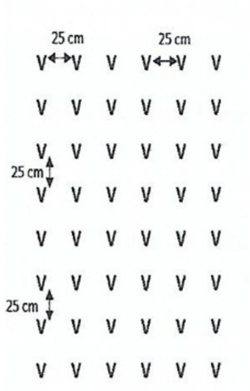

Fig. 1: Cubic Planting System

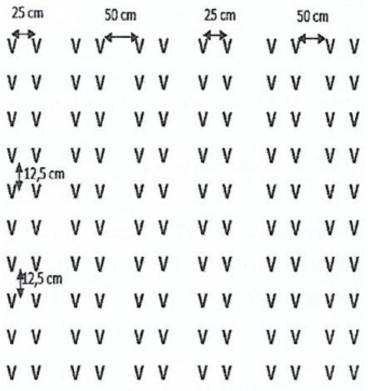

Fig. 2: Doublr Row Planting System

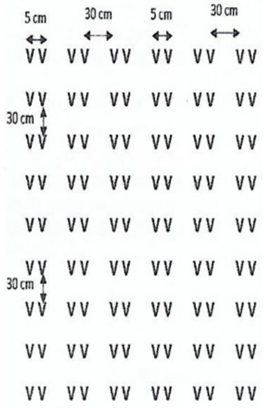

Fig. 3: Twin Seed Planting System

The dose of fertilizer used in this study was: 200 kg urea + 300 kg NPK per hectare. The irrigation used was the technical irrigation with an intermittent system. The pest management was done wisely, meaning that if there was no attack of pests or disease, there will be no pesticides spraying; this was to reduce the excessive use of chemicals.

The observation parameters in this study included: a) physical quality of grains (moisture, empty grains+dirts, grains density, 1000 grains weight, green lime grains, broken yellow grains, and red grains); b) quality of milled rice (moisture, broken skin rice and milled rice rendements, head rice, broken rice, rice groats, lime grains, and broken yellow grains); c) physical quality of rice (length, width, length/width ratio, white degree, translucence, and rationing degree); d) nutritional analyses of rice (14% moisture, ash, fat, protein, crude fiber, carbohydrate and amylose).

Analysis of physical quality of grains and milled rice were carried out in the Laboratory of Indonesian Center for Rice Research (ICRR), Subang, West Java Province, while rice nutrition analysis was conducted according to AOAC[12] in the Laboratory of Lampung State Polytechnic, Lampung. Measurement of moisture and ash contents were carried out using the gravimetric method, fat content using method of extraction (soxhlet extraction), protein content with kjedahl method, crude fiber using acid-base hydrolysis method, carbohydrate content by spectrophotometric method, and amylose content was done by colorimetric iodo method[13].

The collected data were then analyzed statistically using analysis of variance (ANOVA) and if there are differences between treatments, it will be then continued by the Duncan Multiple Range Test (DMRT) at 5% level by Gomez and Gomez[14], while for the quality analysis of nutrition of rice was done in a qualitative descriptive.

Results and Discussion

The grain physical quality produced is influenced by internal and external factors. Internal factors are genetic traits that have existed in the grain, while external factors influenced by the previous primary post-harvest treatment include pests and diseases during cropping and drying processes. The grain physical quality obtained in this study is presented in Table 1. It was found that the 6 treatments applied did not significantly affect the water content. The grain water content normally ranges from 11.80 to 12.70%, therefore the values obtained from this study indicated that the grain samples were in the safe criteria for storage, because in accordance with NSI[15] the maximum moisture content for a safe storage of grains (unshelled rice) and rice is 14%.

Table 1: Results of observation on physical quality of grains (according to NSI 6128-2008)*

Treatment	Moisture Content (%)	Empty grains+ dirts (%)	Grains density (g/l)	1000 grains weight (g)	Green lime grains (%)	Broken yellow grains (%)	Red grains (%)
S1V1	12.70	2.84^{a}	546^{b}	25.30^{a}	2.30^{ab}	9.46^{d}	0.00
S2V1	12.20	2.28^{b}	543^{b}	24.79^{a}	2.73^{b}	8.43^{c}	0.00
S3V1	12.70	2.68^{b}	543^{b}	25.33^{a}	2.08^{a}	5.67^{a}	0.00
S1V2	12.00	2.59^{a}	525^{a}	27.10^{b}	4.39^{c}	7.04^{b}	0.04
S2V2	12.00	2.51^{b}	528^{a}	27.30^{b}	2.59^{b}	6.65^{b}	0.12
S3V2	11.80	2.52^{b}	524^{a}	26.53^{b}	2.08^{a}	5.10^{a}	0.01

$^{a,\ b)}$ Different superscripts in the same column shows significantly different ($P<0.05$), using the DMRT test.

Table 1 show that the percentage of empty grains+dirts showed a significant difference when using the cubic planting system compared to using the double row or twin seed planting system. However, there was no significant difference in the percentage of empty grains+dirts when the two rice varieties used were planted using the cubic system. Likewise, there was the same percentage of empty grains+dirts if both varieties of rice were grown using the double row or twin seed system.

It was seen that the percentage of empty grains with cubic planting system was higher than the double row and twin seed for the two rice varieties used. This may be related to the intensity of sunlight received on the cubic planting system which is generally lower than the sunlight received on the double row and twin seed planting system. In the cubic planting system, plants accept more sunlight because of the wide plant spacing, however the number of plants per hectare is only small, i.e. 160,000 plants. In the double row planting system, the amount of sunlight entering the plants is less because of there are shadows of the neighbouring plants, and the distance between plants is only 12.5 cm, although the number of plants are more (213,000 plants/ha) compared to the cubic planting system. In the twin seed planting system, on the other hand, more sunlight entering the plans and the plant population is also higher (211,000 plants/ha) compared to the cubic planting system.

It was found in this study that a more dense spacing caused an increase in the number of empty grains in rice plants. This may be due to the low temperatures and high humidity at the time of flowering will disrupt the process of fertilization that resulted in the grain becomes empty due to the un-open seeds[16]. This is reinforced by the results of research by Alridiwirsah *et al.,*[17], which suggests that a more dense spacing would decrease the intensity of light at the time of flowering of rice and cause the decline of the carbohydrates formed, resulting in increased empty grains.

In this research, the weight of 1000 grains was more influenced by genetic factor such as varieties, while planting system was less influential. it was found that from the 3 planting system applied did not show significant difference both for rice varieties of Ciherang and Inpari 10. But from the average result it is seen that weight of 1000 grains for the Inpari 10 variety was higher than the Ciherang. The results of this study are in line with Supartha *et al.,*[18], which shows that the weight of 1000 grains is affected by the rice varieties and the type and dose of fertilization.

The twin seed cropping system yielded less green lime grains and damaged yellow grains compared to other cropping systems, both in Ciherang and Inpari 10 varieties, while the red grains did not show significant differences for all treatments. This may be due to that the lime grains are easily attacked by pests of *Sytophilus sp*. at the time of storage thereby decreasing the storage ability of the rice. In addition, the lack of sunlight also causes increased moisture in rice cultivation, resulting in increased microorganism activity that causes the occurrence of yellow and red grains.

Milled rice quality is more influenced by external factors such as harvest age, pest rate of disease when in the crop and drying process of grains. Observations on the quality of rice milled (Table 2) showed that the Main effects (planting system and rice varieties) and their interactions were significantly different. The Ciherang rice varietiy for the 3 planting systems applied, had a higher percentage of broken skin rice, milled rice, and head rice compared to the Inpari 10 rice. Allegedly this may be due to the epidermis of Ciherang rice veriety which is thinner than the Inpari 10 variety.

According to Mardiah and Indrasari[19], the total rendement of rice is also determined by the ratio of husk, epidermis, and endosperm parts. Other factors that determine the total rice yield are varieties, seed types, lime grains, cultivation methods, environmental factors, and post-harvest treatment that started from harvesting, threshing, drying, storage, to grinding. In addition the Ciherang rice variety has harder rice grains compared to Inpari 10 variety, and when milling it is not easily broken, so the percentage of broken rice and rice groats were lower than that of Inpari 10 variety.

The data in Table 2 also shows that the twin seed planting system, resulting in lower percentage of broken yellow grains compared to the cubic and double row 2:1 planting systems. Presumably this was due to the acceptance of light was optimal in the twin seed planting system, causing the photosynthesis in the leaves to also become optimal, the rice plants grow perfectly, especially during the generative periods so that the grains are denser (fully ripen), and this will then reduce the percentage of broken yellow grains. Sunlight is a source of energy for the process of photosynthesis, so that the absorption of sunlight by plant canopy is an important factor to produce assimilate for the formation of flowers, fruits and seeds. Sunlight is absorbed by the plant canopy in proportion to the total area covered by the canopy. The amount, distribution, and angle of leaves in a plant canopy determines the absorption and distribution of sunlight thus affecting photosynthesis and crop yield[17]. Although the need for light depends on the type of plant, the lack of sunlight and water greatly interferes with the process of photosynthesis, growth, and crop production.

Table 2: Results of observation on quality of milled rice (according to SNI 6128-2008)

Planting system	Rice Varieties	Moisture content (%)	Broken skin (%)	Milled rice (%)	Head rice (%)	Broken rice (%)	Rice groats (%)	Lime grains (%)	Broken yellow grain (%)
S1	V1	11.60	78.22^{b}	69.14^{b}	94.31^{c}	5.51^{a}	0.18^{a}	1.75^{c}	6.41^{c}
	V2	11.50	76.86^{a}	67.09^{a}	86.18^{a}	13.45^{b}	0.37^{c}	1.78^{c}	4.20^{b}
S2	V1	11.70	78.65^{bc}	69.44^{bc}	93.96^{c}	5.83^{a}	0.21^{a}	1.48^{b}	6.37^{c}
	V2	11.30	77.90^{b}	68.24^{b}	85.92^{a}	13.82^{b}	0.26^{b}	1.60^{b}	3.05^{a}
S3	V1	11.80	79.41^{c}	70.84^{c}	94.98^{c}	5.82^{a}	0.20^{a}	1.38^{b}	4.14^{b}
	V2	11.50	78.07^{b}	68.82^{b}	89.80^{b}	9.82^{b}	0.38^{c}	1.10^{a}	2.48^{a}
Main Effect:									
Planting sytem		Ns	**	**	**	**	**	**	**
Rice Varieties		Ns	**	**	**	**	**	**	**
Planting system x Rice Varieties		Ns	**	**	**	**	**	**	**

a, b) Different superscripts in the same column shows significantly different (P<0.05), using the DMRT test.

The physical quality of rice affects the level of consumer acceptance of the rice. In general, consumers prefer the long and white colored rice. The result of observation on physical quality of rice is presented in Table 3. It was found that planting system does not significantly affect the physical quality of rice, but variety seemed to have a significant effect on the physical quality of rice produced.

The ratio of length and width (L/W) of rice determines the classification of the shapes of grains of rice. The results showed that the L/W ratio of rice observed ranged from 2.92-3.19, which was included in moderate to long and lean categories. The IRRI[20] classified the rice into 4 forms: i.e. a) slender (long and lean) with L/W ratio of 3.0, b) medium with L/W ratio of 2.1-3.0, c) bold (short and slightly oval) with L/W ratio of 1.1-2.0, and d) round with L/W ratio ≤ 1.0.

The value of white rice degree is proportional to the rationing degree, the higher the rationing degree, the higher the degree of white rice. Rationing will improve the appearance of rice more visually appealing and the cooking quality, as well as having the preferred flavor and taste[21]. This is in line with the results of research by Tarigan and Kusbiantoro[22], which states that the rationing and storage affect the assessment of organoleptic tests that include color, flavor, waxiness and taste of rice produced. The color of milled rice is generally measured from the value of the white degree of rice due to the process of rationing, the longer the rationing time, and the resulting milled rice becomes whiter. This can be seen from the higher rationing degrees of Inpari 10 varieties resulting in higher white degree values. Mardiah *et al.,*[23], stated that the apparent white degree of rice is related to consumer preferences based on color and is significantly based on the luster and taste of rice.

Table 3: Results of observation on physical quality of rice (according to SNI 6128-2008)

Planting system	Varieties	Rice measurement			Milling meter		
		Length (mm)	Width (mm)	Length/ Width Ratio	White degree (%)	Tranculence (%)	Rationing degree
S1	V1	6.74^{a}	2.31	2.92^{a}	45.10^{a}	2.45^{b}	116^{a}
	V2	7.17^{b}	2.28	3.14^{b}	53.05^{b}	2.00^{a}	148^{b}
S2	V1	6.89^{a}	2.28	3.02^{a}	44.85^{a}	2.45^{b}	114^{a}
	V2	7.31^{b}	2.29	3.19^{b}	52.85^{b}	2.04^{a}	147^{b}
S3	V1	6.67^{a}	2.28	2.93^{a}	46.20^{a}	2.50^{b}	114^{a}
	V2	7.14^{b}	2.28	3.13^{b}	52.75^{b}	2.29^{b}	149^{b}
Main Effect:							
Planting sytem		Ns	Ns	Ns	Ns	Ns	Ns
Varieties		**	**	**	**	**	**
Planting system x Varieties		Ns	Ns	Ns	Ns	Ns	Ns

[a, b] Different superscripts in the same column shows significantly different ($P<0.05$), using the DMRT test.

In addition to the color of rice, the quality component of milling that directly affects consumer acceptance is the nature of translucence. The higher the value of the translucence indicates that the rice is more clear. Generally, rice consumers like milled rice that is white and clear. The general value of the rice translucence ranged from 2.00 to 2.50, and it was obtained from this study that the value of rice translucence for the Ciherang rice variety was higher than the value for the Inpari 10 variety. The value of translucence is influenced by the genetic factors and the method of rationing, illustrating the ability of rice beans to pass the light, and the value varies between varieties. The color and rice translucence are used by consumers in the selection of rice. Indrasari *et al.,*[24], indicated that based on the value of the preferred rank in the rice selection for consumption, the color of the rice was chosen by 42% of respondents as the fourth consideration, followed by 16% and 15% respectively for second and third considerations, while the luster of rice was chosen by 70% of respondents as the sixth consideration, followed by 13% and 12% of respondents who chose luster rice as the fourth and fifth considerations.

The nutritional value of rice is generally influenced by genetic factors, while the primary post-harvest treatment is less important. The primary post-harvest treatment conducted in this study was the method of threshing rice (by hand and using the thresher) and the method of drying (using the tarpaulin and drying floor). The results of the nutritional analysis of rice are presented in Table 4.

The results of the study in Table 4 show that, in addition to the genetic nature of each variety influences, the nutrition contents of rice were also influenced by the planting system and rice varieties. This was evident from the results of different laboratory analyses for the 6 treatments applied. The lowest water content was found in rice grown with the double row planting system using Ciherang variety, and the highest was found in rice grown with the cubic system also using the Ciherang variety. The lowest ash content was found in rice grown by the double row system using Inpari 10 variety, and the highest was found in rice grown with the cubic planting system and also using the Inpari 10 variety.

Table 4: Results of the nutritional analysis of rice

Treatment	Percentage (%)						
	Moisture	**Ash**	**Protein**	**Fat**	**Crude fiber**	**Carbohidrate**	**Amylose**
S1V1	12.16	5.69	5.76	2.81	10.03	63.55	17.37
S2V1	10.81	5.89	4.26	2.69	10.41	65.94	17.13
S3V1	12.03	6.66	4.47	2.72	8.87	65.24	16.84
S1V2	11.06	7.15	6.71	2.58	10.84	61.66	18.34
S2V2	11.57	5.54	4.93	3.04	10.31	64.61	17.97
S3V2	10.82	6.40	5.42	2.38	10.24	64.74	18.94

The lowest protein content was found in rice grown with double row planting system using Ciherang variety, and the highest was found in rice grown with the cubic system using Inpari 10 variety. The lowest fat content was found in rice grown with twin seed system using Inpari 10 variety, and the highest was found in rice grown with the double row system also using the Inpari 10 variety. The lowest crude fiber content was found in rice grown with the twin seed system using Ciherang variety, and the highest was found in rice grown by the cubic planting system using Inpari 10 variety.

The lowest carbohydrate levels were found in rice grown on the cubic planting system using Inpari 10 variety, and the highest was found in rice grown with the double row system using Ciherang variety. The lowest level of amylose was found in rice grown with the twin seed system using Ciherang variety, and the highest amylose content was found in rice grown with the twin seed system using Inpari 10 variety.

According to Lestari *et al.,*[25], the low amylose content is <20% with the taste of waxy rice; medium amylose is between 20 to 24% with medium flavor, and high amylose is between 25 to 30%, with loose flavor of rice, because the higher the amylose content of rice the taste is more loose. Amylose content of rice is a characteristic of rice varieties, therefore amylose levels can be used to detect the level of rice waxiness generated. Wang *et al.,*[26] says that the diverse amylose content is influenced by genetics, growth zones, and environment. Amylose content also affects water absorption and expansion rate in the cooking process; Generally, rice with low amylose content is considered delicious, this is related to the pecular structure, anti-swelling character, good range of span, and adjacent amylose gel character[27].

Conclusion

The Ciherang and Inpari 10 rice varieties produced rice with similar physical qualities and nutrien contents when they were planted either with the cubic, double row or twin seed planting systems. The Ciherang rice did not produce similar physical quality rice when compared to the Inpari 10 rice, but both of them produced rice with similar nutrient contents.

Acknowledgements

The authors would like to give sincere thanks to Mrs. Fitri, Mrs. Novilia and Mr. Sunaryo of the Assessment Institute for Agricultural Technology (AIAT) of Lampung Province and to all extension co-workers at the Agriculture Extension Office of Central Lampung Regency who have helped the implementation of this research activity. The authors would also like to thank the Sustainable Management of Agricultural Research and Technology Dissemination (SMARTD) program of Indonesian Agency for Agricultural Reserch and Development (IAARD) for providing the financial support for this study through the KKP3SL's competitive research fund of 2015.

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