Unhulled rice performance of M7 of local rice mutant lines in two locations of swamp land in South Kalimantan, Indonesia

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Unhulled rice performance of M7 of local rice mutant lines in two locations of swamp land in South Kalimantan, Indonesia

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Abstract

Swamp land is divided into tidal swamp land and swampy ("lebak") land. Selection and evaluation up to M6 generation have been done in swampy land. Because the parents of the mutant lines originated from tidal swamp land, then the experiment framework testing lines of mutant should also be conducted in the tidal swamp land. The purpose of this research was to study the appearance of physical characteristics of grain and amylose content of genotypes in swamp land and tidal swamp land. Two experiment were carried out for 5 months at Tanjung Harapan Village, Barito Kuala Regency and at Sungai Rangas Hambuku Village, Banjar Regency, South Kalimantan Province, Indonesia. Result showed that effect of G x L interaction were significant on unhulled rice width (W), ratio of L/W, and weight of 1000 seeds. There are several lines that have unhulled rice width equivalent to local rice varieties. Only G-14 which has moderate L/ W (2.67) and the others were slim (>3). The highest weight of 1000 grains was in G-23 (25.92g) at Sungai Rangas Hambuku and wasn't significantly different from K-1 and 15 other lines at the same location and G-20 at the Tanjung Harapan. The lowest weight of the 1000 grains was on K-1 (15.77g) at Tanjung Harapan, and not significantly different from G-18 at the same location. Amylose content of rice at Tanjung Harapan was bigger than at Sungai Rangas Hambuku. The range of amylose content among genotype of rice was 19.84% - 47.62%.

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Introduction

Swamp land is divided into tidal swamp land and swampy ("lebak") land (Widjaja-Adhi *et al.*, 2000). Differences in typology of land have implications for chemical, physical, and biological fertility. Tidal swamp land area in Indonesia reached 25.29 millionha (Djaenudin, 2008). According to Maamun and Sabran (1998) about 20.15 millionha, spread over Sumatra, Kalimantan, Sulawesi, and Papua. The area of swampy ("lebak") land is 13,283,000ha included 729,000ha has been utilized (Alichamsyah 2004 in Sudana 2005).

Utilization of tidal swamp land faces several limitations, including land and water problems (Sudana, 2005). The high acidity of the soil is also an agricultural problem in tidal land. Soil acidity characterized by low pH that affects the balance of chemical reactions and the availability of soil nutrients, especially phosphates (Jumberi and Alihamsyah, 2005). The development of tidal farming is a strategic step in responding to the increasing challenge of increasing agricultural production (Abdurachman and Ananto, 2000). Utilization of swamp land needs to be accompanied by the development of varieties that have high adaptability in suboptimal land.

Farmers preferences for local rice varieties in South Kalimantan, Indonesia are high due easy cultivation, the need for production facilities is low, high selling price, and characteristics of rice favored by community. However, local rice varieties also has weakness, that is but long-lived and low yield (Wahdah and Langai, 2009). Therefore, it is necessary to improve local varieties while maintaining the characteristics of grain (unhulled rice) and rice according to consumer tastes.

Induction of mutation with gamma rays 0, 10, 20, and 30 krad have been done in 2010 (Wahdah and Langai, 2010). Selection and evaluation up to M6 generation have been done in swampy land in Sungai Rangas Hambuku Village, Martapura Barat district, Banjar Regency, South Kalimantan, Indonesia. Data showed that some of M6 of mutant lines have some characters better than the controls, either Bestari and Inpara-2 as superior varieties or Cantik local variety. All M6 lines classified as short (90.48cm - 100.70cm) for plant height. The days after seeding to harvest were 111.00 – 115.00 days. The yields ranged from 3.83 tha^{-1} - 6.03 tha^{-1}, while the yields of Bestari, Inpara-2, and Cantik were 5.06 tha^{-1}, 6.79 tha^{-1} and 3.09 tha^{-1} respectivily. (Wahdah *et al.*, 2016). None of M6 mutant lines which slenderness equivalent to Cantik local variety (L/W = 5.58), but all lines classified as slender (the range of L/W ratio of unhulled rice were 3.73 - 4.99). There are some lines that have amylose content of rice were smaller, equal, or lower than Bestari, Inpara-2, and or Cantik varieties. The amylose content of rice of M6 mutant lines ranged from 3.23% - 29.63% (Wahdah, 2017).

Because the parents of the mutant lines tested originated from tidal swamp land, then the experiment framework testing lines of mutant should also be conducted in the tidal swamp land, so that the interaction effect between the genetic x location on the physical characteristics of the grain and the amylose content can be studied. The purpose of this research is to study the appearance response of physical characteristics of grain and amylose content of genotype in two typology of swamp land, namely swamp land and tidal swamp land.

Materials and methods

Two experiment were carried out for Rice cultivation for 5 months at Tanjung Harapan Village, Alalak District, Barito Kuala Regency and at Sungai Rangas Hambuku Village, Martapura Barat District, Banjar Regency, South Kalimantan Province, Indonesia.

Materials & equipment

Materials that have been used as 25 lines of M7 of mutant lines and three controls (Bestari and Inpara-2 as high yielding varieties and Cantik local variety), fertilizer (Phonska and Urea), pesticides (insecticide, fungicide, and moluscocide), and herbicide, and chemicals for testing amylose content of rice. The equipment used were tools for rice cultivation, scale, vernier calipers, and tools for analysis of amylose content of rice.

Cultivation techniques

Seeding has been done in each location. Seeding done per row per mutant line and transplanted 25 days after seeding to each plot measuring 3m x 4m. Spacing used was 25cm x 30cm based on 2 : 1 of "legowo" planting system (two rows planted and one row unplanted). Fertilization of 300kg Phonskaha^{-1} given at the age of 4 weeks after planting. Fertilization of 100kg Urea ha^{-1} given twice (50kgha^{-1} at 2 weeks after planting and 50kgha^{-1} at 6 weeks after planting). Pests control were done with pesticides as needed, while the weeds control were done manually and with herbicide according to recommended dosage. Harvesting was done if more than 90 percent of the panicles have matured.

Methods

Two experiments have been carried out based on Randomized Block Design with 2 replication each. Factor to be tested was genotypes (25 lines and 3 controls). Variables analyzed were unhulled rice length (L), unhulled rice width (W), and L/W ratio of unhulled rice, weight of 1000 grains, and amylose content of hulled rice. To determine the genetic x environment interactions, then performed a combined analysis of both locations, namely:

$Y_{ijk} = \mu + G_i + L_j + GL_{ij} + €_{ijk}$;

Y_{ijk} = the appearance of a penotype affected by the i^{-th} genotype and j^{-th} location

μ = the mean value of treatment

G_i = the effect of i^{-th} genotype

L_j = the effect of j^{-th} location

GL_{ij} = the interaction effect of i^{-th} genotype and j^{-th} location

$€_{ijk}$ = the effect of random error

If the treatment effect was significant, then the test was continued by the LSD test at 5% level.

Result and discussion

Recapitulation of variance analysis can be seen in Table 1. Table 1 showed that the location effect were highly signigicant on unhulled rice length, weight of 1000 seeds, and rice amylose content. Effect of genotype were significant on unhulled rice length (L), unhulled rice width (W), ratio of L/W, weight of 1000 seeds, and amylose content. The effect of G x L interaction on unhulled rice width (W), ratio of L/W, and weight of 1000 seeds were significant.

Table 1. Recapitulation of variance analysis of unhulled rice length (L), unhulled rice width (W), ratio of L/W, weight of 1000 seeds and rice amylose content.

Source of Variance	df	$F_{-0.05}$	$F_{-0.01}$	F-values				
				L	W	L/W	W1000	AC (%)
Location(L)	1	4.02	7.13	10.82**	2.22	0.48	215.10	45.23**
Replication in location	2	3.17	5.02	0.03	1.95	1.69	0.43	0.41
Genotypes (G)	27	1.71	3.24	2.15*	2.56*	1.91*	2.45	19.19**
G x L	27	1.71	3.24	1.19	2.95*	1.81*	3.95	1.32
Error	54							
Total	111							
CV (%)				4.10	10.90	12.18	5.19	44.34

** = highly significant, * = significant.

Unhulled rice length (L), unhulled rice width (W), and ratio of L/W

The Least Significant Different (LSD) test result on the effect of location on unhulled rice lenght can be seen on Table 2, while the effect of genotype can be seen on Table 3. The length of unhulled rice that planted in Sungai Rangas Hambuku, Banjar Regency was shorter than that planted in Tanjung Harapan, Barito Kuala Regency (Table 2). Based on Table 3, it can be seen that the longest unhulled rice was at G-14 (9.97mm) which is not significantly different from G-4, G-6, G-8, G-11, G-12, G-18 and G- 25. The shortest length of unhulled rice was on K-2 (Bestari) and K-3 (Inpara-2), namely 8.76mm and both were significantly smaller than all lines and Cantik local varieties.

Table 2. Result of LSD test for location effect on mean of unhulled rice length (L).

L of Tanjung Harapan (mm)	L of Sungai Rangas Hambuku (mm)
9.65b	9.41a

The number followed by the same letter showed no significant difference at the 5% level

Table 3. LSD test result on the effect of genotype on unhulled rice length (L).

Genotype	L (mm)	Genotype	L (mm)
G1	9.51cdefg	G15	9.66efgh
G2	9.29bc	G16	9.66efgh
G3	9.63efgh	G17	9.34bc
G4	9.70efghi	G18	9.85hi
G5	9.16bc	G19	9.59defgh
G6	9.70efghi	G20	9.43cde
G7	9.51cdefg	G21	9.63efgh
G8	9.72fghi	G22	9.49cdefgh
G9	9.68efgh	G23	9.08b
G10	9.57defgh	G24	9.72fghi
G11	9.72fghi	G25	9.82ghi
G12	9.75ghi	K-1	9.46cdef
G13	9.66efgh	K-2	8.76a
G14	9.97i	K-3	8.76a

The number followed by the same letter on column 2 and 4 showed no significant difference at the 5% level

According to Silitonga *et al.* (2003), and Irawan & Purbasari (2008), the length of unhulled grains of rice are classified into 4 groups, namely very long (> 7.50mm), length (6.61mm - 7.50mm), medium (5.51mm - 6.61mm), and short (<5, 51mm). Thus, although based on LSD test, there are difference in length average of unhulled rice between some lines and controls, but all genotypes (both lines and controls) were very long, namely 9.08mm - 9.97mm on lines, 9.46mm, 8.76mm, and 8.76mm on Cantik, Bestari, and Inpara-2 respectively. The length of unhulled rice of local rice varieties of South Kalimantan classified into long to very long, namely 7.14mm - 9.98mm (Wahdah and Langai, 2009) and very long according to Khairullah *et al.* (2006), which ranged from 7.7mm - 8.8mm. According to Liu *et al.* (2009), the length of rice grains varied very significantly with different cultivars. Mao *et al.* (2010) state that a major quantitative trait locus for grain size regulated by GS3. It functions as a negative regulator of grain size. The wild-type isoform is composed of four putative domains: a plant-specific organ size regulation (OSR). The wild-type allele corresponds to medium grain. Loss of function of OSR results in long grain. Loss of function mutations of these domains produced very short grain.

The LSD test of the interaction effect between genotype x location on unhulled rice width and ratio of length/width of unhulled rice can be seen in Table 4. Based on Table 4, it can be seen that the lines having the most narrow unhulled rice width was G-6 (1.69mm). The width of the G-6 lines wasn't significantly different from the G-1 G-2, and the G-22 planted at Sungai Rangas Hambuku, Banjar Regency and with the G-23 planted at Tanjung Harapan, Barito Kuala Regency. The strain showed the widest width of unhulled rice was G-14 at the location of the Sungai Rangas Hambuku, Banjar Regency (3.68mm) and significantly different either with all lines or with all controls.

Table 4. Result of LSD test for interaction effect between genotype and location on unhulled rice width (W) and ratio of unhulled rice lenght with unhulled rice width (L/W).

Geno-type	W (mm)		L/W	
	Tanjung Harapan	Sungai Rangas Hambuku	Tanjung Harapan	Sungai Rangas Hambuku
G-1	2.18defghijk	2.01abcde	4.36defghijk	4.89ijklm
G-2	2.61mnop	2.25efghijkl	3.6bcde	4.10bcdefgh
G-3	2.20defghijk	2.18defghijk	4.48efghijk	4.35cdefghijk
G-4	2.33efghijklmo	2.32efghijklmno	4.23bcdefghij	4.13bcdefgh
G-5	2.55lmnop	2.20defghijk	3.62bc	4.16bcdefghi
G-6	2.48jklmnop	1.69a	3.95bcdefg	5.72n
G-7	2.18defghijk	2.52klmnop	4.53fghijkl	3.68bcde
G-8	2.43ijklmnop	2.08cdefgh	4.16bcdefghi	4.66ghijkl
G-9	2.40ghijklmnop	2.44jklmnop	4.15bcdefgh	3.86bcdef
G-10	2.22efghijkl	2.09cdefghi	4.32cdefghij	4.59fghijkl
G-11	2.43ijklmnop	2.30efghijklmn	3.94bcdefg	4.34cdefghijk
G-12	2.44jklmnop	2.05bcdef	4.14bcdefgh	4.61ghijkl
G-13	2.20defghijk	2.24efghijkl	4.53fghijkl	4.23bcdefghij
G-14	2.22efghijkl	3.68q	4.55fghijkl	2.67a
G-15	1.87abcd	2.29efghijklm	5.06klmn	4.33cdefghijk
G-16	2.48jklmnop	2.42hijklmnop	3.89bcdefg	4.00bcdefgh
G-17	2.42hijklmnop	2.23efghijkl	3.93bcdefg	4.11bcdefgh

Geno-type	W (mm)		L/W	
	Tanjung Harapan	Sungai Rangas Hambuku	Tanjung Harapan	Sungai Rangas Hambuku
G-18	2.14cdefghij	1.83abc	4.69hijklm	5.40mn
G-19	2.46jklmnop	2.37fghijklmno	4.00bcdefgh	4.02bcdefgh
G-20	2.07cdefg	2.49klmnop	4.66ghijkl	3.79bcde
G-21	2.46jklmnop	2.31efghijklmno	4.01bcdefgh	4.10bcdefgh
G-22	2.12cdefghi	1.99abcde	4.53fghijkl	4.96jklm
G-23	1.72ab	2.20defghijk	5.26lmn	4.15bcdefgh
G-24	2.26efghijkl	2.28efghijklm	4.28cdefghij	4.35cdefghijk
G-25	2.73p	2.26efghijkl	3.67bcde	4.27cdefghij
K-1	2.65op	2.08cdefgh	3.61b	4.20bcdefghi
K-2	2.06bcdefg	2.18defghijk	4.44efghijk	4.55fghijkl
K-3	2.64nop	2.18defghijk	3.52a	3.89bcdefg

The number followed by the same letter showed no significant difference at the 5% level

Local rice varieties of South Kalimantan generally have unhulled rice width ranged from 1.7mm - 1.9mm (Khairullah *et al.*, 2006). Wahdah and Langai (2009) reported that the average width of unhulled rice of local rice varieties at tidal land was 1.23mm. The width of unhulled rice in this research were 1.69mm - 3.68mm. Thus, in M7 mutant generation there are several lines that have unhulled rice width equivalent to local rice varieties, but some are wider than local rice varieties.

Ellya *et al.* (2013) reported that the width of unhulled rice of M3 mutant lines (4 generations before M7 in these experiments) have width of unhulled rice ranged from 2,18mm to 2,53mm. According to Liu *et al.* (2009), the width of rice grain varied very significantly with different cultivars. The width and weight of rice grain controlled by a new QTL namely GW2 (Song *et al.*, 2007). Further reported that loss of GW2 function increased cell numbers, resulting in a wider spikelet hull. Shomura *et al.* (2008) reported a newly identified QTL for rice seed width on chromosome 5 was qSW5 (QTL). They reported that a deletion in qSW5 resulted in a significant increase in sink size owing to an increase in cell number in the outer glume of the rice flower.

The line that has the highest of L/W ratio in this experiment was G-6 planted at the Sungai Rangas Hambuku, Banjar Regency and not significantly different with G-15 and G-23 at Tanjung Harapan Barito Kuala Regency, and with G-18 at Sungai Rangas Hambuku. The G-14 line was the line that has the lowest L/W (2.67) and was significantly different than all the lines and controls, whether planted at Sungai Rangas Hambuku or at Tanjung Harapan. The line having the lowest L/W ratio (G-14) was the widest unhulled rice width (3.68mm) although it has the longest unhulled rice length (9.97mm).

The ratio of L/W is a measure of slimness of unhulled rice. According to Sajak *et al.* (2012) and Irawan and Purbasari (2008), unhulled rice are categorized as slender if the ratio of L/W > 3, moderate if in the range of 2.1 - 3.0 and round if < 2.1. Based on this classification, all lines and all controls were relatively slim (P / L > 3), except for G-14 which has L/ W was 2.67 (moderate L/W ratio).

None of 50 of M6 mutant lines which slenderness equivalent to Cantik local variety (L/W = 5.58) based on data analized of Sungai Rangas Hambuku only, but all lines classified as slender with the range of L/W ratio of unhulled rice were 3.73 - 4.99 (Wahdah, 2017). Based on data from experiments at Sungai Rangas Hambuku, Banjar Regency and Tanjung Harapan, Barito Kuala Regency showed that all of the 25 of M7 lines (selected from 50 of M6 lines) were selender, except G14 lines grown at Tanjung Harapan. There are several varieties which have unhulled rice slenderness equivalent to Cantik local variety, even there are more slender lines than Cantik. Only 1 line was less selender than Cantik, namely G14 grown at the Sungai Rangas Hambuku.

The L/W ratio of rice grain varied very significantly with different cultivars (Liu *et al.*, 2009). The grain shape of unhulled rice based on the ratio of the length and the width of unhulled rice, the following scale is used, namely slender, if > 3.0), medium (2.1 to 3.0), bold (1.0 to 2.0), and round if < 1.0 (Sajak *et al.* 2012); Irawan and Purbasari, 2008).

Weight of 1000 grains

The LSD test of the effect of genotype x location interaction on the weight of 1000 grains can be seen in Table 5. The highest weight of 1000 grains was in G-23 (25.92g) which is not significantly different from control (K-1) and 15 other lines which planted at the Sungai Rangas Hambuku, Banjar Regency, namely G-1 - G-6, G-8 - G-11, G-13, G-15, G-17, G-18, G-24 and not significantly different from 1 line which planted at the Tanjung Harapan, Barito Kuala Regency, ie. G-20. The lowest weight of the 1000 grains was on K-1 which planted at Tanjung Harapan, Barito Kuala Regency and not significantly different from G-18 which planted in the same location. The interaction between genetic x location can be seen from the change in the ranking of a genotype from one location to another as seen in the G-23 genotype. At Sungai Rangas Hambuku, the weight of 1000 grains of G-23 was heaviest grain, but in the Tanjung Harapan it was ranked 22th. K-1 was the genotype that has the lightest 1000 grains weight in Tanjung Harapan but was ranked 14th in the Sungai Rangas Hambuku.

Table 5. Result of LSD test for interaction effect between genotype and location on weight of 1000 grains.

Genotype	W 1000 (g)		Genotype	The Weight of 1000 grains (g)	
	Tanjung Harapan	Sungai Rangas Hambuku		Tanjung Haparan	Sungai Rangas Hambuku
G-1	21.61ghijk	24.01lmnop	G-15	20.64defgh	23.95lmnopq
G-2	20.80defghi	25.47q	G-16	20.10cdefg	23.36lmno
G-3	18.68bc	25.23pq	G-17	20.77defgh	23.87lmnopq
G-4	20.99efghij	24.31nopq	G-18	17.26ab	24.11nopq
G-5	20.13cdefg	24.51opq	G-19	23.15klmno	23.68lmnop
G-6	20.66defgh	24.64opq	G-20	23.91lmnopq	23.56lmno
G-7	22.43ijklm	22.57jklmn	G-21	22.80klmn	23.65lmnop
G-8	22.38hijklm	24.12nopq	G-22	21.09fghij	23.42lmno
G-9	23.29lmno	23.90lmnopq	G-23	19.52cdef	25.92q
G-10	23.28lmno	24.32nopq	G-24	19.34cde	25.39q
G-11	20.49defgh	24.23nopq	G-25	20.52defgh	23.23klmno
G-12	18.56bc	23.54lmno	K-1	15.77a	23.96lmnopq
G-13	20.01cdefg	24.61opq	K-2	22.76klmn	23.05klmno
G-14	19.19cd	23.36lmno	K-3	22.07hijkl	22.51klm

The number followed by the same letter showed no significant difference at the 5% level

The effect of genetic factor on the weight of 1000 grains of rice was also reported by Daradjat and Rumanti (2002). According to Sreedhar *et al.* (2011) there is an interaction effect between G x E on the weight of 1000 grains. The range of weight of 1000 grains tested in this experiment was 17.6g The range of weight of 1000 filled grains of rice were tested by Hairmansis *et al.* (2013) was 22 g - 26g. Those lines are selected towards a slim shape like the Siam Mutiara local rice variety as one of parent.

Two very popular local rice varieties in South Kalimantan were Siam Saba and Siam Mutiara. BPSBTPH Kalsel (2012) states that, each having an average weight of 1000 grains were 17.87g and 17.7g - 17.70g respectivily. Thus, the lines in this experiment can be selected some lines that have the weight of 1000 grains equivalent with Siam Saba and/or Siam Mutiara, because the range of the weight of 1000 grains in this study was 17.6g - 25.9g. All lines in this experiment were relatively mild, except for the G-1, G-23, and G-24 lines planted on the Sungai Rangas Hambuku. According to Sajak *et al.* (2012), the weight of 1000 grains of rice is heavy if > 30 g, moderate if between 25-30g, and light if <25g.

Grain weight is one of the most important components of grain yield and is controlled by quantitative trait loci (QTLs). The width and weight of rice grain controlled by a new QTL namely GW2 (Song *et al.*, 2007). Further reported that loss of GW2 function increased cell numbers, resulting in a wider spikelet hull, and it accelerated the grain milk filling rate, resulting in enhanced grain width, weight, and yield. They stated that GW2 negatively regulates cell division. Li *et al.* (2011) stated that the grain size of rice controlled by quantitative trait locus (QTL) GS5 via regulating grain width, filling, and weight. Therefore GS5 functions as a positive regulator of grain size, such that higher expression of GS5 is correlated with larger grain size. GS5 contributes to grain size diversity in rice.

Rice amylose content

The result of LSD test of the location effect on the amylose content can be seen in Table 6, while the genotype effect can be seen in Table 7. Only single factor of genotype and location each, that have a significant effect on the amylose content of rice, while genotype x location interaction did'not significantly different. The results of the LSD test of location can be seen in Table 11, while the genotype effect in Table 12. Amylose content of rice that planted at Tanjung Harapan was bigger than at Sungai Rangas Hambuku. According to Table 11, it appears that the range of amylose content among genotype of rice was 19.84 (G-13) - 47.62 (K-1). According to Hairmansis *et al.*, (2013), the range of amylose content of rice that derive from plant breeding selection directed to "pera" rice were 19.25% -28.63%.

Table 6. Result of LSD test for location effect on amylose content (A).

Amylose content (%)	
Tanjung Harapan	Sungai Rangas Hambuku
40.8b	20.6a

The number followed by the same letter showed no significant difference at the 5% level

Somantri (1983) in Aliawati (2003) state that the amylose content in rice can range from 1% - 37%. Thus, there is the possibility of bias in the measurement. Inpara-2 in the description of varieties have amylose content of 22.06% (Indonesian Center for Rice Research, 2008b), while in this study 34.67%. However, it appears that local varieties Cantik has the highest amylose content in this experiment. This means consistent with the nature of the local varieties of South Kalimantan, which are generally "pera" (high amylose content of rice). The results of this study also showed that 1 line only that has the amylose content of grain wasn't significantly different from Cantik, namely G-10.

Table 7. LSD test result on the effect of genotype on rice amylose content.

Genotype (Lines/ Control)	Rice Amylose Content (%)	Genotype (Lines/ Control)	Rice Amylose Content (%)
G-1	31.61cdefg	G-15	24.95abcde
G-2	27.58abcdefg	G-16	35.13g
G-3	23.02abc	G-17	34.42efg
G-4	35.39g	G-18	24.29abcd
G-5	24.99abcdef	G-19	37.36h
G-6	36.49g	G-20	34.16defg
G-7	28.35abcdefg	G-21	30.21bcdefg
G-8	27.81abcdefg	G-22	25.36abcdef
G-9	24.63abcd	G-23	33.40defg
G-10	47.62i	G-24	20.73ab
G-11	21.53ab	G-25	19.93a
G-12	29.36abcdefg	K-1	49.52i
G-13	19.84a	K-2	35.07g
G-14	36.42g	K-3	34.67fg

The number followed by the same letter showed no significant difference at the 5% level

Based on combined analysis of 2 location, the interaction effect between genotype x location was not significant and based on Allidawati and Bambang (1989), there are 2 lines were pulen, ie G-13 and G-25, 7 lines were medium "pulen", ie G-3, G-5, G-9, G-11, G-15, G-18, and G-24, while the other lines were pera. The range of rice amylose content based on the avarage of 25 of M7 mutant lines at Sungai Rangas Hambuku and Tanjung Harapan was 19.84% - 49.52%. Wahdah (2017) reported that the rice amylose content of 50 of M6 mutant lines at Sungai Rangas Hambuku only, ranged from 3.23% - 29.63%).

In general, the classification of rice based on the amylose index according to Allidawati and Bambang (1989) is glutinous (< 10%), "pulen" (10 - 20%), medium "pulen" (20-24%), and "pera" (> 25%). There are variations of amylose content of rice between genotypes (Gomez, 1979). Amylose content of rice affected by temperature. Ripening of rice grains under high temperature showed low amylose content, and containing amylopectin with longer side chains (Asaoka *et al.*, 1985; Yamakawa *et al.*, 2007). Amylose content of rice affected by environmental factor especially temperature and N fertilizer (Gomez, 1979).

Conclusion

The effect of G x L interaction were significant on unhulled rice width (W), ratio of L/W, and weight of 1000 seeds. There are several lines that have unhulled rice width equivalent to local rice varieties. Only G-14 which has moderate L/ W (2.67) and the others were slim (>3). The highest weight of 1000 grains was in G-23 (25.92g) at Sungai Rangas Hambuku and wasn't significantly different from K-1 and 15 other lines at the same location and G-20 at the Tanjung Harapan. The lowest weight of the 1000 grains was on K-1 (15.77g) at Tanjung Harapan, and not significantly different from G-18 at the same location. Amylose content of rice at Tanjung Harapan was bigger than at Sungai Rangas Hambuku. The range of amylose content among genotypes of rice were 19.84% - 47.62%. There are 2 lines were "pulen", 7 lines were medium "pulen", while the other lines were "pera".

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