THE SELECTION OF LOCAL GENETIC SOURCE RICE POPULATION DIFFERENTIATED BY THEIR GENETIC MARKERS IN LOWLAND AND UPLAND ORGANIC ENVIRONMENT

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ABSTRACT

In resolving the global decrease of water supply, the selection of rice population ought to be accomplished in lowland as well as upland environment. The rice population was selected from local genetic source (LGS) in Lampung, Indonesia in order to revive rice lines which have been marked obsolete along the way of the Green Revolution since 1960. The lines were differentiated by their expressed quantitative trait loci (QTL) as genetic marker responsible for increasing seed production. The study accomplished in a Randomized Complete-Block Design with three replicates in the Polytechnic Research Field, Bandar Lampung using the 4 LGS-QTL lines; and the best 3 upland-introduction lines and 2 National lines as control. Data analyses included: population performances, anova mean squares which will continue on to ranking of varieties and calculating of genetic variances, broad-sense heritabilities and coefficients of genetic variances; and correlations analysis among variables in determining effective strategies in cross-combining the rice lines. The results indicated that prospective lines of Local Genetic Source- Quantitative Trait Loci (LGS-QTL) lowland rice were PBBogor-Plant Height, Gendut-Grain Number, and Tewe-Grain Number having Milled-Dry Grain (MDG) yield > 6 t ha^{-1} to the extent of 1186.00, 766.70, and 1165.30 g m^{-2} equivalent to 11.86, 7.67, and 11.65 t ha^{-1}, respectively. The prospective lines LGS-QTL for upland rice were PBBogor-Plant Height, Gendut-Grain Number, and Kesit-Plant Height having MDG yield > 4 t ha^{-1} to the extent of 430.10, 448.50, and 432.20 g m^{-2} equivalent to 4.30, 44.85, and 4.32 t ha^{-1}, respectively. The LGS-QTL lines: PBBogor-Plant Height, Tewe-Grain Number, Gendut-Grain Number, Kesit-Plant Height and the National line Ciherang-Grain Number ranked the first in all populations were prominent to be parental lines to accumulate QTL. The lines PBBogor-Plant Height, Tewe-Grain Number, Gendut-Grain Number, and Kesit-Plant Height were prospective to be drafted to the Plant Variety Protection (PVP) Committee.

Keywords: plant breeding, rice, genetic marker, local genetic source, quantitative trait loci, upland rice, lowland rice, plant variety protection

INTRODUCTION

The rice germplasms in gene pool I had exhausted due to their excessive utilization since 1990 (Sanchez *et al*., 1993) affecting the efforts inasmuch that to increase rice production through breeding programs were hardly effective. Rice breeding programs using germplasms of the gene pool I had been since 1960 were marked with about 250 lowland rice varieties developed through hybridization followed by 6 – 9 generation of selfing, thus quality inbred rice varieties were developed (BB Padi, 2015). However, of the 250 varieties more than 90 % of them had been obsolete (Suprihatno *et al*., 2009). In Indonesia, during the period 2008 – 2016 only some 15 varieties grown by the farmers.

Most of the obsolete varieties were out listed from the gene pool I mostly because of their vulnerability to pests and diseases, decreasing supply of water, and consumer preference to ask for the better quality and taste of rice they consumed. If the obsolete varieties in fact were remained grown, generally was because of the varieties ensured *in situ* superiorities like short growing time, productivity in par with newer varieties, resistant to pests and diseases *in situ*, tolerant to drought, and had a good taste (Hikam *et al*., 2015). The farmers grew the obsolete varieties as local varieties rather faithfully due to their independence to seed market. The farmers' practice to grow local rice varieties and produce own seed thereafter passing through man-made and natural selection for decades rewarded the seed to become LGS (local genetic source) germplasms (Hikam *et al*., 2014). The LGS germplasms were numerous in kind, number, and distribution which readily available to utilize as to replenish genetic sources in gene pool I (Hikam, 2013).

Rice breeding program started with phenotype difference which variabilities could be great. However, phenotypic selection was biased by environment where the rice population was grown and tested (Fehr, 1987; Hallauer *et al*., 2010). Rieseberg *et al*. (2003) and Hallauer *et al*. (2010) stated that qualitative gene action positively correlated with productivity would make genetic marker in which the phenotype performance was controlled by qualitative gene. More over, Rieseberg et al. (2003) indicated that QTL (*quantitative trait loci*) analyses proofed the existence of gene in controlling genetic marker expression. Some key QTL-controlled genetic markers utilized in the study were tolerance to drought (Prince *et al*., 2015), having great number of productive tillers (Bian *et al*., 2013; Hussein *et al*., 2014), and having great number of spikelet (Koide *et al*., 2013) and superiority in grain characteristics (Hagiwara *et al*., 2006).

To select for the rice lines tolerance to drought became the main objective in this study. Hikam *et al*. (2015) collected 27 entries consisted of nine local varieties differentiated into three distinct classes based on QTL and tested on five locations to evaluate the QTL expression. The tests were accomplished in lowland environment and four LGS-QTL lines PBBogor-Plant Height, Tewe-Grain Number, Gendut-Grain Number, and Kesit-Plant Height were tested for their tolerance to drought on rainfed-upland environment. To test the lines for drought tolerance was in line with Bayer Crop Science which targeted non-GMO wheat traits to develop heat and drought tolerance new wheat varieties (Reuter, 2011). In the Philippines, the IRRI developed "climate change-ready rice" which included drought, flood, heat, cold, high salt and iron toxicity.

Our objective in the study was to evaluate the growth and yield performances of LGS-QTL lowland rice lines on an organic rainfed upland environment. On the accomplishment of the study we could determine the adaptability of the lines to much drier environment.

MATERIALS AND METHODS

The study was done on two contrasting environment, irrigated lowland and rainfed upland in the State Polytechnics of Lampung Test Field. The soil was of Red-Yellow Podsolic with pH 5.6. The study was done from April – August 2016 growing four LGS-QTL (Local Genetic Source-Quantitative Trait Loci) lines PBBogor-Plant Height, Tewe-Grain Number, Gendut-Grain Number, Kesit-Plant Height, two National lines Ciherang-Grain Number and IR64-Grain Number, and three introducing upland lines CSG1, CSG2, and CSG3. The National and introducing lines were control to the LGS-QTL lines.

The study accomplished in a Randomized Complete-Block Design with three replicates (Steel and Torrie, 1981). Data analyses included: population performances, anova mean squares which will continue on to ranking of varieties and calculating of genetic variances, broad-sense heritabilities and coefficients of genetic variances; and correlations analysis among variables in determining effective strategies in cross-combining the rice lines (Hallauer *et al*., 2010).

The plots for lowland and upland planting were fertilized with 400 kg urea, 150 kg SP-36, and 100 kg KCl ha^{-1} with additional 5 t ha^{-1} partly decomposed cow dung as organic amendment.

The seeds were grown to seedlings for 21 days before transplanted to the lowland plots, while on the upland plots the seeds were planted directly. The planting distance was 25 cm X 25 cm resulted in a 160000 plants ha^{-1}.

Data were measured on variables plant height (cm), tiller number $hill^{-1}$, productive tiller number $hill^{-1}$, percent productive tiller number $hill^{-1}$ (%), grain number $spike^{-1}$, spike weight $hill^{-1}$ (g), total grain number $hill^{-1}$, total grain weight $hill^{-1}$ (g), 100-grain weight (g), and milled-dry grain yield m^{-2} (g).

RESULTS AND DISCUSSION

Performance Analysis

Lines of lowland rice endured environmental stress when grown on organic upland and their performances decreased accordingly as shown in Table 1. The stress affected on eight of 10 variables: plant height, productive tiller number $hill^{-1}$, percent productive tiller number $hill^{-1}$, spike weight $hill^{-1}$, grain number $hill^{-1}$, grain weight $hill^{-1}$, 100-grain weight, and milled-dry grain (MDG) yield m^{-2}. The two variables not affected were tiller number $hill^{-1}$ and grain number $spike^{-1}$. The resistance of the variables to water stress might indicate that the variables were controlled qualitatively (Fehr, 1987).

The seed yield decreased 45.8 % from 937.63 to 429.75 g m^{-2} when the lines were grown upland due to the decrease of grain number $hill^{-1}$ and 100-grain weight affected by limited water supply (Hikam *et al.*, 2016). The introduction lines CSG1, CSG2, and CSG3 employed as control responded similarly as tested lines on upland environment. Hence, the finding indicated that selection should advance to improve the adaptability of tested lines to upland environment.

More further, Table 1 revealed that LGS-QTL (Local Genetic Source-Quantitative Trait Loci) lowland rice lines prospective to draft to the PVP (Plant Variety Protection) Committee were PBBogor-Plant Height, Gendut-Grain Number, and Tewe-Grain Number having MDG yield > 6 t ha^{-1} as much as 1186.00, 766.70, and 1165.30 g m^{-2} equivalent to 11.86, 7.67, and 11.65 t ha^{-1}, respectively. For LGS-QTL upland rice lines prospective to draft were PBBogor-Plant Height, Gendut-Grain Number, and Kesit-Plant Height having MDG yield > 4 t ha^{-1} each of 430.10, 448.50, dan 432.20 g m^{-2} equivalent to 4.30, 44.85, dan 4.32 t ha^{-1}, respectively.

Table 1. The vegetative and generative performances for each parameter

Environment	Line	PH Average	s.e.	TN Average	s.e.	PTN Average	s.e.	PPTN Average	s.e.
Lowland	PBBogor	98.83	0.84	26.33	2.19	25.00	1.73	95.28	3.16
	Tewe	126.33	0.88	23.00	1.53	22.67	1.86	98.33	1.67
	Gendut	107.90	3.55	14.67	1.76	14.67	1.76	100.00	0.00
	Kesit	104.00	1.00	16.67	2.03	16.67	2.03	100.00	0.00
	Ciherang	104.67	4.84	24.00	2.08	24.00	2.08	100.00	0.00
	IR64	92.20	3.53	21.33	2.73	19.33	1.76	91.65	4.18
	Average	105.66	2.44	21.00	2.05	20.39	1.87	97.54	1.50
Upland	PBBogor	89.67	3.27	20.53	2.73	15.03	1.89	73.86	5.73
	Tewe	91.29	4.49	24.03	1.04	19.90	1.72	82.82	6.17
	Gendut	91.53	4.73	24.57	1.91	15.53	0.82	63.65	3.84
	Kesit	109.20	14.50	19.07	2.13	12.69	0.67	67.56	5.15
	Ciherang	73.90	10.20	20.80	2.75	14.63	2.23	70.09	5.11
	IR64	96.57	9.51	20.80	0.31	12.73	2.41	60.90	10.80
	Average	92.03	7.78	21.63	1.81	15.09	1.62	69.81	6.13
Upland Introduction Line	CSG1	73.46	0.67	22.07	2.74	12.98	1.46	60.18	7.68
	CSG2	105.47	8.81	23.27	3.49	17.57	3.17	75.14	3.97
	CSG3	96.21	2.71	22.03	3.01	18.73	3.47	83.79	4.52
	Average	89.61	6.61	21.77	2.35	15.29	2.39	69.99	6.37

Notes: PBBogor= PBBogor-Plant Height, Tewe= Tewe-Grain Number, Gendut= Gendut-Grain Number, Kesit= Kesit-Plant Height, Ciherang= Ciherang-Grain Number, IR64= IR64-Grain Number. PH= plant height (cm), TN= tiller number hill^{-1}, PTN= productive tiller number hill^{-1}, PPTN= percent productive tiller number hill^{-1} (%).

Table 1. (Continued)

Environment	Line	GNS Average	s.e.	SW Average	s.e.	TGN Average	s.e.
Lowland	PBBogor	89.69	4.82	3.30	0.12	2257.00	274.00
	Tewe	91.14	7.71	2.35	0.18	2037.30	15.40
	Gendut	101.43	4.27	2.50	0.31	1473.00	116.00
	Kesit	65.80	17.70	1.55	0.19	1026.00	143.00
	Ciherang	86.01	7.08	2.95	0.38	2038.00	102.00
	IR64	81.39	7.74	2.37	0.37	1561.00	162.00
	Average	85.91	8.22	2.50	0.25	1732.05	135.40
Upland	PBBogor	89.40	8.81	1.59	0.23	1420.00	284.00
	Tewe	65.10	8.57	1.15	0.17	1298.00	101.00
	Gendut	85.17	9.27	1.59	0.16	1419.00	150.00
	Kesit	86.40	14.10	1.37	0.17	1217.00	208.00
	Ciherang	66.63	9.86	1.56	0.18	1042.00	256.00
	IR64	101.30	11.60	1.33	0.38	1410.00	406.00
	Rerata	82.33	10.37	1.43	0.21	1301.00	234.17
Upland Introduction	CSG1	56.46	9.53	0.58	0.16	770.00	153.00
	CSG2	91.80	10.80	1.26	0.13	1628.00	260.00
	CSG3	96.73	3.81	1.60	0.33	1829.00	294.00
	Average	82.54	9.33	1.29	0.23	1330.00	267.19

Notes: PBBogor= PBBogor-Plant Height, Tewe= Tewe-Grain Number, Gendut= Gendut-Grain Number, Kesit= Kesit-Plant Height, Ciherang= Ciherang-Grain Number, IR64= IR64-Grain Number. GNS= grain number spike^{-1}, SW= spike weight hill^{-1} (g), TGN= total grain number hill^{-1}.

Table 1. (Continued)

Environment	Line	TGW Average	s.e.	W100 Average	s.e.	MDGY Average	s.e.
Lowland	PBBogor	59.30	6.67	2.63	0.03	1186.00	133.00
	Tewe	58.27	0.29	2.86	0.01	1165.30	5.87
	Gendut	38.33	3.29	2.60	0.06	766.70	65.80
	Kesit	27.74	3.84	2.70	0.02	554.90	76.70
	Ciherang	56.48	2.25	2.77	0.03	1129.60	45.10
	IR64	41.17	4.73	2.63	0.07	823.30	94.50
	Average	46.88	3.51	2.70	0.04	937.63	70.16
Upland	PBBogor	21.50	1.96	1.93	0.18	430.10	39.20
	Tewe	18.06	0.93	1.73	0.02	361.10	18.60
	Gendut	22.42	1.65	1.99	0.08	448.50	43.80
	Kesit	21.61	1.49	1.84	0.06	432.20	29.90
	Ciherang	15.58	3.33	1.91	0.05	311.60	66.50
	IR64	29.74	6.99	2.35	0.10	595.00	140.00
	Average	21.48	2.73	1.96	0.08	429.75	56.33
Upland Introduction	CSG1	11.44	2.19	1.78	0.08	228.90	49.30
	CSG2	21.10	2.47	1.61	0.12	422.00	85.80
	CSG3	29.34	4.29	1.99	0.10	586.80	32.90
	Average	21.45	3.67	1.93	0.09	429.01	71.81

Notes: PBBogor= PBBogor-Plant Height, Tewe= Tewe-Grain Number, Gendut= Gendut-Grain Number, Kesit= Kesit-Plant Height, Ciherang= Ciherang-Grain Number, IR64= IR64-Grain Number. TGW= total grain weight hill^{-1} (g), W100= 100-grain weight (g), MDGY= Milled-Dry Grain yield m^{-2} (g).

Mean Square Analysis

Mean square analyses (MSA) summarized from Anova were provided in Table 4. Data in Table 2 showed that lines were different at P <0.01 except for grain number spike^{-1}. The different suggested that the lines adaptability was low still on organic upland.

Table 2. The summary of mean square values for vegetative and generative variables

Source of Variation	db	PH	TN	PTN	PPTN	GNS
Replicate	2	313.549	40.372	21.72	42.564	112.871
Line	14	543.624**	27.707	49.0736**	692.059**	579.329
Error	28	104.849	14.09	12.1246	78.457	294.48
CV %		10.512	17.423	19.925	10.861	20.52

Source of Variation	db	SW	TGN	TGW	W100	MDGY

Replicate	2	0.05	279433.6	24.99	0.032	10008.8
Line	14	1.61**	511992.9**	749.99**	0.575**	300002.6**
Error	28	0.19	132074.2	40.314	0.017	16123.01
CV %		17.42	10.512	19.92	10.86	20.52

Notes: **= P< 0.01. PH= plant height, TN= tiller number hill^{-1}, PTN= productive tiller number hill^{-1}, PPTN= percent productive tiller number hill^{-1}, GNS= grain number spike^{-1}, SW= spike weight hill^{-1}, TGN= total grain number hill^{-1}, TGW= total grain weight hill^{-1}, W100= 100-grain weight, MDGY= Milled-Dry Grain yield m^{-2}.

Rank of Line Analysis

Table 3 provided rank of lines accomplished using Tukey's $HSD_{0.05}$ test (Hikam *et al*., 2015). The ranking categorized to six classes with the lowland rice lines were the best on 1st – 4th rank and the upland lines were on 4th – 6th. The line rank suggested that the selection on lowland rice lines could be independent on that of upland lines. Therefore in advancing the selection program, the evaluation of upland rice lines having drought resistance QTL were done separately from the evaluation of lowland lines.

The LGS-QTL lowland rice lines worth to advance were the same as those of the upland lines which were PBBogor-Plant Height dan Tewe-Grain Number.

Table 3. The rank of lines using Tukey's $HSD_{0.05}$

Environment	Line	PH	TN	PTN	PPTN	GNS
Lowland	PB Bogor	98.83a-c	26.33a	25.00a	95.28ab	89.69a
	Tewe	126.33a-c	23.00a	22.67ab	98.33a	91.14a
	Gendut	107.90ab	14.67a	14.67ab	100.00a	101.43a
	Kesit	104.00a-c	16.67a	16.67ab	100.00a	65.79a
	Ciherang	104.67a-c	24.00a	24.00a	100.00a	86.01a
	IR64	92.20bc	21.33a	19.33ab	91.65a-c	81.39a
Upland	PB Bogor	89.67bc	20.53a	15.03ab	73.86a-d	89.4a
	Tewe	91.29bc	24.03a	19.90ab	82.82a-d	65.1a
	Gendut	91.53bc	24.57a	15.53ab	63.64d	85.17a
	Kesit	109.17ab	19.07a	12.69b	67.56cd	86.36a
	Ciherang	73.87c	20.80a	14.63ab	70.09b-d	66.63a
	IR64	96.57a-c	20.80a	12.73b	60.94d	101.3a
Upland Introduction	CSG1	73.46c	22.07a	12.98b	60.18d	56.46a
	CSG2	105.47a-c	23.27a	17.57ab	75.14a-d	91.83a
	CSG3	96.21a-c	22.03a	18.73ab	83.79a-d	96.73a
	$HSD_{0.05}$	32.79	11.98	10.75	26.24	50.56

Notes: Numbers followed by the same letter were not different as tested with $HSD_{0.05}$. The letter "a" indicated the best. PBBogor= PBBogor-Plant Height, Tewe= Tewe-Grain Number, Gendut= Gendut-Grain Number, Kesit= Kesit-Plant Height, Ciherang= Ciherang-Grain Number, IR64= IR64-Grain Number. PH= plant height (cm), TN= tiller number hill^{-1}, PTN= productive tiller number hill^{-1}, PPTN= percent productive tiller number hill^{-1} (%). GNS= grain number spike^{-1}.

Table 3. (Continued)

Environment	Line	SW	TGN	W100	TGW	MDGY
Lowland	PB Bogor	3.30a	2257.0a	2.63ab	59.30a	1186.0a
	Tewe	2.35a-c	2037.3ab	2.86a	58.27a	1165.3a
	Gendut	2.50ab	1473.0a-c	2.60ab	38.33b-d	766.7b-d
	Kesit	1.55b-d	1026.0bc	2.70ab	27.74c-e	554.9c-e
	Ciherang	2.95a	2038.3ab	2.77a	56.48ab	1129.6 ab
	IR64	2.37a-c	1561.3a-c	2.63ab	41.17a-c	823.3a-c
Upland	PB Bogor	1.59b-d	1420.3a-c	1.93a	21.50de	430.1de
	Tewe	1.15cd	1297.6a-c	1.73a	18.06e	361.1e
	Gendut	1.59b-d	1418.6a-c	1.99cd	22.42c-e	448.5c-e
	Kesit	1.37b-d	1216.9a-c	1.84d	21.61de	432.2de
	Ciherang	1.56b-d	1042.1bc	1.91d	15.58e	311.6e
	IR64	1.33b-d	1410.0a-c	2.35bc	29.74c-e	594.7c-e
Upland Introduction	CSG1	0.58d	770.4c	1.78d	11.44e	228.9e
	CSG2	1.26b-d	1627.7a-c	1.61d	21.10de	422.0de
	CSG3	1.60b-d	1829.2a-c	1.99cd	29.34c-e	586.8c-e
	$HSD_{0.05}$	1.28	1134.40	0.41	18.86	377.19

Notes: Numbers followed by the same letter were not different as tested with $HSD_{0.05}$. The letter "a" indicated the best. PBBogor= PBBogor-Plant Height, Tewe= Tewe-Grain Number, Gendut= Gendut-Grain Number, Kesit= Kesit-Plant Height, Ciherang= Ciherang-Grain Number, IR64= IR64-Grain Number. SW= spike weight hill^{-1} (g), TGN= total grain number hill^{-1}, TGW= total grain weight hill^{-1} (g), W100= 100-grain weight (g), MDGY= Milled-Dry Grain yield m^{-2} (g).

Table 3. (Continued)

Environment	Line	Number of "a"	Rank
Lowland	PB Bogor	10	1
	Tewe	10	1
	Gendut	8	3
	Kesit	6	4
	Ciherang	10	1
	IR64	9	2
Upland	PB Bogor	6	4
	Tewe	6	4
	Gendut	4	5
	Kesit	4	5
	Ciherang	3	5

	IR64	4	5
Upland Introduction	CSG1	2	6
	CSG2	6	4
	CSG3	6	4
	$HSD_{0.05}$		

Notes: PBBogor= PBBogor-Plant Height, Tewe= Tewe-Grain Number, Gendut= Gendut-Grain Number, Kesit= Kesit-Plant Height, Ciherang= Ciherang-Grain Number, IR64= IR64-Grain Number lines.

Genetic Variation, Heritability, and Genetic Coefficient of Variation Analysis

The values of genetic variation (σ^2_g), broad-sense heritability (h^2_{BS}), and genetic coefficient of variation (CV_g) were calculated following Hallauer *et al*. (2010) and were presented in Table 4 for lowland rice lines and for upland lines in Table 5. Data in Table 4 indicated that the variables plant height, tiller number hill^{-1}, productive tiller number hill^{-1}, spike weight hill^{-1}, total grain number hill^{-1}, 100-grain weight, and MDG yield m^{-2} had the values of σ^2_g and h^2_{BS} different from 0 ($P < 0.05$), whereas in Table 5 the variables were plant height, productive tiller number hill^{-1}, grain number spike^{-1}, total grain weight hill^{-1}, 100-grain weight, and MDG yield m^{-2} ($P < 0.05$).

The values of σ^2_g different from 0 implied that the variation existed on the variables valuable in advancing the selection program using the variables (Hikam *et al*., 2015). The values of h^2_{BS} different from 0 suggested that the variables expressed in the progenies especially when the value of h^2_{BS} >85 % (Hikam *et al*., 2015).

The data in Table 4 and 5 concluded that tested population consisted of PBBogor-Plant Height, Tewe-Grain Number, Gendut-Grain Number, Kesit-Plant Height, dan Ciherang-Grain Number lines were prospective for advance selection program which would result in superior inbred lines or be utilized as parents in a hybridization program to accumulate QTL geometrically (Hikam *et al*., 2015).

Table 4. The values of genetic variation (σ^2g), broad-sense heritability (h^2_{BS}), and genetic coefficient of variation (CV_g) for lowland rice line variables.

Variable	σ^2g	±	s.e. σ^2g	h^2_{BS} (%)	±	s.e. h^2_{BS} (%)	CV_g
PH	127.853*	±	71.005	96.29*	±	53.47	10.70

TN	14.911*	±	10.944	74.23*	±	54.48	18.39
PTN	13.378*	±	9.469	76.70*	±	54.29	17.94
PPTN	6.372	±	6.627	54.42	±	56.59	2.59
SW	0.301*	±	0.192	84.38*	±	53.83	21.91
GNS	40.358	±	86.186	28.52	±	60.90	7.39
TGN	186857.211*	±	113479.777	88.36*	±	53.66	24.96
TGW	153.692	±	90.884	90.62*	±	53.59	26.44
W100	0.008*	±	0.005	80.60*	±	54.04	3.32
MDGY	61476.892*	±	36353.686	90.62*	±	53.59	26.44

Notes: *= σ^2_g and h^2_{BS} differed from 0 at P< 0.05. PH= plant height, TN= tiller number hill^{-1}, PTN= productive tiller number hill^{-1}, PJAP= percent productive tiller number hill^{-1}, SW= spike weight hill^{-1}, GNS= grain number spike^{-1}, TGN= total grain number hill^{-1}, TGW= total grain weight hill^{-1} (g), W100= 100-grain weight, MDGY= Milled-Dry Grain yield m^{-2}.

Table 5. The values of genetic variation (σ^2g), broad-sense heritability (h^2_{BS}), and genetic coefficient of variation (CV_g) for upland rice line variables.

Variable	σ^2g	±	s.e. σ^2g	h^2_{BS} (%)	±	s.e. h^2_{BS} (%)	CV_g (%)
PH	95.972*	±	70.931	73.76*	±	54.51	10.65
TN	1.466	±	2.845	31.12	±	60.39	5.60
PTN	5.231*	±	3.792	75.07*	±	54.41	15.16
PPTN	19.029	±	37.180	30.93	±	60.43	6.25
SW	0	±	0	0	±	0	0
GNS	127.958*	±	108.059	65.46*	±	55.28	13.74
TGN	0	±	0	0	±	0	0
TGW	14.627*	±	12.831	63.28*	±	55.51	17.80
W100	0.038*	±	0.024	85.82*	±	53.76	9.99
MDGY	5855.544*	±	5134.115	63.31*	±	55.51	17.81

Notes: *= σ^2_g and h^2_{BS} differed from 0 at P< 0.05. PH= plant height, TN= tiller number hill^{-1}, PTN= productive tiller number hill^{-1}, PJAP= percent productive tiller number hill^{-1}, SW= spike weight hill^{-1}, GNS= grain number spike^{-1}, TGN= total grain number hill^{-1}, TGW= total grain weight hill^{-1} (g), W100= 100-grain weight, MDGY= Milled-Dry Grain yield m^{-2}.

Correlation Analysis

The correlation analysis among variables was done to reveal variables significantly correlated with MDGY m^{-2} and whether the variables would increase or decrease MDGY m^{-2}. Data in Table 6 showed that MDGY m^{-2} positively correlated (P< 0.01) with all other variables but tiller number hill^{-1}. On the other hand, productive tiller number hill^{-1} positively correlated (P< 0.01) with MDGY m^{-2}. The finding indicated that there was interference between tiller number hill^{-1}

and productive tiller number hill^{-1} suggestive that not all of the tillers grown produced spike especially in the organic-upland environment (Bian *et al*., 2013, Table 3). The data in Table 3 showed that productive tiller number hill^{-1} averaged 97.54 % on the lowland rice lines and decreased to 69.81 % on the upland lines presumably due to lower water supply for the upland lines. Therefore, increasing MDGY m^{-2} of the upland rice lines could be achieved with selecting hills which produced a greater number of spikes.

Table 6. The Pearson's correlation among variables

	PH	TN	PTN	PPTN	GNS	SW	TGN	TGW	W100
TN	0.108								
PTN	0.446**	0.682**							
PPTN	0.509**	-0.132	0.623**						
GNS	0.487**	-0.146	0.003	0.168					
SW	0.46**	0.299*	0.728**	0.665**	0.328*				
TGN	0.605**	0.481**	0.765**	0.517**	0.617**	0.761**			
TGW	0.58**	0.252	0.715**	0.689**	0.413**	0.876**	0.815**		
W100	0.39**	-0.139	0.393**	0.684*	0.124	0.666**	0.34*	0.781	
MDGY	0.58**	0.252	0.715**	0.689**	0.413**	0.876**	0.815**	0998**	0.781**

Notes: Numbers in columns were the Pearson's correlation values. *= P < 0.05, **= P< 0.01. PH= plant height, TN= tiller number hill^{-1}, PTN= productive tiller number hill^{-1}, PJAP= percent productive tiller number hill^{-1}, SW= spike weight hill^{-1}, GNS= grain number spike^{-1}, TGN= total grain number hill^{-1}, TGW= total grain weight hill^{-1} (g), W100= 100-grain weight, MDGY= Milled-Dry Grain yield m^{-2}.

CONCLUSIONS

The results indicated that the lowland rice lines decreased in their performance when grown in upland environment presumably due to lower water supply. The prospective lines of Local Genetic Source-Quantitative Trait Loci (LGS-QTL) lowland rice were PBBogor-Plant Height, Gendut-Grain Number, and Tewe-Grain Number having Milled-Dry Grain (MDG) yield > 6 t ha^{-1} to the extent of 1186.00, 766.70, and 1165.30 g m^{-2} equivalent to 11.86, 7.67, dan 11.65 t ha^{-1}, respectively. The prospective lines LGS-QTL for upland rice were PBBogor-Plant Height, Gendut-Grain Number, and Kesit-Plant Height having MDGY > 4 t ha^{-1} to the extent of 430.10, 448.50, dan 432.20 g m^{-2} equivalent to 4.30, 44.85, dan 4.32 t ha^{-1}, respectively. The LGS-QTL lines: PBBogor-Plant Height, Tewe-Grain Number, Gendut-Grain Number, Kesit-Plant Height and the National line Ciherang-Grain Number ranked the 1st in all populations were prominent to be parental lines to accumulate QTL. The lines PBBogor-Plant Height, Tewe-Grain Number, Gendut-Grain Number, and Kesit-Plant Height were prospective to be drafted to the Plant Variety Protection (PVP) Committee.

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