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Effect of genotype × location interaction on some agronomic characters of M7 of local rice mutant lines of South Kalimantan, Indonesia

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Abstract

Differences in land typology have implications for yield, that are influenced by genetic (G), environment (E), and G × E. The aim of this experiment was to study G × E interaction on performance of M7 mutant lines. This experiment have been done based on RBD at 2 locations for 6 months. Variables observed were plant height (PH), flowering date (FD) and plant age (PA), panicles number (PN), panicle length (PL), filled grains/panicle (FG/P), % of filled grains (PFG), and yield (Y). Results of experiment showed that G × E effect were significantly on FD, PA, PN, GW/P, PFG, and Y. The shortest of FD was G-10 (81 DAS) in Sungai Rangas Hambuku (SRH) but not significantly from 14 lines in SRH and 1 line in Tanjung Harapan (TH). The PA was G-1 in SRH (111 DAS), but not significantly from 5 lines in SRH and 1 lines in TH. The highest PN, GW/P, PFG, and Y were respectively 27.5 (G-25 in SRH) and not significantly from 4 lines and 1 control in SRH, 2.52 g (K-3 in SRH) but not significantly from 3 lines in RSH, 92.02 % (G-19 in TH) but not significantly from 2 lines in SRH, and 8.01 t ha^{-1} (G-13 in SRH) but not significantly from 5 lines and 1 control in SRH. The consistent of lines or controls performance in 2 locations were 12 lines and 1 control for FD, none for PA, 5 lines for PN, 5 lines and 3 kontrol for GW/P, 7 lines for % of filled grains, and 2 lines for Y.

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Introduction

Rice is the primary food for most of the world community. The increasing of world population will increase the need for food, including rice. Mulyani *et al.* (2011), states that rice production in Indonesia can be improved, among others, with the expansion of paddy fields and upland rice, and the utilization of abandoned land that needs to be accompanied by the development of varieties that have high adaptability in suboptimal land area.

Tidal land are suboptimal land. Maamun and Sabran (1998), stated that in Indonesia there are about 20.15 million ha of tidal swamp. According Djaenudin (2008), tidal swamp land area reached 25.29 million ha. The spread of tidal swamp is wide enough, namely in Sumatra, Kalimantan, Sulawesi and Papua. According to Sulaiman and Imberan (1996), land area of tidal swamp that planted to rice in South Kalimantan about143 738 ha, mostly planted with local rice varieties once per year (132.438ha). The preference of farmers to local rice varieties is high caused by ease of cultivation, don't require a lot of inputs, higher selling prices, and have characteristics that favored by local peoples (Wahdah and Langai, 2010). One of the weaknesses of local rice varieties are a long-lived and have a low yield. Siam Unus, Pandak, Bayar Palas, Lemo, Kuatek, and Lakatan Gadur have aged respectively 291, 305, 305, 272, and 295 days after seeding (Khairullah *et al.*, 2006), so that local rice plantations is generally only once a year, although some farmers has planted twice per year (Wahdah and Langai, 2010). In the newly opened areas, the average of yields of local rice varieties were about 1.0 t ha^{-1}, while in areas of rice fields have long been used were about 2.5 t ha^{-1} (Noorsyamsi *et al.*, 1984). The average yields of local rice varieties ranged 1.5 t ha^{-1} - 6.1 t ha^{-1}, depending on the varieties and planting location (Wahdah and Langai, 2009).

The induction of mutations by gamma rays (0, 10, 20, and 30 Krad) has been carried out in 2010. The Difference responses of local rice varieties to gamma rays have appeared on the M1 generation. Wahdah *et al.* (2016a) reported that some of M5 mutant lines better than it's parent. Data of M6 of mutant lines showed that some characters better than the control, either compared with superior varieties (Bestari and Inpara-2) or local variety (Cantik), namely on plant height, plant age, percentage of filled grains characters, grains weight per panicle, and yield. All M6 lines classified as short-stature, namely ranged 90.48 cm .- 100.70 cm and short-lived namely ranged 111.00 – 115.00 days after seeding. The yields ranged from 3.83 t ha^{-1} - 6.03 t ha^{-1}, while the yields of Bestari, Inpara-2, and Cantik were 5.06 t ha^{-1}, 6.79 t ha^{-1} and 3.09 t ha^{-1} respectivily (Wahdah *et al.*, 2016b).

Swamplands can be divided into the tidal swamp and swampy areas (Widjaja-Adhi *et al.*, 2000). Differences in land typology have implications for chemical, physical and biological of soil fertility, and finally have implications for yield of crops, that are not only influenced by genetic and environment, but also by the interaction between genetic with environment (G × E).

According Gillespie and Turelli (1998) the phenotype of an individual may be written P=G+Z+E, where G is the average of phenotype produced by its genotype averaged over all environments. They assume that the effect of the environment has two stochastically independent components, one that depends on the genotype of the individual and one that doesn't. Z is genotype-dependent component of environmental effects and will depend on both the genotype and the state of the environment that an individual experiences. Purcell (2002) state that G × E is often conceptualized as genetic control of sensitivity to different environments. Equivalent to that, G × E is control of environment from the effects of differential gene.

The parents of line mutants in this research came from the tidal swamp. Therefore, in addition tested in the area of swampy area, the testing also needs to be carried out on tidal swamp, so that the interaction of genetic x environment can be studied in the hope of promising lines are suitable to be cultivated in tidal swamp and or swampy area.

Materials and methods

Rice cultivation for 6 months was carried out in two location, namely 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

Materials that have been used as 25 lines of M7 of mutant lines and 3 controls (Bestari and Inpara-2 as high yielding varieties and Cantik local variety), fertilizer (Phonska and Urea), pesticides (insecticide, fungicide, and moluscocide), and herbicide.

Cultivation techniques

Seeding in each location done per row per mutant line and transplanted 25 days after seeding in each plot measuring 3 m × 4 m. Spacing used was 25 cm × 30 cm based on 2 : 1 of "legowo" planting system (two rows planted and one row unplanted). Fertilization of 300 kg Phonska ha^{-1} given at the age of 4 weeks after planting. Fertilization of 100 kg Urea ha^{-1} given twice (50 kg ha^{-1} at 2 weeks after planting and 50 kg ha^{-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, namely Cantik, Bestari, and Inpara-2). Variables analyzed were plant height at harvest, plant age, panicles number, panicle length, number of total and filled grains per panicle, percentage of filled grains per panicle, weight of filled grains per panicle, and yield. The analysis of the variance was a combined analysis of two locations. If the results of analysis of variance showed a significant difference, then followed by Least Significant Difference (LSD) test (Steel and Torrie, 1994). Data analysis has been done with excel.2010.

Results and discussion

Plant height

Data of plant height was homogeneous after transformation of data into SQRT of values. No significant effect of interaction between genotype with location (G x L) on plant height, but effect of genotype and location were significant. The effect of genotype and location on plant height can be seen in Table 1 and 2.

Table 1. Result of LSD test of genotype effect on plant height at harvest.

Geno-types	Plant heihgt (cm)		Geno-types	Plant height (cm)		Geno-types	Plant height (cm)	
G1	83.51	(9.10bcdef)	G11	84.61	(9.18cdef)	G21	85.65	(9.23def)
G2	84.09	(9.12bcdef)	G12	86.60	(9.28f)	G22	76.02	(8.70a)
G3	83.54	(9.10bcdef)	G13	80.87	(8.96bc)	G23	80.46	(8.89ab)
G4	80.49	(8.92ab)	G14	80.23	(8.92ab)	G24	81.89	(9.00bcde)
G5	83.80	(9.10bcdef)	G15	81.44	(8.98bcd)	G25	80.13	(8.93abc)
G6	80.06	(8.92ab)	G16	79.91	(8.89ab)	K-1	123.79	(11.10h)
G7	85.18	(9.20cdef)	G17	82.55	(9.06bcdef)	K-2	85.95	(9.25ef)
G8	84.14	(9.10bcdef)	G18	85.76	(9.24ef)	K-3	103.49	(10.16g)
G9	*83.89*	(9.12bcdef)	G19	79.03	(8.86a)	-	-	
G10	84.85	(9.20cdef)	G20	82.16	(9.04(bcdef)	-	-	

The same letters in plant height columns indicate significant differences LSD test at 5% of significance level; numbers in parentheses are the data after transformed into √X.

Table 1 showed the effect of single factor of genotype on plant height at harvest. The highest plant height was on K-1 (123.79 cm) and significantly different with all lines as well as two other controls. All lines were also shorter than the K-3 (103.49 cm). K-1 are Cantik variety is local rice variety of South Kalimantan, Indonesia, while K-3 are Inpara-2 variety which is assembled to the swamp area such as the two study sites in this experiment.

Table 2. Result of LSD test of location effect on plant height at harvest.

Character	Tanjung Harapan	Sungai Rangas Hambuku
Plant Height (cm)	71.23(8.44a)	97.81(9.89b)

The same letters indicate significant differences LSD test at 5% of significance level; numbers in parentheses are the data after transformed into √X.

There are 10 lines whose height was shorter than K-2 (Bestari), namely the G-4, G-6, G-13, G-14, G-15, G-16, G-19, G-22 and G-23, while 15 other lines with a height equivalent to K-2. Bestari is a variety that is assembled with mutation technique. Plant height of K-2 was 85.95 cm. Based on Table 2 can be stated that the plant height in Sungai Rangas Hambuku (97.81 cm) was higher than Tanjung Harapan (71.23 cm).

Table 3. Result of LSD test of genotype x location interaction effect on flowering date and plant age.

Geno-type	Flowering date (DAS)		Plant age (DAS)	
	Tanjung Harapan	Sungai Rangas Hambuku	Tanjung Harapan	Sungai Rangas Hambuku
G-1	84.0abcde	93.0hijk	111a	136l
G-2	83.0abc	96.0jk	111a	135kl
G-3	84.5abcde	95.0ijk	114abc	134jkl
G-4	87.0bcdefgh	97.0k	124gh	137.5l
G-5	86.0abcdefg	88.0cdefgh	122gh	129.5i
G-6	83.5abcd	87.0bcdefgh	122gh	114abc
G-7	84.5abcde	92.0hijk	116cde	134jkl
G-8	83.5abcd	91.0ghij	116cde	132ijk
G-9	84.0abcde	93.0hijk	123gh	134jkl
G-10	81.0a	93.0hijk	114abc	132ijk
G-11	86.5bcdefg	90.0fghij	112ab	134.5jkl
G-12	83.5abcd	94.0ijk	111a	135.5kl
G-13	85.5abcdef	93.0hijk	115bcde	132ijk
G-14	89.0efghi	90.0fghij	118def	135kl
G-15	90.0fghij	93.0hijk	120fg	134jkl
G-16	90.0fghij	90.0fghij	121fg	134jkl
G-17	88.5defgh	90.0fghij	125h	135kl
G-18	82.5ab	90.0fghij	111a	131ij
G-19	82.5ab	93.0hijk	124gh	136.5l
G-20	87.0bcdefgh	92.0hijk	118def	134jkl
G-21	87.5bcdefgh	96.0jk	124gh	135.5kl
G-22	83.5abcd	86.0abcdefg	122gh	133ijk
G-23	86.0abcdefg	93.0hijk	123gh	137.5l
G-24	88.0cdefgh	92.0hijk	121fg	135kl
G-25	92.5hijk	93.0hijk	120fg	134jkl
K-1	154.5m	132.0l	174.5n	164m
K-2	88.5defgh	94.0ijk	115bcde	133ijkl
K-3	92.5hijk	88.0cdefgh	125h	134jkl

The same letters at same variable indicate significant differences LSD test at 5% of significance level.

The absence of interaction effect of genotype x location (G×L) on the plant height in this study, showed that the response of plant height of all varieties at two locations just the same or in other words are additive. If a genotype (either lines or control) is higher than the other genotypes (either lines or control) in Tanjung Harapan village, then this variety are also higher than the other genotypes (either lines or control) in Sungai Rangas Hambuku village.

Table 4. Result of LSD test of genotypes effect on panicle length.

Location	Panicle lenght (cm)
Tanjung Harapan	20.45 (1.31a)
Sungai Rangas Hambuku	22.57 (1.35b)

The same letters in column indicate significant differences LSD test at 5% of significance level; numbers in parentheses are the data after transformed into log10 X.

Similar to the result of this research, Munarso (2011) reported that genotype × environment interaction wasn't significant on plant height of rice. Otherwise Yan *et al.* (1998) and Dewi *et al.* (2015) reported that the effect of genotype x location interaction on plant height of rice significantly different. Munarso (2011) stated plant genotype is dominant factor determining plant height, while Tubur *et al.* (2012) reported that drought periods as environment factor suppressed plant height.

Table 5. Result of LSD test of genotype x location effect on panicles number and filled grains weight per panicle.

Genotype (lines or control)	Panicles number				Grains weight per panicle (g)			
	Tanjung Harapan		Sungai Rangas Hambuku		Tanjung Harapan		Sungai Rangas Hambuku	
G-1	10.83	(1.03bcdef)	19.79	(1.30nopgr)	1.09	cdefg	2.10	opqrs
G-2	15.03	(1.18ijklm)	19.38	(1.29nopq)	1.09	cdefg	2.42	st
G-3	13.50	(1.13fghi)	21.00	(1.32pqr)	0.84	abc	1.93	mnopq
G-4	12.67	(1.10efghi)	26.25	(1.42s)	0.93	abcde	2.06	nopqrs
G-5	13.42	(1.13fghi)	18.38	(1.26mnop)	0.53	a	1.94	mnopq
G-6	17.56	(1.24lmnop)	19.75	(1.29nopq)	1.20	cdefgh	2.20	qrst
G-7	17.28	(1.24lmnop)	18.83	(1.27nopq)	1.67	ijklmn	2.00	nopqr
G-8	12.08	(1.08defgh)	16.75	(1.22jklmn)	1.44	fghijk	1.87	lmnopq
G-9	12.75	(1.10efghi)	20.63	(1.31opqr)	1.50	ghijkl	1.71	jklmno
`G-10	12.56	(1.10efghi)	19.63	(1.29nopq)	1.83	klmnopq	1.90	lmnopq
G-11	12.11	(1.08defgh)	20.96	(1.31opqr)	1.33	efghij	1.88	lmnopq
G-12	13.06	(1.12fghi)	17.00	(1.23klmno)	1.00	bcde	2.40	rst
G-13	13.50	(1.13fghi)	26.13	(1.41s)	0.88	abcd	2.11	opqrst
G-14	9.56	(0.98abc)	19.13	(1.28nopq)	0.82	abc	1.98	mnopq
G-15	9.42	(0.97ab)	21.00	(1.32pqr)	0.98	bcde	2.18	qrst
G-16	11.39	(1.06cdef)	23.88	(1.38rs)	1.04	bcdef	1.62	ijklmn
G-17	10.89	(1.03bcde)	15.00	(1.18ijklm)	1.29	defghi	2.01	nopqrs
G-18	13.00	(1.11efghi)	14.13	(1.15ghijk)	0.92	abcde	1.85	klmnopq
G-19	10.14	(1.01bcd)	19.38	(1.29nopq)	1.75	klmnop	1.89	lmnopq
G-20	17.06	(1.23klmno)	17.75	(1.25mnop)	1.91	lmnopq	1.92	mnopq
G-21	13.17	(1.12fghi)	20.34	(1.30nopqr)	1.57	hijklm	2.18	qrst
G-22	11.72	(1.07defg)	13.75	(1.14fghijk)	1.12	cdefg	1.96	mnopq
G-23	9.97	(1.00bcd)	25.88	(1.41s)	0.90	abcd	1.95	mnopq
G-24	11.36	(1.06cdef)	23.38	(1.35qrs)	1.13	cdefg	2.13	pqrst
G-25	9.11	(0.96ab)	27.75	(1.43s)	0.66	ab	1.90	lmnopq
K-1	9.36	(0.97ab)	20.63	(1.41s)	1.72	jklmnop	1.57	hijklm
K-2	7.86	(0.90a)	26.13	(1.16hijkl)	1.58	hijklm	1.97	mnopq
K-3	10.03	(1.00bcd)	14.38	(1.31opqr)	2.16	Pqrst	2.52	t

The same letters in the same variables indicate significant differences LSD test at 5% of significance level; numbers in parentheses are the data after transformed into log10 of X.

Flowering date and plant age

Data of flowering date and plant age were homogeneous. Results of analysis of variance showed that genotype, location and interaction between genotype with location (G × E) significantly affected the flowering date and plant age. The LSD test for interaction G × E on flowering date and plant age can be seen in Table 3.

Based on Table 3, can be stated that the shortest of flowering date in this study was on the G-10 in Tanjung Harapan (81.0 DAS) but wasn't significantly different to 14 lines in the same location (G-1, G-2, G-3, G-5, G-6, G-7, G-8, G-9, G-12, G-13, G-18 G-19, G-22, G-23 in Sungai Rangas Hambuku) and 1 line in Tanjung Harapan (G-22).

Table 6. Result of LSD test of location effect on grains number per panicle.

Location	Filled grains number per panicle
TanjungHarapan	59.50a
Sungai RangasHambuku	85.50b

The same letters in the same variables indicate significant differences LSD test at 5% of significance level.

There are 12 lines (G-4, G-5, G-6, G-11, G-14, G-15, G-16, G-17, G-20, G-22, G-24, G-25) and 1 control (K3) that have flowering date weren't significantly different between Tanjung Harapan with Sungai Rangas Hambuku. There are 13 lines that have flowering that shorter in Tanjung Harapan than Sungai Rangas Hambuku and 2 control opposite. All lines in the Tanjung Harapan and Sungai Rangas Hambuku have a significantly shorter flowering date than the Cantik local variety (K-1).

Table 3 also showed that the shortest plant age was G-1 in Sungai Rangas Hambuku (111 DAS), but not significantly different from 5 lines (G-2, G-3, G-10, G-11, G-12 in Sungai Rangan Hambuku) and 1 line in Tanjung Harapan (G-18). There are 24 lines and 2 controls (K-2 and K-3) that have plant age in Tanjung Harapan were shorter than in Sungai Rangas Hambuku. Only G-6 and Cantik local varieties (K-1) which have a longer plant age in Tanjung Harapan than in Sungai Rangas Hambuku. None of lines or control that not significant between Tanjung Harapan dan Sungai Rangas Hambuku.

Based on Table 3, can be stated that in general it appears that plant age in Sungai Rangas Hambuku longer than in Tanjung Harapan. This is presumably caused by late planting in Sungai Rangas Hambuku due to flooding so that transplanting couldn't done at the proper time. The presence of interactions between genotype with location on the flowering date and plant age showed that the magnitude and ranks of every genotypes at both locations yet necessarily the same. Purchase (1997) suggests that the interaction G×E show that genetic and environmental influences aren't additive, or in other words the genetic influence depends on environmental factors. The influence of interaction G × L can cause changes in rank of the appearance of the characters in one location to another.

According Yamada (1962) a character under two different environments is not the same, the relationship of the character under different environments should be expressed in terms of genetic and environmental correlations. Itoh & Yamada (1990) state that good performance plant in one environment does not necessarily similar with another environment, if there is genotype x environment interaction.

Effect of genotype × environment (some tidal swamp area) interaction on plant age significantly different (Hairmansis *et al.*, 2013). The cultivars of popcorn showed different agronomic performance, according to sowing time (Miranda *et al.* 2009). As at the flowering date, the significant effect of intercation between genotype × location on the plant age also showed that plant age at both locations is not necessarily the same.

Table 7. Result of LSD test of genotype x location effect on percentage of grains number per panicle and yield.

Geno-type/ Lines/ Con-trol	Percentage of filled grains (%)				Yield (t ha^{-1})					
	Tanjung Harapan		Sungai RangasHambuku		Tanjung Harapan			Sungai RangasHambuku		
G-1	72.67	c	88.35	nopqr	1.75	(0.24	d)	6.18	(0.79	vwx)
G-2	63.10	a	87.00	mnop	2.43	(0.39	fghi)	6.95	(0.84	wxyz)
G-3	59.94	a	86.31	lmno	1.67	(0.22	cd)	4.42	(0.64	pqrs)
G-4	79.98	fghij	88.91	nopqr	1.73	(0.24	d)	7.99	(0.90	yz)
G-5	67.78	b	87.80	mnopqr	1.06	(0.01	ab)	5.12	(0.71	qstuvw)
G-6	84.62	jklmn	90.91	opqr	3.06	(0.48	ijlm)	6.22	(0.79	vwx)
G-7	91.29	pqr	83.32	ijklm	4.28	(0.63	opqr)	4.10	(0.61	nopq)
G-8	86.62	mno	85.66	klmn	2.58	(0.41	ghij)	4.63	(0.67	pqrstu)
G-9	86.09	lmn	86.30	lmno	2.83	(0.45	hij)	5.22	(0.72	rstuvw)
G-10	79.85	fghi	88.89	nopqr	3.37	(0.53	lmno)	5.57	(0.74	stuvw)
G-11	84.78	klmn	85.26	klmn	2.38	(0.37	efgh)	5.64	(0.75	tuvw)
G-12	81.31	ghijk	85.46	klmn	1.93	(0.28	de)	5.99	(0.78	uvwx)
G-13	74.03	cde	88.26	nopqr	1.76	(0.24	d)	8.01	(0.90	z)
G-14	77.66	defgh	85.66	klmn	1.16	(0.06	bc)	5.58	(0.74	stuvw)
G-15	78.07	efgh	87.22	mnopq	1.37	(0.13	c)	6.65	(0.82	wxy)
G-16	75.47	cdef	87.64	mnopqr	1.76	(0.25	d)	5.71	(0.76	tuvwx)
G-17	83.61	ijklmn	91.68	qr	2.09	(0.32	defg)	4.51	(0.64	pqrs)
G-18	79.19	fghi	85.08	klmn	1.75	(0.24	d)	3.88	(0.58	mnop)
G-19	92.02	r	87.24	mnopq	2.62	(0.42	ghij)	5.41	(0.72	rstuvw)
G-20	89.22	nopqr	85.73	klmn	4.88	(0.68	pqrst)	4.97	(0.70	`qstuv)
G-21	79.22	fghi	85.84	klmn	3.05	(0.48	ijlm)	6.42	(0.81	wxy)
G-22	76.85	cdefg	85.37	klmn	1.95	(0.29	def)	3.96	(0.59	nop)
G-23	78.04	efgh	81.77	hijkl	1.32	(0.12	c)	7.44	(0.87	xyz)
G-24	78.29	efgh	85.80	klmn	1.91	(0.28	de)	7.42	(0.85	xyz)
G-25	73.37	cd	89.10	nopqr	0.91	(0.06	a)	7.74	(0.88	xyz)
K-1	83.22	ijklm	77.68	defgh	2.36	(0.37	efgh)	4.16	(0.62	opqr)
K-2	84.75	klmn	79.99	fghij	1.85	(0.27	de)	8.00	(0.90	z)
K-3	72.30	bc	79.51	fghi	3.20	(0.51	jlmn)	6.07	(0.78	uvwx)

The same letters in the same variables indicate significant differences LSD test at 5% of significance level; numbers in parentheses are the data after transformed into log10 X.

Contrary to the results of this study, Munarso (2011), stated that irrigation as environment factor has no effect on flowering date and plant age, as well as genetic×location interactions. Difference of flowering date and plant age more determined by the difference in the genotype itself.

Panicle length, panicles number, and filled grain weight per panicle

Data of panicle length and panicles number were homogeneous after transformated into log10 of X, while data of filled grains weight per panicle was homogeneous without data transformated. Analysis of variance on panicle length showed that the significant factor was location only, whereas genotype × location interaction and genotype effects were insignificant. Analysis of variance on the panicles number and filled grains weight per panicle showed that the location, genotype and genotype x location interaction were significant.

The influence of the location on the panicle length can be seen in Table 4, whereas the effect of the interaction between genotype x location on the panicles number and filled grains weight per panicle can be seen in Table 5.

Table 4 showed that panicle length of rice planted in the Sungai Rangas Hambuku (22.57 cm) was longer than those grown in Tanjung Harapan (20.45 cm). Like in this research, Hatta (2012b) reported that no interaction effect of genotype x environment ie. planting spacing on panicle length. The influence of environmental factors such as intermittent irrigation and stagnant on the panicle length were reported by Munarso (2011). The result of research of Tubur *et al.* (2012) also showed that the environment (drought periods) suppressed panicles length.

In the Table 5 can be seen that the most panicles number was in G-25 at Sungai Rangas Hambuku (27.75 panicles) but not significantly different from the other 4 lines and 1 control (G-4, G-16, G-23, G-24, and K-1). Five lines (G-6, G-7, G-18, G-20, G-22) have a number of panicles that were not significantly different between in Tanjung Harapan and Sungai Rangas Hambuku, while the other 20 lines had more panicles number in the Sungai Rangas Hambuku than in the Tanjung Harapan. None of the lines or control in Sungai Rangas Hambuku had less panicles number than Tanjung Harapan.

Based on Table 5, it can also be seen that the highest grain weight per panicle was in K-3 at Sungai Rangas Hambuku (2.52 g) but not significantly different from the other 3 lines in same location (G-1, G-4, and G-6). There are 5 lines and 3 controls have a grain weight per panicle that were not significantly different between in Tanjung Harapan and Sungai Rangas Hambuku (G-7, G-9, G-10, G-19, G-20, G-23, K1, K2, and K3), while the other 20 lines had more panicle numbers in the Sungai Rangas Hambuku than in the Tanjung Harapan.

As in this study, some researchers report that there is an interaction between G x E to the number of panicles, ie between varieties with periods of drought (Tubur *et al.*, 2012), varieties with plant spacings (Hatta, 2011, 2012a), varieties with locations (Sreedhar *et al.*, 2011). According to Hatta (2011), panicles number at Pandan Wangi and Ciherang varieties not affected by plant spacing, while at Cot Irie variety affected by plant spacing. Dewi *et al.* (2015) reported the effect of genotype on tillers number significantly different all location planting. The result of research of Tubur *et al.* (2012) showed interaction between drought periods and rice varieties significantly affected productive tiller number. Contrary to the results of this study, Hatta (2012b) reported that no interaction effect of genotype x environment ie. planting spacing on panicles number. The effect of interaction between G x E on filled grains weight per panicle also reported by some researchers. Tubur *et al.* (2012) and Sreedhar *et al.* (2011) reported that there are significant effect of interaction between genotype × location on filled grain weight per panicle.

Filled grains number per panicle, percentage of filled grain, and yield

Data of filled grains number per panicle and percentage of filled grain were homogeneous, while the data of yield per ha was homogeny after transformated into log10 of values. Analysis of variance on the filled grains number per panicle showed that the only location factor was significant. The effect of location on filled grains number per panicle can be seen in Table 6, namely 85.5 grains at Sungai Rangas Hambuku and 59.5 grains at Tanjung Harapan. Peng *at al.* (2004) reported that environment factor namely differential effects of night versus day temperature affect on grain filling. Dissimilar from the results of this study which showed no effect of varieties on the number of grains per panicle, Daradjat and Rumanti (2002), reported the different number of grains per panicle of rice. According Munarso (2011), only genotype was significant on filled grains number.

Percentage of filled grain and yield per ha were affected by the location, genotype, and interaction between genotype × location. The influence of interaction genotype × location on the percentage of filled grains and yield can be seen in Table 7. Table 7 showed that the highest percentage of filled grains was on G-19 (92.02 %) at Tanjung Harapan but not significantly different with 2 lines in same location

(G-7 and G-20) and not significantly different with 9 lines at Sungai Rangas Hambuku (G-1, G-4, G-5, G-6, G-10, G-13, G-16, G-17, and G-25). There are 2 lines and 2 controls showed that the percentage of filled grain in Tanjung Harapan higher than in Sungai Rangas Hambuku (G-7, G-19, K1, and K-2), while 16 lines and 1 control showed that the percentage of filled grain in Sungai Rangas Hambuku higher than Tanjung Harapan (G-1, G-2, G-3, G-4, G-5, G-6, G-10, G-13, G-14, G-15, G-16, G-17, G-18, G-21, G-22, G-25, and K-1). There are 7 lines that have percentage of filled grains were not significantly different in the two locations (G-8, G-9, G-11, G-12, G-20, G-23, and G-24). Based on the Table 7 also can be seen that the highest yield was showed by G-13 in Sungai Rangas Hambuku (8.01 t ha^{-1}) but not significantly different with the Bestari variety as control (K-2) as high yielding variety in the same location. There are 6 lines were not significantly different from G-13 and K-2 in Sungai Rangas Hambuku, namely G-2, G-4, G-23, G-24 and G-25 in same location. None of the lines and controls were grown in Tanjung Harapan better than in Sungai Rangas Hambuku, but there are two lines (G-7 and G-20) that the yields were not significantly different between in Tanjung Harapan and Sungai Rangas Hambuku.

Like this study, Munarso (2011) also reported that the percentage of filled grain is affected by the genetic of hybrid rice is used.

Accordance with this research, Benmoussa (2005) state that breeding populations usually show genetic x environment interaction when tested in different environments. The genetic effect is cumulative, which consists of the main effects of genetic and genetic x environment interaction effects. Peng *at al.* (2004) also reported that environment factor affect yield. Grain yield declined by 10% for each 1°C increase in growing-season minimum temperature in the dry season, whereas the effect of maximum temperature on crop yield was insignificant.

According to Aryana (2009), if combined analysis of variance for grain yield per hectare showed that the effect of genotype, environment and genotype x environment interactions highly significant, this means that the ratings superiority of genotypes tested are not the same in all environments. Sreedhar *et al.* (2011), Sa'diah (2012) also reported that there are significant effect of interactions between genetic x environment on rice yield per plant. Sial *et al.* (2000) stated that the existence of interactions between genotypes × location indicated by the difference in outcome, ie some varieties showed higher yields at a location than the others location, and vice versa.

The existence of the G × E interaction is also shown by other plants. There are genotype × environment interaction on yield of green beans. The genotypes were tested in several locations showed the difference of yield. There are some high yielding lines were consistent in some location and some lines specific location (Trustinah and Iswanto, 2013). Twenty-five genotypes of bean evaluated on 12 environments.

The interaction between genotype with environment (G x E) is used as an index to determine the stability of genotype in all environments (Arshad *et al.*, 2003).

Munarso (2011) stated that only genotype was significant on rice yield. Hatta (2012a) state that effect of plant spacing on the yield per hectare is consistent in all varieties tested. Cot Irie line have the highest yield per hectare, while the yield of Ciherang variety not significantly different from the Pandan Wangi variety.

Rice yield testing at various locations and seasons using inbred and hybrid varieties showed the occurrence of yield gap patterns. In East Java during the 2001- 2003 testing showed inconsistence yield gap between planting seasons across locations. Factors which presumably affected the yield gap include air temperature, CO_2 concentration, and solar radiation during grain filling period (Satoto *et al.*, 2013). The result of research of Tubur *et al.* (2012) showed that interaction between drought periods and rice varieties significantly affected grain weight per hill.

Conclusion

Effect of G × E interaction were significant on flowering date, plant age, panicles number, grains weight per panicle, percentage of filled grains, and yield. The shortest of flowering date was G-10 (81 DAS) in Sungai Rangas Hambuku (SRH), but not significant from 14 lines in SRH (G-1, G-2, G-3, G-5, G-6, G-7, G-8, G-9, G-12, G-13, G-18, G-19, G-22, and G-23) and 1 line in Tanjung Harapan (TH), namely G-2.

The shortest of plant age was G-1 in Sungai Rangas Hambuku (SRH), namely 111 DAS, but not significant from 5 lines in SRH (G-2, G-3, G-10, G-11, G-12) and 1 line in TH (G-6). The highest panicles number, grain weight per panicle, percentage of filled grains, and yield were respectively 27.5 panicles (G-25 in SRH) and not significantly different from the other 4 strains and 1 control in SRH (G-4, G-16, G-23, G-24, and K-1), 2.52 g (K-3 in SRH) but not significantly different from the other 3 lines in same location (G-1, G-4, and G-6), 92.02 % (G-19 in TH) but not significantly different from 2 lines in same location (G-7 and G-20) and 9 lines at Sungai Rangas Hambuku (G-1, G-4, G-5, G-6, G-10, G-13, G-16, G-17, and G-25), and 8.01 t ha-1 (G-13 in SRH) but not significantly different from 5 lines and 1 control in SRH (G-2, G-4, G-23, G-24 and G-25).

The consistent of lines or controls performance in 2 locations were 12 lines and 1 kontrol for flowering date (G-4, G-5, G-6, G-11, G-14, G-15, G-16, G-17, G-20, G-22, G-24, G-25, and K-1), none for plant age, 5 lines (G-19, G-20, K1, K2, and K3) for panicles number, 5 lines and 3 control (G-6, G-7, G-18, G-20, G-22) for grain weight per panicle, 7 lines (G-8, G-9, G-11, G-12, G-20, G-23, and G-24) for percentage of filled grains, and 2 line (G-7 and G-20) for yield.

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References

Arshad MA, Bakhsh AM, Haqqani, Bashir M. 2003. Genotype - environment interaction for grain yield in chickpea (Cicer arietinum L.). Pakistan Journal Botany **35(2),**181-186.

Aryana IGPM. 2009. Adaptasi dan stabilitas hasil galur-galur padi beras merah pada tiga lingkungan tumbuh. Jurnal Agronomy Indonesia **37(2),**95 – 100.

Benmoussa Achouch A, Zhu J. 2005. QTL analysis of genetic main effects and genotype × environment interaction effects for yield components in rice (Oryza sativa L.). Journal of Food, Agriculture & Environment **3(4),** 133-137. Abstract.

Daradjat AA, Dan Rumanti IA. 2002. Pola pewarisan sifat ukuran dan bentuk biji padi sawah. Penelitian Pertanian Tanaman Pangan **21(2),** 1-4.

Dewi IS, Lestari EG, Chaerani, Yunita R. 2015. Penampilan galur harapan mutan dihaploid padi tipe baru di Sulawesi Selatan. Jurnal Agronomy Indonesia **43(2),** 89 – 98.

Djaenudin D. 2008. Perkembangan penelitian sumberdaya lahan dan kontribusinya untuk mengatasi kebutuhan lahan pertanian di Indonesia. Jurnal Litbang Pertanian **27(4),** 137-145.

Gillespie JH, Turelli M. 1989. Genotype-environment interactions and the maintenance of polygenic variation. Genetics **121(1),** 129-138.

Hairmansis A, Aswidinoor H, Supartopo, Suwarno WB, Suprihatno B, danSuwarno. 2013. Potensi hasil dan mutu beras sepuluh galur harapan padi untuk lahan rawa pasang-surut. Jurnal Agronomi Indonesia **41(1),** 1 – 8.

Hatta M. 2011. Pengaruh tipe jarak tanam terhadap anakan, komponen hasil, dan hasil dua varietas padi pada metode SRI. Jurnal Floratek **6(2),** 104-113 104. https://doi.org/10.24815/floratek.v7i2.529

Hatta M. 2012a. Pengaruh jarak tanam heksagonal terhadap pertumbuhan dan hasil tiga varietas padi. Jurnal Floratek **7(-),** 150 – 156. https://doi.org/10.24815/floratek.v7i2.529

Hatta M. 2012b. Uji jarak tanam system legowo terhadap pertumbuhan dan hasil beberapa varietas padi pada metode SRI. Jurnal Agrista **16(2),** 87-93.

Itoh Y, Yamada Y. 1990. Relationships between genotype x environment interaction and genetic correlation of the same trait measured in different environments. Theoritical and Applied Genetics. International Journal of Plant Breeding Research **80(1),** 11-16. Summary**.**

Khairullah I, Mawardi, danSarwani M. 2006. Karakteristik dan Pengelolaan Lahan Rawa: 7. Sumberdaya hayati pertanian lahan rawa. Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian. H. 203-228.

Maamun MY, Sabran M. 1998. Sintesis hasil penelitian tanaman pangan lahan rawa. Dalam Sabran M, Maamun MY, Sjachrani A, Prayudi B, Noor I, danSulaiman S (eds.). Prosiding Hasil Penelitian Menunjang Akselarasi Pengembangan Lahan Pasang Surut. Balitbang Pertanian. Puslitbang Tanaman Pangan. Balai Penelitian Tanaman Pangan Lahan Rawa. H. 27-39.

Miranda GV, de Souza LV, Guimarães LJS, Namorato H, Oliveira LR, Soares MO. 2009. Multivariate analyses of genotype x environment interaction of popcorn. Pesquisa Agropecuaria Brasiliera **44(1).** http://dx.doi.org/10.1590/S0100204X2009000100007

Mulyani A, Ritung S, dan Las I. 2011. Potensi dan ketersediaan sumberdaya lahan untuk mendukung ketahanan pangan. Jurnal Litbang Pertanian **30(2)**,73-80.

Munarso YP. 2011. Keragaan padi hibrida pada system pengairan intermittent dan tergenang. Penelitian Pertanian Tanaman Pangan **30(3),** 189-195. http://dx.doi.org/10.21082/jpptp.v30n3.2011.p%25p

Noorsyamsi H, Anwarhan, Sulaiman S, Beachell HM. 1984. Rice cultivation of the tidal swamps of Kalimantan. In. Workshop on Research Priorities in Tidal Swamp Rice. IRRI. Philippines.

Peng S, Huang J, Sheehy JE, Laza RC, Visperas RM, Zhong X, Centeno GS, Khush GS, and Cassman KG. 2004. Rice yields decline with higher night temperature from global warming. PNAS **101(27),** 9971–9975.

Purcell S. 2002. Variance components models for gene–environment interaction in twin analysis. Twin Research **5(6),** 554–571. http://dx.doi.org/10.1375/twin.5.6.554.

Purchase JL. 1997. Parametric analysis to describe genetic x environment interaction and yield stability in winter wheat. Thesis Presented for PhD in The Faculty of Agriculture, Department of Agronomy at University of The Orange Free State, Bloemfontein. 83 p.

Sa'diyah H. 2012. Pendugaan non-parametrik dan analisis komponen terhadap stabilitas padi sawah (OryzaSativa). Statistika **12(2),** 103 – 108. ejournal.unisba.ac.id

Satoto, Widyastuti Y, Susanto U, dan Mejaya MJ. 2013. Perbedaan hasil padi antar musim di lahan sawah irigasi. Iptek Tanaman Pangan **8(2),** 55-61.

Sial MA, Arain MA, Ahmad M. 2000. Genotype x enviroment interaction on bread wheat grown over multiple sites and years in Pakistan. Pakistan Journal of Botany **32(1)**, 85-91. pakbs.org

Sreedhar S, Reddy TD, Ramesha MS. 2011. Genotype x environment interaction stability for yield and its components in hybrid rice cultivars (Oryza sativa L.). Internasional Journal of Plant Breeding and Genetics **5(3),** 194-208. http://dx.doi.org/10.3923/ijpbg.2011.194.208

Steel RGD, Torrie JH. 1994. Prinsip dan Prosedur Statistika**.** Edisi 2. Terjemahan Sumantri B. PT Gramedia Pustaka Utama. Jakarta.

Sulaiman S, Imberan M. 1996. Varietas unggul padi peka fotoperiod diperlukan untuk lahan rawa. Dalam Prayudi B, Maamun MY, Sulaiman S, Saderi DI, dan Noor I (eds.). Prosiding Seminar Teknologi Sistem Usaha Tani Lahan Rawa & Lahan Kering. Balitbang Pertanian, Puslitbang Tanaman Pangan. Balai Penelitian Tanaman Pangan Lahan Rawa. Banjarbaru.H.227-231.

Trustinah dan Iswanto R. 2013. Pengaruh interaksi genotype dan lingkungan terhadap hasil kacang hijau. Penelitian Pertanian Tanaman Pangan **32(1),** 36-42. http://dx.doi.org/10.2108/jpptp.v32n1.2013.p%25p

Tubur HW, Chozin MA, Santosa E, Junaedi A. 2012. Respon agronomi varietas padi terhadap periode kekeringan pada system sawah. Jurnal Agronomi Indonesia **40(3),** 167 – 173. http://dx.doi.org/10.2483/jai.v40i3.6796

Wahdah R dan Langai BF. 2009. Observasi varietas padi lokal di lahan pasang surut Kalimantan Selatan (Observation of rice local varieties on tidal swamp area of South Kalimantan). Agroscientiae **16(3)**, 177-184.

Wahdah R dan Langai BF. 2010. Preferensi petani terhadap varietas padi lokal di area pasang surut Kabupaten Tanah Laut dan Kabupaten Barito Kuala. Media Sains **2(1),** 114-120.

Wahdah R, Rumayadi G dan Zulhidiani R. 2016a. Keseragaman dalam galur dan keragaman antar galur mutan padi hasil iradiasi varietas lokal Kalimantan Selatan. Jurnal Ilmiah Aplikasi Isotop dan Radiasi. A Scientific Journal for The Applications of Isotopes and Radiation **12(2),** 113-121. http://dx.doi.org/10.17146/jair.2016.12.2.1602

Wahdah R, Rusmayadi G, Zulhidiani R. 2016b. Performing of agronomic characters of M6 of local rice mutant lines of South Kalimantan. International Journal of Bioscience **9(6)**,114-124. http://dx.doi.org.10.12692/ijb/96.114-124.

Widjaja-Adhi IPG, Suriadikarta DA, Sutriadi MT, Subiksa IGM, dan Suastika IW. 2000. Pengelolaan, pemanfaatan, dan pengembangan lahan rawa. hal. 127-164. Dalam: Adimihardja A, Amien LI, AgusF,dan Jaenuddin D (eds.). Sumberdaya Lahan Indonesia dan Pengelolaannya. Pusat Penelitian Tanah dan Agroklimat, Bogor.

Yamada Y. 1962. Genotype by environment interaction and genetic correlation of the same trait under different environments. Japan Journal Genetic **37(6),** 498-509. http://doi.org/10.1266/jjg.37.498

Yan J, Zhu J, He C, Benmoussa M, Wu P. 1998. Molecular dissection of developmental behavior of plant height in rice (Oryza sativa L.). Genetics **150(3),** 1257–1265. http://www.genetics.org/content/150/3