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Short Communication

CORRELATION ANALYSIS OF AGRONOMIC CHARACTERS AND GRAIN YIELD OF RICE FOR TIDAL SWAMP AREAS

Aris Hairmansis, Bambang Kustianto, Supartopo, and Suwarno

Muara Experimental Station, Indonesian Center for Rice Research
Jalan Raya Ciapus No. 25C, Muara, Bogor 16610, Indonesia, Phone (0251) 8322064, Facs. (0251) 8322064
E-mail: balitpamuara@telkom.net

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ABSTRACT

Development of rice varieties for tidal swamp areas is emphasized on the improvement of rice yield potential in specific environment. However, grain yield is a complex trait and highly dependent on the other agronomic characters; while information related to the relationship between agronomic characters and grain yield in the breeding program particularly for tidal swamp areas is very limited. The objective of this study was to investigate relationship between agronomic characters and grain yield of rice as a basis for selection of high yielding rice varieties for tidal swamp areas. Agronomic characters and grain yield of nine advanced rice breeding lines and two rice varieties were evaluated in a series of experiments in tidal swamp areas, Karang Agung Ulu Village, Banyuasin, South Sumatra, for four cropping seasons in dry season (DS) 2005, wet season (WS) 2005/2006, DS 2006, and DS 2007. Result from path analysis revealed that the following characters had positive direct effect on grain yield, i.e. number of productive tillers per hill (p = 0.356), number of filled grains per panicle (p = 0.544), and spikelet fertility (p = 0.215). Plant height had negative direct effect (p = -0.332) on grain yield, while maturity, number of spikelets per panicle, and 1000-grain weight showed negligible effect on rice grain yield. Present study suggests that indirect selection of high yielding tidal swamp rice can be done by selecting breeding lines which have many productive tillers, dense filled grains, and high spikelet fertility.

[***Keywords***: *Oryza sativa*, agronomic characters, path analysis, grain yield, swamps]

INTRODUCTION

Improvement of rice grain yield is the main target of breeding program to develop rice varieties for diverse ecosystems including tidal swamp areas. However, grain yield is a complex trait, controlled by many genes and highly affected by environment (Jennings *et al*. 1979). In addition, grain yield also related with other characters such as plant type, growth duration, and yield components (Yoshida 1981). The low heritability of grain yield characters made selection for high yielding varieties usually use secondary traits associated with yield (Atlin 2003). Thus, information on contribution of each plant character to grain yield is important to make selection process more efficient.

Causal relationship between predictor variables and response variable can be defined by path analysis (Samonte *et al*. 1998). Using path analysis, correlation coefficient is partitioned into two components, which are direct effect of a predictor variable on its response variable and indirect effect of that predictor variable on the response variable through other related variables (Williams *et al*. 1990). Path analysis has been intensively used to estimate contribution of yield related traits to grain yield of rice and assisted breeders to determine selection criteria to improve yield (Gravois and Helms 1992; Samonte *et al*. 1998; Oad *et al*. 2002; Babar *et al*. 2007). However, information on relationship of agronomic traits and grain yield in the breeding program for specific environment particularly for tidal swamp areas is very limited.

Rice improvement program for tidal swamp areas is addressed to develop rice varieties which can adapt with the problems which hamper rice growth in this type of ecosystem (Hairmansis *et al*. 2008). Some important traits are required for rice to adapt with tidal land condition which is different with irrigated lowland rice. Rice varieties for tidal land are generally tall and grow rapidly, have strong culms and medium growth duration, and tolerant to abiotic stresses such as soil acidity and salinity (Harahap and Silitonga 1998). Further information on relationship among plant characteristics is important to optimize selection for desirable rice breeding lines which are suitable for tidal land.

The objective of present study was to investigate relationship between agronomic characters and grain yield of rice as the basis for selection of high yielding rice varieties for tidal swamp areas.

MATERIALS AND METHODS

The rice breeding lines and varieties used in this study are shown in Table 1. The materials consisted of nine advanced breeding lines and two improved rice varieties for tidal swamp areas, IR42 and Batanghari. These breeding lines have been selected for several generations in tidal swamp areas and derived from different crosses. Most of the rice lines were developed by the Indonesian Center for Rice Research in Sukamandi, West Java. Two breeding lines, KAL9414F-MR-2-KN-0 and KAL9418F-MR-2-KN-0, were developed by the Indonesian Swampland Agricultural Research Institute in Banjarbaru, South Kalimantan. The IR61242-3B-B-2 line was introduced from the International Rice Research Institute, Philippines.

The experiments were carried out in Karang Agung Ulu village, Banyuasin district, South Sumatra, during four seasons which were dry season (DS) 2005, wet season (WS) 2005/2006, DS 2006, and DS 2007. This site was characterized as potential acid sulphate area. The soil type was alluvial with soil pH of 4.5. The trials were arranged in a randomized complete block design with four replications. Each line was grown in a 4 m x 5 m plot. The 21-day-old seedlings from wet-bed nurseries were transplanted at three seedlings per hill at a spacing of 25 cm x 25 cm. Each plot was fertilized with urea 200 kg, SP36 100 kg, and KCl 100 kg ha^{-1}.

Data were collected for plant height (cm), number of productive tillers per hill, maturity (day), number of filled grains per panicle, number of spikelets per panicle, spikelet fertility per panicle (%), 1000-grain weight (g), and grain yield (t ha^{-1}). Measurement of rice characters referred to standard evaluation system for rice (IRRI 1996).

Relationships between agronomic characters and grain yield were analyzed using simple correlation analysis and path analysis (Singh and Chaundhary 1979). Analysis was taken based on average data in each environment. Simple correlation and path analysis were computed using computer software package of SAS version 8.

Table 1. Rice breeding lines and varieties used in the study.

Lines/varieties	Parentage
B9833C-KA-14	IR52///Batang Agam/IR54742//Batang Ombilin/IR68
B9852E-KA-66	Batang Ombilin/IR9884-54-3
B5244G-SM-61-2-1	IR13168-143-1/LMN III//IR13292-5-3
B7003D-MR-24-3-1	Kapuas3/IR56
B9858D-KA-55	Batang Ombilin/Dukuh
B10214F-TB-7-2-3	Pucuk/Cisanggarung//Sita
KAL9414F-MR-2-KN-0	Siam Unus/Cisokan
KAL9418F-MR-2-KN-0	Rantai/Cisokan
IR61242-3B-B-2	IR42253-63-1-2-3/BW100
IR42	Released variety
Batanghari	Released variety

RESULTS AND DISCUSSION

Coefficients of correlation between all pairs of tidal swamp rice characters are shown in Table 2. The agronomic characters which had positive relationship with grain yield were number of filled grains per panicle (r = 0.677), number of spikelets per panicle (r = 0.217), and spikelet fertility per panicle (r = 0.445). On the contrary, plant height (r = -0.258) was inversely correlated with grain yield. Among these traits, filled grains and spikelet fertility were significantly correlated with grain yield. The other characters, number of productive tillers (r = 0.056) and 1000-grain weight (r = -0.020), showed very weak correlation with grain yield. Gravois and Helms (1992) reported the importance of number of filled grains per panicle in determination of rice yield. In addition, Silitonga (1989) observed significant positive correlation between number of filled grains and grain yield of hybrid rice

Table 2. Simple correlation between all pairs of tidal swamp rice characters.

Characters	No. of productive tillers per hill	Maturity	No. of filled grains per panicle	No. of spikelets per panicle	Spikelet fertility per panicle	1000-grain weight	Grain yield
Plant height	0.570**	-0.251	-0.131	-0.219	0.098	-0.687**	-0.258
No. of productive tillers per hill		-0.219	-0.120	-0.241	0.147	-0.637**	0.056
Maturity			0.019	0.318*	-0.302*	-0.065	-0.020
No. of filled grains per panicle				0.478**	0.493**	-0.140	0.677**
No. of spikelets per panicle					-0.526**	0.000	0.217
Spikelet fertility per panicle						-0.148	0.445**
1000-grain weight							-0.020

* and ** = significantly different at $P < 0.05$ and $P < 0.01$, respectively.

and suggested to use this trait in selecting high yielding hybrid rice.

Correlation coefficients between agronomic characters of tidal swamp rice as predictor variables and grain yield as response variable were partitioned into direct effect (p) and indirect effect (rp) through path analysis. Path coefficient of agronomic traits on grain yield of tidal swamp rice is shown in Table 3.

Plant height had negative direct effect (p = -0.332) on grain yield. Its indirect effects on grain yield through maturity, number of filled grains per panicle, number of spikelets per panicle, and 1000-grain weight were negative, but it had positive indirect effect via number of productive tillers per hill. Product of these direct and indirect effects made this characters negatively correlated (r = -0.258) with grain yield. Number of productive tillers had positive and moderate direct effect (p = 0.356) on grain yield, however its indirect effect through other characters was mostly negative. This character only had positive indirect effect through spikelet fertility per panicle (rp = 0.032). When positive direct effect of number of productive tillers added with its indirect effect through other agronomic traits, the sum (correlation between number of productive tillers and grain yield) was very low (r = 0.056). Previous papers also mentioned that number of tillers had positive direct effect on grain yield (Samonte *et al*. 1998; Oad *et al*. 2002). On the other hand, the low correlation between maturity and grain yield was figured by its low direct and indirect effects through other yield related traits. Its negative indirect effects through number of productive tillers, spikelet fertility, and 1000-grain weight resulted in negative correlation between maturity and grain yield.

Number of filled grains per panicle showed the highest correlation (r = 0.677) with grain yield compared to the other characters. This strong relationship was mostly determined by its direct effect on grain yield (p = 0.544). Its low indirect effects through other traits indicated that direct selection using this trait to select high yielding breeding lines will be effective. This result coincided with the previous studies which also reported that number of filled grains per panicle had significant positive direct effect on rice grain yield (Gravois and Helms 1992; Samonte *et al*. 1998). On the contrary, number of spikelets per panicle exhibited very weak direct effect (p = 0.080) on grain yield, even though its correlation coefficient with number of filled grains per panicle was significantly positive.

Another character that positively correlated with grain yield was spikelet fertility (r = 0.445). Partitioning

Table 3. Path coefficients of agronomic characters on grain yield of tidal swamp rice.

Correlation	r value
Plant height vs grain yield	-0.258
Direct effect	-0.332
Indirect effect via:	
No. of productive tillers per hill	0.203
Maturity	-0.002
No. of filled grains per panicle	-0.071
No. of spikelets per panicle	-0.017
Spikelet fertility per panicle	0.021
1000-grain weight	-0.060
No. of productive tillers vs grain yield	0.056
Direct effect	0.356
Indirect effect via:	
Plant height	-0.189
Maturity	-0.002
No. of filled grains per panicle	-0.066
No. of spikelets per panicle	-0.019
Spikelet fertility per panicle	0.032
1000-grain weight	-0.055
Maturity vs grain yield	-0.020
Direct effect	0.009
Indirect effect via:	
Plant height	0.083
No. of productive tillers per hill	-0.078
No. of filled grains per panicle	0.010
No. of spikelets per panicle	0.025
Spikelet fertility per panicle	-0.065
1000-grain weight	-0.006
No. of filled grains vs grain yield	0.677
Direct effect	0.544
Indirect effect via:	
Plant height	0.044
No. of productive tillers per hill	-0.043
Maturity	0.000
No. of spikelets per panicle	0.038
Spikelet fertility per panicle	0.106
1000-grain weight	-0.012
No. of spikelets vs grain yield	0.217
Direct effect	0.080
Indirect effect via:	
Plant height	0.073
No. of productive tillers per hill	-0.086
Maturity	0.003
No. of filled grains per panicle	0.260
Spikelet fertility per panicle	-0.113
1000-grain weight	0.000
Spikelet fertility vs grain yield	0.445
Direct effect	0.215
Indirect effect via:	
Plant height	-0.033
No. of productive tillers per hill	0.052
Maturity	-0.003
No. of filled grains per panicle	0.268
No. of spikelets per panicle	-0.042
1000-grain weight	-0.013
1000-grain weight vs grain yield	-0.020
Direct effect	0.087

Table 3. (continued).

Correlation	r value
Indirect effect via:	
Plant height	0.228
No. of productive tillers per hill	-0.227
Maturity	-0.001
No. of filled grains per panicle	-0.076
No. of spikelets per panicle	0.000
Spikelet fertility	-0.032
Residual effect	0.644

this coefficient correlation showed that the relationship was mostly determined by its positive direct effect (p = 0.215) on grain yield and its positive indirect effect through number of filled grains (rp = 0.268). Furthermore, loose association between 1000-grain weight and grain yield was caused by its low direct effect and indirect effect coefficients. Yoshida (1981) described that the components of rice grain yield consisted of number of spikelets, percentage of filled spikelets, and 1000-grain weight; and among those, number of spikelets was the most important component limiting rice yield, while 1000-grain weight was rarely affected grain yield.

Figure 1 explains detailed pathway of agronomic character effects on grain yield and its relationship of each other in determination of rice yield. Positive path coefficients of number of filled grains per panicle, number of productive tillers and spikelet fertility indicated the importance of these characters as a secondary trait in the selection to increase grain yield. In addition, plant height character which had negative direct effect on grain yield should be considered in the selection process by selecting rice plant type with semi-dwarf or intermediate plant height. Even though tidal swamp rice varieties are generally taller than irrigated rice, result from the present study indicated the importance of selection to reduce plant height to increase rice yield in tidal swamp areas. Yoshida (1981) suggested that high yield gain in rice varieties with reduced plant height associated with increase in lodging resistance of rice plant.

Knowledge on contribution of each agronomic character to grain yield will be useful to assist rice

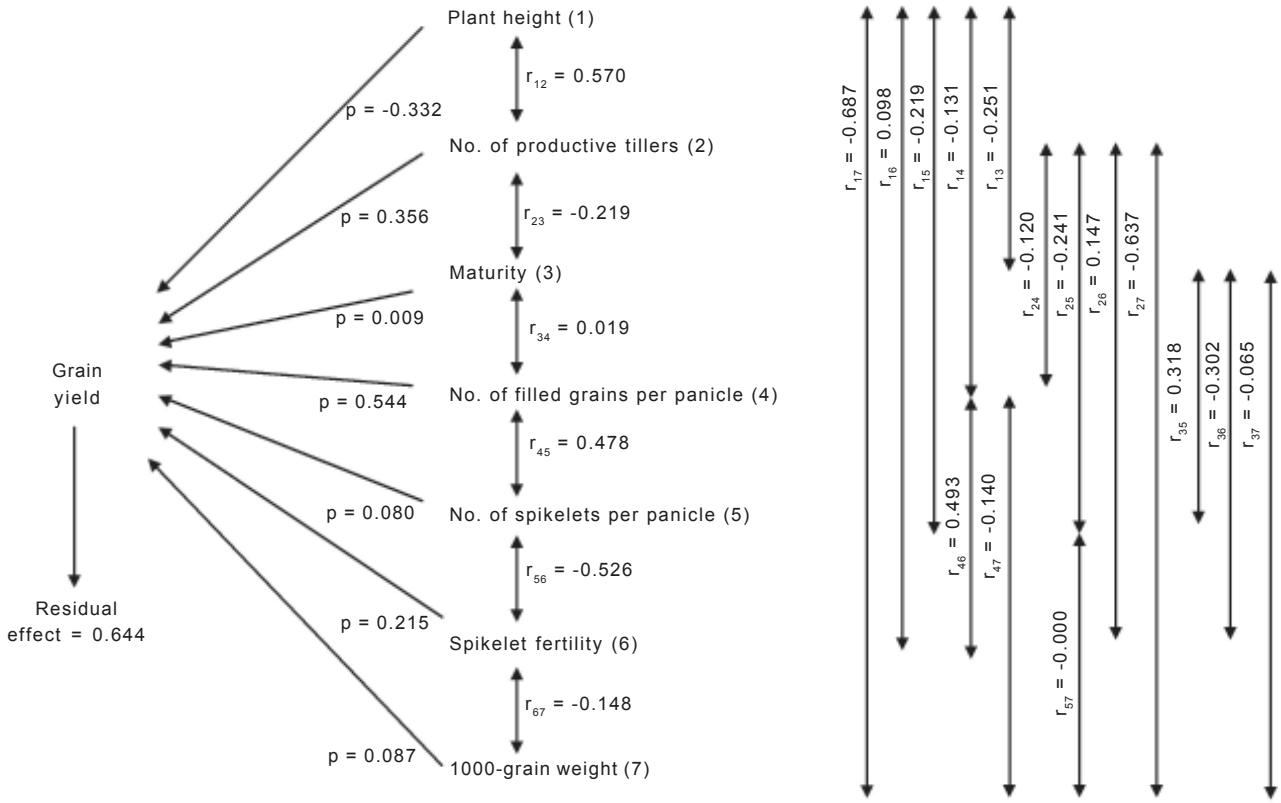

Fig. 1. Path diagram of tidal swamp rice agronomic characters. Single headed arrow lines indicate path coefficient of agronomic characters on grain yield, double headed arrow lines indicate correlation coefficient between all pairs of agronomic characters.

breeders as the indirect selection of grain yield during the early generation before conducting replicated yield trials (Samonte *et al*. 1998). However, this study also showed high residual effect coefficient that was 0.644, which indicated there were other variables which determined rice grain yield and were not yet explained in this experiment. Further studies are needed to elucidate relationship of grain yield and the other morpho-physiological traits which is related to soil stress tolerance in tidal swamp areas such soil acidity, iron toxicity, aluminum toxicity, and nutrient deficiency.

CONCLUSION

Partitioning correlation coefficient through path analysis clarified direct effect of each agronomic character on grain yield of tidal swamp rice. Characters with positive direct effects on grain yield included number of productive tillers per hill, number of filled grains per panicle, and spikelet fertility. Plant height had negative direct effect on grain yield, while maturity, number of spikelets per panicle, and 1000-grain weight showed a weak direct effect on rice grain yield. Based on this information, indirect selection of high yielding tidal swamp rice can be taken by selecting breeding lines which have many productive tillers, dense filled grains, and high spikelet fertility.

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REFERENCES

Atlin, G. 2003. Improving drought tolerance by selecting for yield. p. 14-22. *In* K.S. Fischer, R. Lafitte, S. Fukai, G. Atlin, and B. Hardy (Eds.). Breeding Rice for Drought-Prone Environments. IRRI, Los Banos, the Philippines.

Babar, M., A.A. Khan, A. Arif, Y. Zafar, dan M. Arif. 2007. Path analysis of some leaf and panicle traits affecting grain yield in doubled haploid lines of rice (*Oryza sativa* L.). J. Agric. Res. 45(4): 245-252.

Gravois, K.A. and R.S. Helms. 1992. Path analysis of rice yield and yield components as affected by seeding rate. Agron. J. 84: 1-4.

Hairmansis, A., B. Kustianto, Supartopo, dan Suwarno. 2008. Pemuliaan padi rawa pasang surut dan lebak. hlm. 319-328. *Dalam* A.K. Makarim, B. Suprihatno, Z. Zaini, A. Widjono, I.N. Widiarta, Hermanto, dan H. Kasim (Ed.). Inovasi Teknologi Tanaman Pangan, Buku 2. Penelitian dan Pengembangan Padi. Pusat Penelitian dan Pengembangan Tanaman Pangan, Bogor, Indonesia.

Harahap, Z. dan T.S. Silitonga. 1998. Perbaikan varietas padi. hlm. 335-361. *Dalam* M. Ismunadji, M. Syam, dan Yuswadi (Ed.). Padi, Buku 2. Pusat Penelitian dan Pengembangan Tanaman Pangan, Bogor, Indonesia.

IRRI. 1996. Standard Evaluation System for Rice (SES). IRRI, Los Banos, the Philippines.

Jennings, P.R., W.R. Coffman, and H.E. Kaufman. 1979. Rice Improvement. IRRI, Los Banos, the Philippines. 186 pp.

Oad, F.C., M.A. Samo, Z.U. Hassan, P.S. Cruz, and N.L. Oad. 2002. Correlation and path analysis of quantitative characters of rice ratoon cultivars and advance lines. Int. J. Agric. Biol. 4(2): 204-207.

Samonte, S.O.P.B., L.T. Wilson, and A.M. McClung. 1998. Path analyses of yield and yield-related traits of fifteen diverse rice genotypes. Crop Sci. 38: 1130-1136.

Silitonga, T.S. 1989. Analisis koefisien lintasan dari komponen hasil galur-galur padi hibrida. Penelitian Pertanian 9(2): 68-70.

Singh, R.K. and B.D. Chaundhary. 1979. Biometrical Method in Quantitative Genetic Analysis. Kalyani Publishers, New Delhi, India. 304 pp.

Williams, W.A., M.B. Jones, and M.W. Demment. 1990. A concise table for path analysis statistics. Agron. J. 82: 1022-1024.

Yoshida, S. 1981. Fundamentals of Rice Crop Science. IRRI, Los Banos, the Philippines. 269 pp.