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Morphology-based genetic diversity of early maturity rice germplasm, the relation to yield component

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ABSTRACT

Assessment of rice germplasm is fundamental to provide based information of rice diversity for the improvement of current and future rice varieties. Most of local rice germplasm characteristic had late maturity and low yield productivity,to develop modern variety it is important to identify early maturity of local rice germplasm. This study examined the phenotype structure of 112 early maturity local rice accession, collected trough-out different region in Indonesia, and how it is related to yield and yield component. A total of 20 qualitative and quantitative character were examined. Clustering analysis between accession were analyzed using multivariate statistical analysis with ward method. Correlation coefficient and regression equation were carried out by STAR software. Phenotypic diversity of yield component expressed on early maturity rice germplasm observed in this study. Based on cluster analysis, rice germplasm grouped in to 6 main group. Most of the quantitative characters, showed positive correlation with filled grain weight per plant, that represented yield potential. Whereas a positive correlation of qualitative characters, only showed between pubescence of leaf blade surface and culm habitus. This study is expected to give proper information for the selection of early maturity rice germplasm with high yield component as parental lines to be utilized in breeding program as proper parental line(s).

***Key words**: Local variety, Early maturity, Morphology, Yield component*

Introduction

Rice (*Oryza sativa* L.) is staple food for more than half of world's population. With the increasing challenges of food security caused by rapid global population growth, the demand of high rice production is always an urgent task for rice breeders. The variability of germplasm is one of the key for yield improvement and other characters. Plant germplasm have been collected to preserve genetic diversity of crop species and ensure a wide genetic base in plant improvement programs (Brush, 1989). Germplasm research is basically a study of genetic diversity of the germplasm characters in which is the basis of breeding program activities (Zuraida, 2016).

With the high level of biodiversity in Indonesia, the potential of genetic resources variability is abundant, where the distribution covers various regions. Each region in Indonesia has several unique genetic resources, which are often different from those in other regions. Most of local rice germplasm characteristic had late maturity and low yield productivity. In order to develop modern variety, it is important to identified early maturity of local rice germplasm without sacrificing grain yield. Among ICRR gene bank collection we grouped accession categorized as early maturity (Siregar, 1981), and studied the qualitative and quantitative characters of the accessions.

Relationships among plant genotypes of various plant species have been well established using clus-

ter analysis of several quantitative and/or qualitative characters (Kouamé and Quesenberry, 1993; Souza and Sorrells, 1991a, b). The similarity groups derived from such analyses may then be sampled either randomly or by some stratification such as geographical origin to form the germplasm collection. In this study we examine early maturity local rice accession and the relation to yield component. It is intended that the classification will provide a basis for parentalin the breeding program.

Material and Methods

The rice of Indonesian germplasm consisted of 112 early maturity local rice accession, collected trough-out different region in Indonesia. These accessions were selected from ICRR gene bank collection. Phenotyping characterization was carried out at Indonesian Center for Rice Research field experiment, Sukamandi subang. Standard agronomic practices and plant protection measures were applied for optimum cultivation. Phenotype data were collected for 20 agro-morphological characters. Among these 20 characters, 12 were quantitative traits such as Length of flag leaf blade (cm), Width of flag leaf blade (cm), Time of maturity (das), Percentage of filled grain weight/plant (%), Empty grain weight/plant (g), Filled grain weight/plant (g), Tillering ability (tiller/plant), Panicle length (cm), 1000 grain weight (g), Plant Height (cm), Number of filled grain/panicle, Panicle exertion (cm) for quantitative data. Furthermore eight qualitative data observed, consist of Pubescence of leaf blade, Attitude of leaf blade, Leaf color intensity, Leaf sheath blade color, Habitus, Leaf : Collar color, Auricle color, Ligule color. The method of observation conducted based on SES IRRI (2014) and Komisi Nasional Plasma Nutfah (2003). Correlation coefficient, genetic diversityand Cluster analysis was performed using Statistical Tool for Agriculture Research (STAR) ver. 2.0.1.

Results and Discussion

Morpho-agronomic characters of rice germplasm

Agro-morphological characterization of germplasm is fundamental to provide the preliminary information for breeding program (Lin, 1991). The amount of genetic variability consist in germplasm is also essentials to crop improvement and can be exploited for yield improvement(Idahosa et al., 2010). The mean performance of 112 local rice accessions based on 12 quantitative characters indicated high variability among accession (Table 1.), especially in length of flag leaf blade, filled grain weight/plant, tillering ability, and number of filled grain/panicle.

Regarding the qualitative characters (Table 2), most of the local rice accessions had recurve characters of leaf blade with green color on leaf and leaf sheath. The culm habit or habitus showed semi erect characters. Qualitative character(s) will be useful for identification of uniqueness of an accession. Oryza spp. has high variability of morphological traits in each group of species, thus the morphological character can be the easiest identifier to identify lines, otherwise it can be used to determine kinship within or between species (Nezu *et al.,* 1960).

Correlation between characters

The relation between traits of 12 quantitative characters represented as correlation coefficient, are presented in Table 3. Filled grain weight/plant is the variable that represent yield, and it had highly posi-

Table 1. Mean, max and min value for 12 quantitative characters of 112 local rice accessions.

Quantitative Characters	Mean	Max	Min
Length of flag leaf blade (cm)	37.60	72.80	18.40
Width of flag leaf blade (cm)	1.72	2.54	1.00
Time of maturity (das)	109.99	115.00	97.00
Percentage of filled grain weight/plant (%)	90.95	100.00	68.96
Empty grain weight/plant (g)	6.17	22.50	0.60
Filled grain weight/plant (g)	75.96	249.60	15.40
Tillering ability (tiller/plant)	16.41	44.00	5.00
Panicle length (cm)	27.21	36.22	20.80
1000 grain weight (g)	24.81	34.10	10.83
Plant Height (cm)	136.77	200.00	85.40
Number of filled grain/panicle	109.50	362.78	8.00
Panicle exertion (cm)	5.49	18.96	-3.00

tive correlation with percentage of filled grain weight/plant, empty grain weight/plant, tillering ability, and significant positive correlation with number of filled grain/panicle.

Table 2. Most frequently qualitative characters appear on the observed population of 112 local rice acces sions.

Qualitative characters	Most frequently appeared Scale	note
Pubescence of leaf blade	1	absent or very weak
Attitude of leaf blade	7	recurved
Leaf color intensity	2	green
Leaf sheath blade color	2	green
Habitus	3	semi erect
Leaf: Collar color	1	absent or very weak
Auricle color	1	absent or very weak
Ligule color	1	absent or very weak

In contrast, filled grain weight/plant negatively correlated with plant height and time of maturity. The study by Ali *et al.* (2008) showed the same negative correlation between yield and plant height. It seem logical to select short plant for lodging resistance couple with high yielding. Filled grain weight/panicle showed positive but non-significant correlation with 1000 grain weight and panicle exertion. Time of maturity exhibited positive significant correlation with panicle length. Karim *et al.* (2014) found similar result that affirm the present finding.

The relation between qualitative characters showed in Table 4. Positive correlation of qualitative charactersshowed between pubescence of leaf blade surface and culm habitus. Leaf sheath blade color correlated the most with other characters. It showed significant negative correlation with culm habit, leaf collar color, and ligule color. Whereas leaf collar, auricle and ligule color exhibited positive significant positive correlation within each character.

Cluster analysis

Clustering is one of the main approaches for genetic diversity estimation, and has been used frequently in rice (Chandramohan *et al.*, 2016; Gana *et al.*, 2013). The analysis of genetic diversity through the cluster analysis showed in Fig 1. Cluster diagram using agglomerative clustering method, categorized the germplasm into six cluster (Table 5). Highest number of accession (38) were include in cluster II followed respectively by cluster IV(25), III (18), VI (13), V(11) and I (7). The overall clustering pattern indicated that accessions in the same province were distributed in different cluster (data non shown). The same result of non-association of geographical region with the genetic diversity reported by (Chandramohan *et al.*, 2016; Nayak *et al.*, 2014). Grouping of material of same geographical origin into different clusters was an indication of the broad genetic base of genotypes belonging to that origin (Shanmugam and Rangasam, 1982).

Table 3. Phenotypic correlations among different quantitative characters in local rice germplasm.

Quantitative characters	Length of flag leaf blade	Width of flag leaf blade	Time of maturity	Percentage of filled grain weight /plant	Empty grain weight / plant	Filled grain weight /plant	Tillering ability (tiller/ plant)	Panicle length	1000 grain weight	Plant Height (cm)	Number of filled grain/ panicle	Panicle exertion (cm)
Length of flag leaf blade	1											
Width of flag leaf blade	0.31**	1										
Time of maturity	0.06	0.18*	1									
Percentage of filled grain weight/plant	-0.19 *	-0.08	-0.22 *	1								
Empty grain weight/plant	-0.09	0.16	0.06	-0.42 **	1							
Filled grain weight/plant	-0.15	0.02	-0.23 *	0.42 **	0.43 **	1						
Tillering ability	-0.35**	-0.27**	-0.14	0.22	0.31 **	0.61 **	1					
Panicle length	0.48**	0.46**	0.19*	-0.16	0.07	-0.03	-0.35**	1				
1000 grain weight	0.01	0.33 **	-0.02	-0.05	0.14	0.09	-0.15	0.21*	1			
Plant Height	0.57**	0.39**	0.22 *	-0.26 **	0.01	-0.22 *	-0.42 **	0.45 **	0.10	1		
Number of filled grain/panicle	0.31**	0.37 **	-0.04	0.23*	-0.03	0.21*	-0.14	0.24*	-0.06	0.26**	1	
Panicle exertion	0.19*	0.48**	0.08	-0.15	0.27**	0.15	-0.24*	0.57**	0.41**	0.37**	0.18**	1

Table 4. Phenotypic correlations among different qualitative characters in local rice germplasm.; * and ** indicated significant differences at 5%, 1%, and 0.1% level of probability

Qualitative characters	Pubescence of leaf blade	Attitude of leaf blade	Leaf color intensity	Leaf sheath blade color	Habitus	Leaf: Collar color	Auricle color	Ligule color
Pubescence of leaf blade	1							
Attitude of leaf blade	0.05	1						
Leaf color intensity	0.05	0.04	1					
Leaf sheath blade color	-0.13	-0.13	0.13	1				
Habitus	0.41**	0.17	0.16	-0.32**	1			
Leaf: Collar color	-0.11	0.15	-0.02	-0.57**	0.07	1		
Auricle color	-0.17	0.12	-0.01	-0.54**	0.08	0.96**	1	
Ligule color	-0.14	0.07	-0.08	-0.41**	0.01	0.69**	0.70**	1

Genotypes belonging to clusters separated by high cluster distance could be used in breeding program for obtaining wide spectrum of variation among the segregants (De *et al.,* 1992). The magnitude of the diversity or heterosis of a trait depends upon the degree of diversity present in the parental lines.

Cluster mean analysis revealed a wide range of variation for some of the traits observed (Table 6). Genotypes or Accessions belong to cluster III had high filled grain weight/plant, tillering ability, panicle length and number of filled grain/panicle despite of high plant stature, thus it is suggested to use the accessions in cluster III as parental lines on hybridization program for yield improvement. Obtaining high filled grain weight/plant and tillering ability, cluster V also exhibited early maturity character. Hence, it is also possible to develop early maturity variety with high yield by using accessions from cluster V.

Genetic diversity leads to the selection of genotypes with large genetic distance which can be further taken up as parents for hybridization. It is suggested that important yield contributing characters such as 1000 grain weight, tillering ability, panicle length and number of filled grain/panicle could be improved through selection using present experimental material. The hybridization process leads to the introduction of new allelic combinations or to exploit the transgressive segregnts in the later generations. Thus, the selection of diverse accessions from different clusters, expected to showed the maximum cluster distance to produce high variability.

Table 5. Distribution of 112 local rice accession into 6 cluster

Cluster	Number of lines	Name of local accession
I	7	Pae Ndina Ana, Andel Abang, Cere Beureum, Rengka Condong, Pae Loio, Kumpal B, Pae Doiy.
II	38	Ramces, Pera, Gundil Merah, Gundil Putih, Ketan IR, Pasir Honje 5, Rantai Mas, Rantai Mas, Lege Pisah, Ramos, Burana, Buntok, Jalu Niung, Srondot, Sepadan b, Padi Lima Bulan, Padi Lima Bulan, Adil Makmur, Kuriak Kusambik, Molog Bulu, Kuning, Seuweu, Talun Bintik, Kopo, L. Genteng Sukabumi, Padi Erna, Cipendeuy B, Rungsak Kesambik, Hitam, Cipeundeuy D, Laka, Kumpal, Pulut Unggul 1, Pulut Unggul, Omas, Jeletuk Bulu Putih, Padi Lima Bulan, Si Medan, Sipilihan.
III	18	Salumpikit, Klemes, Ketan Buluh, Pulut Ngoti, Sedang Menawan, Ketan Langgar, Sari, Lapang, Lapang, Keketoi, Pae Wita II, Kusim, Marica, Sumada, Si Pulau, andailing, Sigoe, Serai, Cingri, Cingri.
IV	25	Ketan, Midun Putih, Super Win Aromatik, Super win Aromati (Palu), Super Win, Aromatik, Gogo Tuban, Padi Ketan Genjah, Ketan Kelapa, Cempu Kunci, Daliah, Putih, Cere Kepal, Krawang, Padi Banten, Muncang, Muncul, Ketan Nangka, Midun, Sumedang, Mayang Terurai Lima Puluh Kota, Celebes Maros, Padi Putih, Midun Blok Patrol, Solo, Arias A, Sunting Baringin, Aromatik.
V	11	Klemes, Serang, Sutosel, Raden Ayu, Sekemiling, Ketan Nangka, Ketan Rangen, Loneng, Selasih, Lumbuk, Lumbuk
VI	13	Padi Putih, Ketan Hitam, Jembar, Jembar Lokal, Senggani, Lamdaur Ekor Putih, Cungkring, Nengsih, Dolar, Dolar 2, Padi Karan Duku, Lokcan Empok, Ketan Putih 3

Table 6. Mean and standard deviation of six clusters for twelve quantitative characters.

Characters	Mean ± SD											
	Cluster 1		Cluster 2		Cluster 3		Cluster 4		Cluster 5		Cluster 6	
Length of flag leaf blade (cm)	33.80±	7.54	42.20±	8.96	41.42±	7.94	32.96±	5.38	33.90±	2.94	35.27±	7.14
Width of flag leaf blade (cm)	1.62±	0.23	1.79±	0.34	1.79±	0.22	1.50±	0.30	1.60±	0.12	1.91±	0.29
Time of maturity 109± (das)	6	110±	5	110±	4	110±	3	108±	3	113±	0	
Percentage of filled grain weight/plant (%)	93.42±	2.79	89.84±	6.61	92.79±	4.80	89.43±	4.21	95.28±	2.83	86.81±	7.45
Empty grain weight/plant (gr)	2.72±	2.30	4.15±	2.70	6.98±	4.30	4.96±	2.51	10.58±	6.37	11.38±	4.95
Filled grain weight /plant (gr)	34.48±	20.78	45.17±	34.46	117.91±	61.18	43.69±	18.33	215.06±	32.93	85.57±	30.50
Tillering ability (tiller/plant)	9.89±	2.96	13.53±	5.22	17.28±	6.03	18.74±	5.54	30.09±	7.57	12.49±	3.60
Panicle length (cm)	25.94±	1.77	27.93±	3.18	27.84±	3.68	25.03±	1.79	26.69±	3.06	29.66±	3.89
1000 grain weight (gr)	19.84±	5.98	25.68±	3.65	24.01±	3.75	23.90±	2.78	25.35±	3.03	27.25±	2.89
Plant Height (cm)	131.34±	21.63	146.93±	22.98	155.71±	17.37	118.12±	16.76	106.27±	12.56	149.51±	29.13
Number of filled grain/panicles	103.07±	21.06	115.10±	48.94	133.28±	37.99	92.95±	23.28	96.55±	36.30	106.78±	27.45
Panicle exertion (cm)	2.21±	2.47	5.21±	3.82	6.99±	3.58	3.73±	1.75	4.71±	2.85	10.54±	5.42

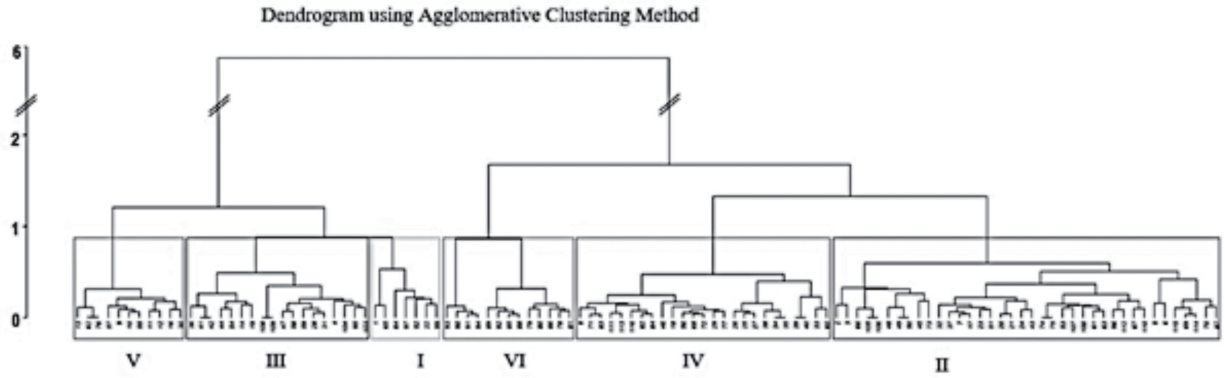

Fig. 1. Cluster diagram of early maturity rice germplasm accession on the basis morpho-agronomic traits.

Conclusion

The result revealed diversity among 112 local early maturity rice accession in the basis of morpho-agronomic characters. Most of the quantitative characters, showed positive correlation with filled grain weight per plant, that represented yield potential, and qualitative characters positive correlation only showed between pubescence of leaf blade surface and culm habitus. Cluster mean analysis revealed a wide range of variation for some of the traits observed. Accession belonging to separated cluster with desirable trait by high cluster distance could be used in breeding program as parental line.It is suggested that important yield contributing characters, could be improved through selection using present experimental materials.

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