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Agronomic Traits, Chemical and Physical Properties of Local Thai Rice, BP2012-009 and BP2012-010 Lines Derived from Bulk Selection Method

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Abstract

Local Thai rice, BP2012-009 and BP2012-010 lines with purple pericarp were derived from improved varieties with bulk selection method for 2 years both in-season and off-season to obtain good phenotypic traits for extended research. The current research was aimed to examine agronomic traits, chemical and physical properties of the 2 rice lines in comparison with Riceberry variety. The experiment was arranged in the randomized complete block design (RCBD) with 5 replications; The 2 rice lines and 1 rice variety were evaluated under 2 conditions of lowland and upland. The experiment was carried out in the paddy field and the plant science research plots in Chonburi province during September to December 2015. The result suggested that the 2 rice lines and 1 variety under lowland condition showed statistical differences in plant height, tillering, harvest age, number of panicles per hill, and yield per rai. BP2012-009 provided the best yield and yield components, with the highest yield of 705.80 kg. per rai, followed by BP2012-010 and Riceberry with yields of 648.80 kg. and 462.20 kg. per rai, respectively. Under the upland condition, the growth and yield were similar to those in lowland condition, however, less use of water than in the upland condition had resulted in reduced vegetative growth and yield per rai. BP2012-009, BP2012-010, and Riceberry produced yields of 654.80, 597.80, and 412.60 kg. per rai, respectively.

This research indicated that BP2012-009 and BP2012-010 yielded greater than Riceberry in both the lowland and upland conditions. Examination of physical traits of BP2012-009, BP2012-010, and Riceberry in lowland condition found that BP2012-009 and BP2012-010 possessed the same traits, i.e. straw-colored husk, relatively round grain shape, dark purple husked grain, gelatinization temperature at 67°C, and soft and sticky cooked rice. Whereas Riceberry had dark purple husk, long and slender grain, dark purple husked grain, gelatinization temperature at 70°C, incoherent soft cooked rice. Regarding chemical properties, BP2012-009 contained a greater amount of GABA, protein, fiber, Omega 3, Gamma oryzanol, and antioxidants than Riceberry, while Riceberry contained more of essential substances including Vitamin B2, Vitamin E, Iron, Zinc, and anthocyanin than BP2012-009. It was also found that BP2012-009 contained low starch and low amylose content of 7.15 % which is considered very low and should thus be suitable for consumers who want to control dietary and sugar intake.

Keywords: Agronomic Traits, Chemical And Physical Properties, Local Thai Rice

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Introduction

Rice with pericarp in red, purple, and black colors that were found and known include 2 lines. The first rice line is red rice grown mixing with white rice in a paddy field and generally known as wild rice or barnyard millet or chicken panic grass (*Oryza rufipogon and Oryza officinali*). Typically, red rice mixed in paddy fields is smaller in grains than other rice commonly grown. Wild rice can grow well in the field and its seeds fall easily, but can survive across seasons, reproduce well to mix with others in a paddy field. Its pericarp ranges from light red to dark red. The grains are small and hard and cannot cook well.

A certain type of wild rice (*Oryza rufipogon*) despite containing only 26 % amylose content in rice starch, requires the high cooking

temperature to achieve gelatinization, produces low gel consistency (hardness) and no aroma. Red rice grains mixing in white rice grains will reduce white rice's physical and chemical quality. It is, therefore, a requirement that all standard varieties of rice are not mixed with red rice. The second rice line has dark purple to black grains which now gains increasing consumer interest for its special properties of containing high protein and other minerals, i.e. iron, zinc, copper, calcium, potassium, and many B-vitamins. The analysis of black purple color of grains suggests that it contains a flavonoid called anthocyanin as an antioxidant in a greater amount than those found in red grapes and prunes. Anthocyanin presents in black rice help promote black and soft hairs and prevent split-end hairs, promote blood circulation, and strengthen hair roots that prevent the hairs to fall off easily.

The pigment also activates increased hair color naturally, delays premature graying hairs. It also helps prevent major serious diseases. A research report in Japan found in Lab animals that anthocyanin can activate hair regrowth 1 time earlier in the treatment group than in comparison group. In vitro studies confirmed that anthocyanin helps stimulate hair roots (hair keratinocytes) and increase hair volume for 3 times. Anthocyanin also helps prevent cognitive decline, hypertension, and diabetes, reduce the development of cancer, and aids better night vision (Wanchai, 1988). The current research aimed to examine agronomic traits and chemical and physical properties of the 2 rice lines with purple pericarp in comparison with Riceberry as a commercial variety.

Material and Method

The research was carried out during September to December 2015 in the paddy field and the plant science research field of the Faculty of Agriculture and Natural Resources, Department of Plant Production Technology, Rajamangala University of Technology Tawan-ok at Bangpra Campus, Bangpra sub-district, Sriracha district, in Chonburi province, Two local Thai rice lines, BP2012-009 and BP2012-010, derived from improved varieties with bulk selection method were compared with Riceberry, a commercial variety, in 2 growing conditions of upland and lowland. The experiment was arranged in the randomized complete block design (RCBD) with 5 replications. Three treatments were assigned to BP2012-009, BP2012-010, and Riceberry in 15 plots each of 10 m 2 in size, by transplanting 30-day-old sprouted seedlings with 30 x 30 cm. spacing in the plots in lowland condition and direct seeding in upland condition with the same spacing.

Rice agronomic traits were recorded following the method of Yoshida (1981) which include plant height, number of plants per hill, harvest age, number of panicles per hill and yield per rai. The chemical and physical traits of grains were analyzed and brought to further analysis by experimental plan and comparison of mean differences using DMRT at 95 % confidence.

Results and Discussion

The research examined the agronomic traits, yielding, physical and chemical properties of 2 rice lines, BP2012-009 and BP2012-010 collected from the research project on biodiversity of native rice in Thailand, funded in 2012 – 2013, as an extension for improved varieties with bulk selection method as it is easy to process with low cost. The selection was based on the criteria of external traits to exclude the varieties of undesired traits and include only those of desired traits from which their seeds were collected for further growth and selecting to obtain good phenotypic traits for extended research. Accordingly, 2 rice lines were selected, i.e. BP2012-009 and BP2012-010. These 2 lines were examined for their agronomic traits, yielding, physical and chemical properties in comparison with Riceberry as commercial varieties.

Two growing conditions, lowland, and upland were investigated. The results revealed that lowland condition provided many better agronomic traits than the upland condition in both the studied lines and the compared varieties. The plants grew higher in lowland than in upland for all of the BP2012-009, BP2012-010, and Riceberry. Yields per rai were also higher in lowland than upland since water logging in lowland affected greater extended nodes and internodes than in upland with no wet area and less humidity. Lowland plantation is common for general rice growing system. With better culm growth, the yields, the number of plants per hill, and the number of panicles per hills are greater. This is because rice with the perfect growth of culm and leaves provides better accumulated dry weight in grains (De Datta and Zarate, 1970) (Table 1).

On the other hand, upland condition offers better certain traits in terms of shorter harvest age and a greater number of panicles per hill. It suggested that lower water upland condition affects earlier flowering age and seed setting as an advantage of growing rice in dry condition. BP2012-009 and BP2012-010 grew better than Riceberry in both the lowland and upland conditions, or it can be said that BP2012-009 and BP2012-010 possess amphibious property. In addition, rice varieties with drought tolerance or ability to grow in low water areas are thus alternatives to agriculturists doing rice farming in the high land as they are suitable for the current dry climate and water shortage in farming season. Moreover, BP2012-009 and BP2012-010 are rice lines with non-photosensitive and short harvest age, so they can be grown all year round. The results showed no differences in the number of plants per hill, harvest age, sizes of husked and un-husked grains in both lowland and upland conditions. With respect to rice yield, BP2012-009 and BP2012-010 provided higher yield per rai than Riceberry in both conditions (Table 1, 2).

Result on physical traits of BP2012-009, BP2012-010 and Riceberry being grown in lowland condition, considered the following characteristics: husk color, grain shape, husked grain color, gelatinization temperature, and cooked rice texture. BP2012-009 and BP2012-010 were found to have similar physical traits including straw-colored husk, relatively round shape, dark purple husked grain, gelatinization temperature at 67°C, and soft and sticky cooked rice, as they share the same genetics. Whereas Riceberry had dark purple husk, long and slender grain, dark purple husked grains, gelatinization temperature at 70°C, soft incoherent cooked rice.

Physical properties, i.e. husk color, husked grain color, size and shape of grain, and gelatinization are indices to measure the quality of grain and rice, including eating (Onanong, 2007). These are the traits of each rice varieties that are controlled by genotypes. The purple color of BP2012-009 and BP2012-010 has nutritional property as an antioxidant as also found in Riceberry. Investigation of rice gelatinization is important as gelatinization temperature affects the texture of cooked rice which indicates eating quality. Rice quality was also affected by factors on chemical properties and physical traits that the processing methods and types of processing products depend upon (Ngamchuen, 1999) (Table 3).

Results on chemical properties of BP2012-009 and Riceberry indicated that BP2012-009 contains a greater amount of GABA, protein, fiber, Omega 3, Gamma oryzanol, an antioxidant than Riceberry, while Riceberry contains more of essential substances including Vitamin B2, Vitamin E, Iron, Zinc, and anthocyanin than BP2012-009. Rich in nutritional values, BP2012-009 is good to consume for health benefits. Essential fatty acids are important to the structure and function of the brain, liver, and nervous system, and help reduce cholesterol. Zinc aids in protein synthesis, generating collagen, healing acne, preventing hair

loss and stimulating hair roots. Iron helps in energy production and transportation in the body, as the essential component of hemoglobin in red blood cells and also of an enzyme involved in oxygen use in the body and brain.

Vitamin E helps slowing down the aging process, promoting healthy skin, reducing the risk of cardiovascular diseases, and improving lung functioning. Vitamin B1 is essential for the functions of brain, nervous system, digestive system, and helps prevent beriberi. Oryzanol reduces cholesterol and triglyceride in blood vessels, promotes normal circulation of blood, reduce the risk of heart disease, diabetes, hypertension, and dementia. The fiber in BP2012-009 helps reduce fat and cholesterol levels, prevent heart disease, control weight, and facilitate excretory system.

Moreover, the result on chemical traits of BP2012-009 showed a low level of starch and very low level of amylose of only 7.15 ranging between 2-9% which is considered very low amylose rice and thus suitable for diabetes patients. The rice can be processed into a variety of foods including Thai desserts for its gel temperature of 67° and offering soft and sticky texture. Low amylose rice is often used as raw material in fermentation for Japan's sake, rice vinegar or Shoyu (Ngamchuen, 1999) Amylose content also affects other physical traits used in identifying the processing method, for example, low amylose rice provides a higher viscosity of rice starch, and requires a longer time for gelatinization. Low amylose rice starch has low gel temperature and longer retrogradation time (Ngamchuen, 2003) (Table 4).

Conclusion

Under lowland condition, BP2012-009 rice line provided the best yield and yield components, with the highest yield of un-husked rice for 705.80 kg. per rai, followed by BP2012-010 rice line and Riceberry variety with yields of 648.80 kg. and 462.20 kg. per rai, respectively. Under the upland condition, the growth and yield were similar to those in lowland condition, however, less use of water than the upland condition had resulted in reduced vegetative growth and yield per rai. BP2012-009, BP2012-010, and Riceberry produced yields of 654.80, 597.80, and 412.60 kg. per rai, respectively.

The present research indicated that BP2012-009 and BP2012-010 rice lines yielded greater than Riceberry variety in both the lowland and upland conditions. Results on physical traits i.e. husk color, grain shape, husked grain color, gelatinization temperature, and cooked rice texture of BP2012-009, BP2012-010, and Riceberry grown in lowland condition suggested similar traits of BP2012-009 and BP2012-010. These included straw-colored husk, relatively round grain shape, dark purple husked grain, gelatinization temperature at 67°C, and soft and sticky cooked rice. In comparison, Riceberry had dark purple husk, long and slender grain, dark purple husked grains, gelatinization temperature at 70°C, and incoherent soft cooked rice. Results on chemical properties of BP2012-009 and Riceberry suggested that BP2012-009 contains a greater amount of GABA, protein, fiber, Omega 3, Gamma Oryzanol, and antioxidants than Riceberry, while Riceberry contains more of essential substances including Vitamin B2, Vitamin E, Iron, Zinc, and anthocyanin than BP2012-009. In addition, BP2012-009 contains fiber that helps in weight control and excretory system. It was also found that BP2012-009 contained low starch and low amylose content of 7.15 % which is considered very low amylose rice.

Table 1: Plant height, number of plants per hill, harvest age, number of panicles per hill and yield per rai of 2 rice lines and 1 rice variety in lowland condition

Rice Line	Agronomic Traits				
	Plant Height (cm.)	Number of Plants per Hill (Plants/Hill)	Harvest Age (Days)	Number of Panicles per Hill (Panicles/Hill	Yield (kg/rai)
BP2012-009	143.08^{a}	14.00^{a}	110.60^{b}	13.50^{a}	705.80^{a}
BP2012-010	142.74^{a}	13.66^{b}	110.80^{b}	13.44^{a}	648.80^{b}
Riceberry	137.00^{b}	13.08^{c}	130.60^{a}	12.80^{b}	462.20^{c}
Mean	140.94	13.58	117.33	13.24	605.60
F-test	**	**	**	**	**
C.V. (%)	0.67	1.33	0.88	2.10	3.70

Remark: ** = Strong statistical significant difference at 99% confidence
In the same column, different letters represent statistical difference when comparing with DMRT

Table 2: Plant height, number of plants per hill, harvest age, number of panicles per hill and yield per rai of 2 rice lines and 1 rice variety in upland condition

Rice Line	Agronomic Traits				
	Plant Height (cm.)	Number of Plants per Hill (Plants/Hill)	Harvest Age (Days)	Number of Panicles per Hill (Panicles/Hill	Yield (kg/rai)
BP2012-009	124.60ª	14.60ª	110.60ᵇ	14.00ª	654.80ª
BP2012-010	126.00ª	14.60ª	110.60ᵇ	14.00ª	597.80ᵇ
Riceberry	102.20ᵇ	13.60ᵇ	130.40ª	13.20ª	412.60ᶜ
Mean	117.60	14.26	117.20	13.73	555.07
F-test	**	**	**	ns	**
C.V. (%)	1.60	4.05	0.95	4.10	3.78

Remark: ns = No statistical significant difference
**** = Strong statistical significant difference at 99% confidence**
In the same column, different letters represent statistical difference when comparing with DMRT

Table 3: Physical traits of BP2012-009, BP2012-010, and Riceberry

Physical Trait	Variety/Line		
	BP2012-009	BP2012-010	Riceberry
Husk Color	Straw Color	Straw Color	Dark Purple
Grain Shape	Relatively Round	Relatively Round	Long and Slender
Husked grain Color	Dark Purple	Dark Purple	Dark Purple
Gel Temperature (°C)	67	67	70
Cooked Rice Texture	Sticky and Soft	Sticky and Soft	Incoherent and Soft

Table 4: Chemical components of BP2012-009 and Riceberry

Chemical components	Variety/Line		Reference Test
	BP2012-009	Riceberry	
GABA (mg. /kg.)	20.54	18.95	TAS 4003-1012
Protein (g. /100 g.)	9.17	8.30	AOAC 2012
Starch (%)	67.87	79.20	EC-Method 1999/79
Fiber (g. /100 g.)	8.02	4.95	AOAC 2012
Vitamin B2	0.029	0.042	Food Chemistry (1984)
Vitamin E (mg.../100 g.)	0.20	0.55	LC Analysis of Food,1979
Iron (mg. /kg.)	11.43	13.80	AOAC 2012
Zinc (mg. /kg.)	21.28	31.90	AOAC 2012
Amylose (%)	7.15	15.6	Department of Agriculture,2004
Omega3 (mg. /100 g.)	30.62	25.51	AOAC 2012
Anthocyanin (mg. /100 g.)	17.42	21.50	AOAC 2005
Gamma Oryzanol (mg. /kg.)	241.22	46.20	AOAC 1993
Antioxidant (mg. Ascorbic acid/100 g.)	106.23	47.50	DPPH-Method

Remark: Chemical components were not analyzed for BP56-010 as it shares the same genetics as BP2012-009

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