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CORRELATIONS AND PATH ANALYSIS TO DETERMINE THE SELECTION CHARACTERS FOR DEVELOPING NEW-TYPE OF UPLAND RICE

Reny Herawati[1]*, Masdar[1], and Alnopri[1],

[1]Department of Agroecotechnology, Faculty of Agriculture, University of Bengkulu, Bengkulu, Indonesia. 38371

*Correspondence: reny.herawati@unib.ac.id

ABSTRACT

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Reny Herawati[1]*, Masdar[1], and Alnopri[1],

[1]Department of Agroecotechnology, Faculty of Agriculture, University of Bengkulu, Bengkulu, Indonesia. 38371

***Correspondence: reny.herawati@unib.ac.id**

ABSTRACT

Correlation between growth characters and yields substantially efforted to determine the right character selection. Other method called path analysis could be used in order to determine important characters, either directly or indirectly, to the crop yield. This research aimed to determine the selection criterion in agronomic characters of several genotypes in new-type upland rice. The experiment was laidout in a Randomized Block Design with three replications. The rice seed used were 50 rice genotypes derived from the recurrent selection. Growth character observed were plant height, total tillers number, number of productive tillers, panicle length, number of filled grain, number of empty grain, flowering age, harvest age, the 1000 grains weight, and grain weight per hill. The results showed that the characters of the total number of tillers, productive tillers number, and fill grains number had a positive correlation and very significant on grain weight per hill were 0.58, 0.64, 0.53 respectively and significant positive correlation with time flowering and 1000-grains weight were 0.23 and 0.29 respectively. Other characters such plant height (0.06), total number of tillers (0.16), productive tillers number (0.59), panicle length (0.01), fill grains number (0.42), and 1000 grains weight (0.26) all directly and positively influenced the grain weight per hill, which character closely related to the yields. Plant characters such as plant height, productive tiller numbers, panicle length, filled grain number, and filled grain weight per hill was applied as selection criteria for developing of new-type of upland rice.

Keywords: correlation, path analysis, characters, new-type, upland rice

INTRODUCTION

Upland rice is a prospective crop as a supporting plant of national production, which has been dominated by lowland rice. In other words, upland rice cultivation is an effort to increase national rice production, due to many difficulties in lowland rice extensification. The development of upland rice cultivation being done through suboptimal land utilization, where more than 11 million hectares could be developed as upland rice fields in Indonesia. The national productivity of upland rice has been only 3.2 tons/ha, which has been lower than the productivity of lowland rice of 5.3 tons/ha (Statistics Indonesia, 2017). Lower productivity of upland rice being caused by varying climatic and soil conditions, applying lower cultivation technology in varieties, fertilization and blast disease control. Applying high adapted varieties has been one of the efforts for the national production.

Plant breeding in the effort of upland rice variety assemblings, in this case, using elder plant pool of wild rice relatives, which have tolerant genetic diversities to both abiotic and biotic stress. Sources of importantly plant breeding, selection, and evaluation techniques yield new improved varieties (Hairmansis et al., 2016). There have been several genetic resources to improve upland rice. Importantly, tolerance to both abiotic and biotic stresses, most of the agronomic quality of rice being obtained from the gene pool of local varieties.

Superior variety of rice types ideally expected to increase the upland rice yield. New-type of upland rice has been assembled through anther culture technique (Herawati et al., 2010), but the criteria for determining the desired character actually limited due to limited of the selected another. Modified agromorphological characters in upland rice have been developed through conventional breeding of recurrent selection (Herawati et al., 2017a). Necessarily, to modify the characteristics in order to assemble the new-type of upland rice, such as the panicle density above 150 filled grain per panicle, productive tiller numbers above 6, grain filling above 70 percent, plant hight below 150 cm, maturity age below 130 days, 10^0-15^0 flag leaf angle, the second and third leaves slightly drooped for a wider canopy, stem diameter above 0.7 cm (Herawati et al., 2010). Improved varieties of upland rice in dispensed these characteristics in order to increase plant yields and upland rice area.

The diversity of plant morphological characters has been crucial in determining the best method to improve the yield. These morphological characters are significantly important in relations to the yield potential that being used as an indirect selection criterion or a to enhance/magnify the variety in the new population. The genetic diversity plays an important aspect in which breeders always work (Gowane et al., 2013; Herawati et al., 2017a; Osundare et al., 2017; Pachauri et al., 2017).

The yield potential character means the complex character that strongly influenced by both growth and yield component character (Zhou et al., 2018; Ikeda et al., 2013). Both yield potential and yield component are controlled by many genes, which are strongly affected by environmental factors. Sravan et al. (2012) revealed that the system of breeding programs involved genetic diversity, and selected genotypes to develop prospective breeding lines. Plant breeders who assemble high yield plants rarely interested in just one character. So, learning about the relationship between yield and many other characters have been necessary (Agyei et al., 2012).

Several types of researches to examine relationships between characters on the basis of correlation illustrate the closeness of two traits (Aryana et al., 2011; Gupta et al., 2015; Osundare et al., 2017). The simple correlations coefficient is used to evaluate the relationship between each character. The correlation coefficient value ranged between -1 and 1 (Krualee et al., 2013). The positive correlation value between each character means the character increases yield with the increase of other character value. In contrast, a negative correlation value means the increased character value decreases other characters. Hussein and Hugo (2011), stated that path analysis helps to measure the indirect effect of one variable on other variables, through the separated correlation coefficient of both, directly and indirectly, influential variables. According to Zare et al. (2012), the yield potential means complex character being derived from several components in both positive and negative influences on the character. Accordingly, important contributions of each component greatly contributed to the yield potential. This research aims to determine the selected agronomic characteristic criteria for developing of new-types of upland rice genotypes through both correlation and path analysis.

MATERIALS AND METHODS

This research had been conducted from July to October 2017 in Rawa Makmur, Bengkulu, as well as in Crop Production Laboratory, Faculty of Agriculture, University of Bengkulu, Indonesia. The experiments were arranged in a Randomized Block Design (RBD) with three replications. The experiments used 50 rice genotypes derived from recurrent selection in the F3 generation, and early-stage screened to tolerate drought stress (Herawati et al., 2017b). Rice grain from 50 lines sown in plastic containers. After 21 days, the seedlings transplanted in the rice fields. Each genotype number planted in two rows, 20 seedlings in each row. Plants fertilized with 200 kgha^{-1} Urea, 100 kgha^{-1} SP36, and 100 kgha^{-1} KCl. The observation of agronomic characters are plant height (cm), total tiller numbers, productive tiller number per hill (stem), flowering age (day after planting), maturity age (day after planting), grain numbers per panicle (grain), filled grain numbers per panicle (grain), 1.000 grain weight (g), and weight of filled grain per hill (g). The effects of agronomic character on grain weight per hill analyzed by both correlation and path analysis. Genotypic correlations calculated by the formula as:

$$r_{g(xixj)} = \frac{cov.g(xixj)}{\sqrt{\sigma^2_{g(xi)}.\sigma^2_{g(xj)}}}$$

cov.g(xixj) = genotypic covariance between i and j,
$\sigma^2_{g(xi)}$ = genotypic variance of character i,
$\sigma^2_{g(xj)}$ = genotypic variance of character j.

The significance of the correlation value between each character used t-test according to Singh and Chaudhary (2010), as follows:

$t = r\,[(n-2):(1-r^2)]^{1/2}$ where, t = obtained value compared with t student, df=degree of freedom (n-2), r = replication, n = observed population. Path coefficient analysis to determine the direct and indirect effects of agronomic characters, based on the following equation (Singh and Chaudary 2010):

$$\begin{bmatrix} r_{11} & r_{12} \ldots r_{1p} \\ r_{21} & r_{22} \ldots r_{2p} \\ \ldots & \ldots \\ r_{p1} & r_{p2} \ldots r_{pp} \end{bmatrix} \begin{bmatrix} c_1 \\ c_2 \\ \ldots \\ c_p \end{bmatrix} = \begin{bmatrix} r_{1y} \\ r_{2y} \\ \ldots \\ r_{py} \end{bmatrix}$$

Rx Ci Ry

Based on the above equation, the C_i value (directed influence) calculated by the formula:

$C_i = R_x$-1.R_y, where;

R_x = correlation matrix between independent variables,
R_{x-1} = inverse matrix Rx
C_i = cross coefficient vector which shows the direct influence of any free variable that standard to the non-free variable
R_y = vector coefficient of correlation between free variables X_i = (i = 1,2, ... p)

RESULTS AND DISCUSSION

Correlation Between Yield and Yield Components

The correlation between plant characters chose the rightly selected character. The pattern of relationships between the yield characters and yields were known from the correlations value. The correlation between each character presented in Table 1. The plant height positively correlated to the filled grain (0.32) and positively correlated to the empty grain number (0.43), but inversely proportional to both productive tiller number (-0.24) and maturity age (-0.23). The data shows that the increased plant height will increase the filled grain number, but the higher the plant height higher the empty grains. Limited photosynthate for grain filling due to most of the photosynthates is partitioned for the vegetative plant. Although the higher the plant height positively correlated with filled grains per panicle, the selection is based on the plant high character needs to be considered due to the plant height related to the plant lodges which limited the yield. Peng et al. (2008) reported that plant height and leaf width are the characters associated with lodge resistance, nutrient content and, the efficiency of photosynthetic.

Total tiller number positively correlates to the productive tiller numbers (0.95) indicates the observed total productive tillers, according to the desired criteria of new types of upland rice which tiller numbers are all productive (Khush, 2013). The productive tiller numbers positively correlated to panicle length (0.29), flowering age (0.35), maturity age (0.31), and significantly affected the grain weight per hill (0.64). The panicle length positively correlated to both the empty grain numbers and the flowering age. However, the panicle length negatively correlated to the 1000 grain weights. Increasing the number of filled grains per panicle will significantly increase grain yield per hill. The results of this study are also shown in the study of Yang et al. (2007) on a new type of upland rice. On the contrary, increased un-fill grains per panicle can decrease grain yield per hill. This is indicated by the negative correlation value (-0.08). A large number of grains per panicle followed by filling grain at a high panicle will increase grain yield. Panda et al. (2015) have reported that the sucrose synthase

(SUS3) enzyme actively involved in the seed filling period, increased spikelets density of panicle affected SUS3 expressions in the basal spikelets.

The characters such total tiller numbers, productive tiller numbers, and filled grain numbers positively correlated to the grain weight per hill, and the panicle length, flowering age and 1000 grain weight. Thus, all five characters could be used as selected criteria to increase grain yield. According to Gomez and Gomez (2002) and Matchik and Sumertajaya (2002), the correlation value between the two characters approached -1 or +1, closer relationship between two characters. The more positively correlation coefficient indicated that, the greater the value of the variable the greater the yield. In contrast, the smaller the value, the lower the yield in drought stress conditions. The negative correlation coefficient value showed the greater the value, the lower the yield of grains obtained.

The increased 1,000-grain weights followed by increased of yield per hill shows by the positive correlations value. The 1,000-grain weight relates to the grain both size and level of un-filled such the larger the filled grain would, the higher the 1000 grain weight. Overall, increased yield per hill obtained by increased total tiller number, productive tiller numbers, panicle length, filled grain number per panicle, and 1000 grain weight, but inversely related to both plant height and empty grain number (Table 1).

The higher the flowering age, the longer the maturity age, indicating the positive correlations value (0.58). The plant characteristics determine the flowering age due to the plant growth determines the vegetative phase. Reproductive phase of rice in the tropics actually 65 days consisted of a 35-day generative phase and a 30-day maturation phase (IRRI, 2008).

Path Analysis to Determine the Effect of Characters on Yields

Characters correlated to the yields (Table 1) were used as a selected character for new-types of upland rice. Path analysis determines growth characters, either directly or indirectly, influenced the yield (Singh and Chaudhary, 2010). So, the path analysis aims to find out the correlation coefficients of either direct or indirect effects. Based on the path analysis (Table 2), plant height, the total number of tillers, productive tiller numbers, panicle length, filled grain weight per panicle, and the 1000 grains weight directly and positively affected the grain weight per hill. Productive tiller numbers, fill grain number per hill, and the 1000 grain weight highly and positively influences the grain weight per panicle respectively 0.59, 0.42, and 0.26. This result shows that the three variables contribute significantly to the yield.

The path analysis creates a path diagram with the one-way causal model. Based on the path analysis results in Table 2, the path diagram of characters influences the yields. If the character that has a direct influence coefficient is low on yield, it is important to pay attention to the value of the character's influence on the yield indirectly through other characters (Singh and Chaudhary, 2010). Characters that do not affect yields through other characters are chosen which have an indirect effect coefficient above 0.09.

The plant height character indirectly and negatively affected the productive tiller numbers with the coefficient value of -0.14. This data has shown that the higher the plant height variable will reduce the formation of productive tillers. However, precisely the plant height increases the filled grain number per panicle by 0.14 (Figure 1).

The total number of tillers affected the productive tiller numbers with a coefficient of 0.56. The coefficient value indicated that almost all of the planted tillers in the genotypes produced panicles. The character of new-type rice clearly with the tiller number more than 12, which were all productive (Herawati et al., 2010; Khush, 2013). The productive tiller numbers per hill have become a character that is used as a selected criterion in order to improve the yield of new-type rice. Reference Peng et al. (2008) at least 330 productive tillers per m^2 (10-14 crops per hill) to increase 10% yield potential in wetland rice.

The high productive tiller number affected by the flowering age and indirectly by maturity age respectively of 0.21 and 0.18. The figure shows that the higher the plant maturity age led to the more prolonged the vegetative period and the chance to form more tillers. However, the tiller numbers depended on the plant ability to produce photosynthate. Khush (2013) revealed that in order to increase the yield potential, the rice increased the biomass production with the harvest index that responsive to nitrogen fertilization, resistant to lodge, and photosynthate partition.

The panicle length showed a negative coefficient value to the 1000 grain weights. The data shows the longer the panicle led to the smaller the grain and the lower the grain yield per hill. This data shows that the longer panicle led to smaller the grain size which causes a decrease in grain yield per hill. Das et al. (2018) revealed that grain filling poorly subjected to the expression of recessive allele for high ethylene production, but the allele being amenable for suppression to the dominant allele in genetic breeding. Based on the path analysis, the residual of 0.47 indicated that other effect on the grain yield could not be explained through this research. Further researches being required in order to explain the relationship between grain yield and morpho-physiological properties such as leaf angle, and selections to drought and resistance to blast disease.

Determination of Selection Characters of Rice Genotype for Developing of New Type of Upland Rice

Correlation between any characters was used as an indirect selection for the main characters so that some information obtained from this research determines the selection character for new-type of upland rice (Table 3). This research found that the yield of new-type of upland rice predicted several characters effect on plant yield such plant height, productive tiller numbers, panicle length, grain number per panicle, and grain weight per hill. Herawati et al. (2010) developed some criteria for new-type of upland rice by modified the characters of new-type rice, big panicle (> 150 grain per panicle), productive tillers (> 6), filled grain > 70%, plant height below 150 cm, short maturity age (less than 130 days), 10^0-15^0 flag leaf angle, the second and third leaves slightly drooped to allow the plant canopy wider, stem diameter > 0.7 cm. The characteristics of new-type upland rice are presented in the selected genotype as Table 3.

Plant height and productive tillers have been an agronomic character as a specific identity of a genotype. The standard of plant height, which IRRI specified in the new-type rice has been at least 100 cm (Peng et al., 2008). While the characteristics of the ideal plant according to Ma et al. (2006) was a plant height of 115-120 cm. These criteria prepared 8 selected genotypes with plant height close to ideal for new-type rice (110-125 cm). Productive tiller numbers, which > 12 filled grain clearly with opportunity for higher yields, this could be seen from the direct effect of the number of productive tillers of 0.59 on the grain weight per hill (Table 2). According to Peng et al. (2008) the number of productive tillers at least 330 tillers per m^2 (10-14 tillers per hill) in order to increase 10% of yield potential in lowland rice.

The panicle length ranges between 30-36 cm presented 31 selected genotypes (Table 3). Although the panicle length effects with a value of 0.01, however, it is necessary to consider indirect effects through productive tillers of 0.17 (Figure 1). Long panicles allow the formation of many panicles, but an insufficient supply of photosynthates from leaves increases the empty grains. Kobata and Iida (2004) showed that lower filled grains in new-type rice attributed to lower efficiency of the assimilate partition from the plant leaf to the grains. Virk et al. (2004) developed a new-type rice strategy on panicle length for 150 grains per panicle. Furtherly, Peng et al. (2008) confirmed that the number of panicles per m^2, the percentage of grain filling, total biomass and harvest index were required for new-type rice. Moreover, Khush (2013) reported that poor grain filling of new plant type line was attributed to lack of apical dominance within a panicle, compact arrangement of spikelets and a limited number of large vascular bundles for assimilating transport to grains. Increased grain fillings after the grain disposal prepared with high photosynthetic rates, increased biomass production, aging of leaf and root (Wei et al., 2016).

Based on the information from path analysis, the filled grain number per panicle highly direct the effect on grain yield as 0.42 (Figure 1). The filled grain number per panicle became one of the important characters to be used as a selected criterion concerning higher grain yield. Selected genotypes filled grain numbers per panicle of 160-200 and grain weight of 25-38 gram per hill (Table 3). Zhengjin et al. (2005) developed the ideal rice, which criteria of the grain numbers per panicle higher than 160 grains, while Virk et al. (2004) developed new-types rice, which character of the filled grain of 150 grains per panicle. The selected genotypes in this F4 generation expected to produce new-superior genotypes on the next generation.

CONCLUSION

The characters of the total number of tillers, productive tillers number, and fill grains number had a positive correlation and very significant on grain weight per hill were 0.58, 0.64, 0.53 respectively and significant positive correlation with time flowering and 1000 grains weight were 0.23 and 0.29 respectively. Other characters such as plant height (0.06), total number of tillers (0.16), productive tillers number (0.59), panicle length (0.01), fill grains number (0.42), and 1000 grains weight (0.26) all directly and positively influenced the grain weight per hill, which character closely related to the yields. Plant characters such plant height, productive tiller numbers, panicle length, filled grain number, and filled grain weight per hill was applied as selection criteria for developing of new-type of upland rice.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

ACKNOWLEDGMENT

Acknowledgments and appreciations to the Indonesian Ministry of Research, Technology and Higher Education of Republic of Indonesia, Directorate for Research and Community Service which funded this research through National Strategic Research in the 2018 budget year (Contract number 584 / UN30.15 / LT / 2018).

AUTHOR CONTRIBUTIONS

All authors contributed equally in all parts of this research.

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Table 1. The Coefficient Correlations of Agronomical Characters of Upland Rice Lines

Characters	PH	TNT	PTN	PL	FG	UFG	TF	TH	1000W	GWH
PH	1	-0.25*	-0.24*	0.14	0.32*	0.43**	0.04	-0.23*	-0.03	-0.06
TNT		1	0.95**	0.28*	0.03	0.15	0.34*	0.35*	-0.25*	0.58**
PTN			1	0.29*	0.09	0.19	0.35*	0.31*	-0.2*	0.64**
PL				1	-0.00	0.37*	0.27*	0.12	-0.43**	0.03*
FG					1	0.09	0.21*	0.07	0.24*	0.53**
UFG						1	0.04	0.05	-0.31*	-0.08
TF							1	0.58**	-0.1	0.23*
TH								1	-0.48**	0.01
1000W									1	0.29*
GWH										1

PH = Plant Height; TNT=Total Number of Tillers; PTN = Productive Tiller Number; PL = Panicle Length; FG = Filled Grain per Panicle; UFG = Unfilled Grains per Panicle; TF=Time of Flowering; TH = Time of Harvest; 1000W = 1,000 Grain Weight; GWH= Grain Weight per Hill
** and ** = significantly different at P < 0.05 and P < 0.01*

Table 2. The Direct and Indirect Effect of Some Agronomic Characters on the Yield

Charac Ters	Direct effects	Indirect effects								
		PH	TNT	PTN	PL	FG	UFG	TF	TH	1000W
PH	0.06	-	-0.02	-0.01	0.01	0.02	0.03	0.00	-0.01	-0.002
TNT	0.16	-0.04	-	0.15	0.05	0.00	0.02	0.05	0.06	-0.04
PTN	0.59	-0.14	0.56	-	0.17	0.06	0.11	0.21	0.18	-0.12
PL	0.01	0.001	0.003	0.003	-	-0.00	0.004	0.003	0.001	-0.004
FG	0.42	0.14	0.01	0.04	-0.001	-	0.04	0.08	0.03	0.09
UFG	-019	-0.09	-0.03	-0.04	-0.07	-0.02	-	-0.007	-0.01	0.06
TF	-0.05	-0.002	-0.017	-0.02	-0.01	-0.01	-0.002	-	-0.03	0.005
TH	-0.08	0.02	-0.03	-0.02	-0.01	-0.01	-0.004	-0.04	-	0.04
1000W	0.26	-0.01	-0.07	-0.05	-0.11	0.06	-0.08	-0.03	-0.13	-

PH = Plant Height; TNT=Total Number of Tillers; PTN = Productive Tiller Number; PL = Panicle Length; FG = Filled Grain per Panicle; UFG = Un-filled Grains per Panicle; TF=Time of Flowering; TH = Time of Harvesting; 1000W = 1,000 Grain Weight; GWH= Grain Weight per Hill

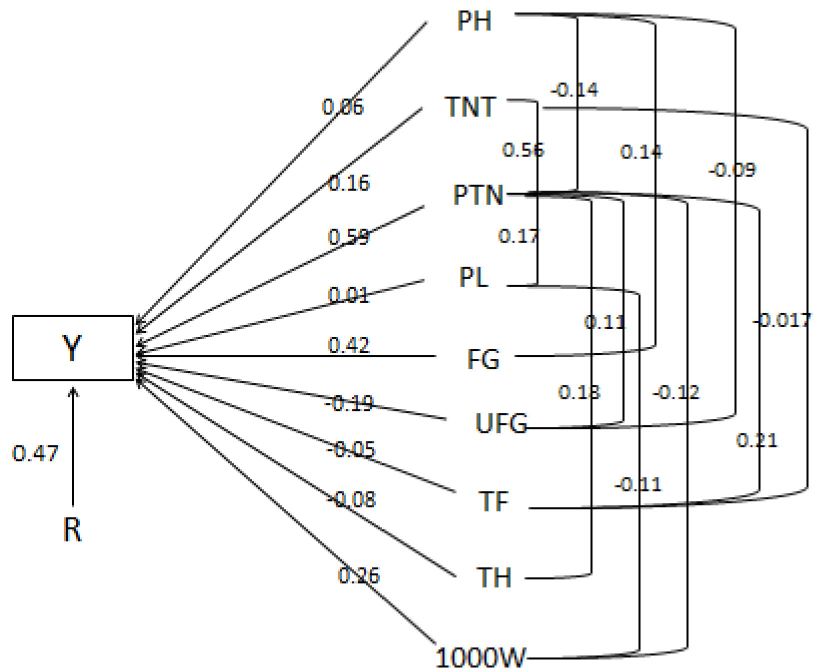

Figure 1. Path Analysis of Some Characters which Directly and Indirectly Affected the Yields

Table 3. Determination of Selection Characters of Rice Genotype for New Type of Upland Rice

Characters	Genotype	Range	Mean
Plant Height (cm)	G29, G50, G49, G38, G46, G25, G44, G45	110-125	120.2
Productive tillers number	G23, G24, G22, G40, G14, G28, G48, G25, G44, G17, G33, G9, G28, G45, G21, G36, G7	12-18	13.9
Panicle length (cm)	G25. G21, G42, G17, G14, G3, G28, G22, G1, G44, G23, G35, G50, G36, G12, G31, G18, G13, G46, G9, G19, G39, G47, G41, G16, G2, G4, G7, G6, G11, G24	30-36	30.87
Number of fill grains	G5, G11, G3, G10, G14, G15, G20, G36, G4, G19, G24, G13, G40	160-200	171.2
Grains Weight per tiller (g)	G14, G24, G40, G10, G44, G23, G29, G28, G45, G25,	25-38	29.5

	G33		

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by Ruli Hati

Submission date: 12-Apr-2018 10:54AM (UTC+0700)
Submission ID: 945362704
File name: NASKAH_SABRAO2_Eng_masdar1.docx (63.58K)
Word count: 3633
Character count: 20179

CORRELATIONS AND PATH ANALYSIS TO DISTINGUISH THE SELECTION CHARACTERS ON NEW-TYPE UPLAND RICE

Correlationship between growth characters and yields substantially efforted to distinguish the right character selection. Other method called path analysis could be used in order to determine influential characters, either directly or indirectly, to the plant yield. The method could sort the correlation coefficients into path-coefficient components. This research aimed to determine the selection criteria in agronomic characters of several genotypes in new-type upland rice, through the correlation analysis and path analysis. The experiment was conducted from July to October 2017 in Kelurahan Rawa Makmur Bengkulu City and Plant Cultivation Laboratory, Faculty of Agriculture, University of Bengkulu. The experiment applied a Randomized Block Design (RBD) with three replications. The rice seed used were 50 rice genotypes of repeated cross-selection in the F3 generation. Growth character observed were plant height, total tillers, number of productive tillers, panicle length, number of filled grain, amount of empty grain, flowering age, harvest age, the 1000 grain weight, and grain weight per hill. The experimental results shown that the character of productive tillers positively correlated with panicle length (0.29), flowering age (0.35), harvest age (0.31), and significantly affected the grain weight per hill (0.64). Other characters such plant height, total tiller numbers, productive tiller numbers, panicle length, filled grains number per panicle, and the 1000 grain weights all directly and posistively influenced the grain weight per hill, which character closely related to the yields. Plant characters such plant height, productive tiller numbers, panicle length, filled grain number, and filled grain weight per hill were applied as selection criteria for new-type upland rice.

Key words: Correlation, path analysis, characters, new-type upland rice

Key findings:

The plant yield potential meant a complex characters positively or negatively determined by many components. Accordingly, the contribution of each component selected from the plant characters that mostly contributed to the yield potential. This research aimed to choose selected criteria by correlation and path analysis on agronomic characters of new-type upland rice.

INTRODUCTION

Upland rice is a prospective crop as a additional supporting plant of national production, which has been dominated by lowland rice. In other word, upland rice cultivation is an additional effort to increase national rice production, due to difficulties in lowland rice extensification. The development of the upland rice cultivation being done through the sleeping land utilization, which over 11 million ha could be potentially developed as upland rice fields (Puslitbangtan, 2006). The national productivity of upland rice is currently only 3.2 tons / ha, which is lower than the productivity of lowland rice of 5.3 tons / ha (Directorate General of Food Crops, 2017). Low productivity of upland rice could caused by varying climatic and soil conditions, applies under-optimal cultivation technology like improved varieties, fertilization and blast disease control (Toha, 2005). Applies high adapted varieties has been one of the other efforts for the national production constrains.

Plant breeding in the effort of upland rice varieties assemblings, in this case, using the elders of the cultivated plant pool of wild rice relatives which have the tolerant genetic diversities of both abiotic and biotic stress. Sources of these important properties combined plant breeding, selection, and evaluation techniques to produce the new improved varieties (Hairmansis, 2016). There have been several genetic resources to improve upland rice. Important traits such as tolerance to both abiotic and biotic stresses, agronomic properties and quality of rice, most of which being obtained from the Oryza sativa gene pool of local varieties. Barus (2008) said that local upland rice which a long life (150-180 days), higher posture (> 150 cm), fewer tillers (<8 bars), with mid number of panicles, light green leaf color. The plant response rate tends relatively low to N fertilization, harvest index of 0.3 with highly adaptive to any environments.

Superior rice varieties types ideally expected to increase the upland rice yield potential. New-type upland rice assembled through anther culture technique (Herawati, et al., 2010;), but the criteria for determining the desired character actually limited due to limited selected anther culture. Modified agromorphological characters in upland rice developed through conventional breeding of recurrent cross-method (Herawati, et al., 2017). It has been necessary to modify the characteristics in order to assemble the new-type upland rice, such as the panicle density (> 150 filled grain per panicle), productive tiller numbers (> 6), seed filling > 70%, plant hight below 150 cm, maturity age (below 130 days), 10^0-15^0 flag leaf angle, the second and third leaves slightly drooped for a wider canopy, stem diameter > 0.7 cm (Herawati et al., 2010). Improved varieties of upland rice indispensed these characteristics in order to increase both yields and the area of rice crops in dry land.

The genetic diversity of plant morphological characters really crucial in determining the best method to improve the yield potential. The knowledge of these morphological characters significantly important related to the yield potential, they could be used as an indirect selection criteria or a guide to enhance / magnify the appearance of varieties in the new population. The population genetic diversity plays important aspect in which breeders always work (Gowane et al., 2013; Herawati et al., 2017, Osundare et al., 2017; Pachauri et al., 2017).

According to Muhamad (2010), the yield potential character means a complex character that strongly influenced by both the growth yield component character. Both the yield potential and yield component controlled by many genes, which are strongly affected by environmental factors. Sravan et al. (2012) revealed that the system of breeding programs involved selected genetic diversity, and selected genotypes to develop prospective breeding lines. Plant breeders who assemble high yields plants rarely interested in just one character. So, it has been necessary to learn about the relationship between yield and many other characters (Agyei et al., 2012).

Several research conducted to examine relationships between characters on the basis of correlations illustrated the closeness of two traits relationships (Aryana et al. (2011: Gupta et al, 2015, Osundare et al., 2017) The simple correlation coefficient used to evaluate the relationship between characters. The correlation coefficient value ranged between -1 and 1 (Krualee et al., 2013). The positive correlation value between characters means the character increased yield with increase of another character value. In contrast, the negative correlation value meant the increased character value caused decreased other characters. Hussein et al. (2011), stated that path analysis helped to measure the indirect effect of a variable on other variables, through the separated correlation coefficient from both direct and indirect of most influential variables. According to Zare et al. (2012) the yield potential meant complex character derived from several components in both positive and negative influence on the character. Accordingly, the important calculated contribution of each component known that the character greatly contributed to the yield potential. This research aimed to determine the selected agronomic character criteria of several new-type upland rice genotypes through both correlation and path analysis.

MATERIALS AND METHODS

The Research being conducted from July to October 2017 at Rawa Makmur, Bengkulu and Plant Cultivation Laboratory, Faculty of Agriculture, University of Bengkulu. The experiment used a Randomized Block Design (RBD) with three replications. The rice seed used 50 rice genotypes from repeated cross-selection in the F3 generation and early stage screened of tolerated drought stress (Herawati et al., 2017). Rice seed from 50 strains sown in plastic containers mud. After 21 days, the seedlings transplanted in the rice fields. Each genotype number planted in two rows, 20 seedlings in each row. Plants fertilized with 200 kg / ha Urea, 100 kg / ha SP36, and 100 kg / ha KCl. The agronomic character such plant height (cm), total number of tillers per hill, productive tiller number per hill (stem), flowering age (days after planting), harvest age (day after planting), grain of content per panicle (grain), number of grain of hollow of permalai (grain), 1.000 grain weight (g), and weight of filled grain per hill (g). The effects of agronomic character on grain weight per hill analyzed by both correlation and path analysis. Genotypic correlations calculated by the formula: $r_{g(xixj)} = \dfrac{kov.g(x_i x_j)}{\sqrt{(\sigma^2_{g(xi)}\sigma^2_{g(xj)})}}$

in this case, kov. g (xixj) = genotypic uniform between i and j,

g(xi) = genetic variant of character i, g(xj) = genetic variant of character j.

The significance of correlation value between characters used t-test according to the formula of Singh and Chaudhary (2010), as follows: t = r [(n-2): (1-r2)] $^{1/2}$ where, t = obtained value compared with t student, db = (n-2), r = replication, n = observed population. Path coefficient analysis used to distinguish the direct and indirect effects of agronomic characters, based on the following equation (Singh and Chaudary 2010):

$$\begin{bmatrix} r_{11} & r_{12}\ldots r_{1p} \\ r_{21} & r_{22}\ldots r_{2p} \\ \ldots\ldots & \ldots\ldots \\ r_{p1} & r_{p2}\ldots r_{pp} \end{bmatrix} \begin{bmatrix} c_1 \\ c_2 \\ \ldots \\ c_p \end{bmatrix} = \begin{bmatrix} r_{1y} \\ r_{2y} \\ \ldots \\ r_{py} \end{bmatrix}$$

Rx Ci Ry

Based on the above equation, the Ci value (directed influence) calculated by the formula: Ci = Rx-1Ry, where, Rx = correlation matrix between independent variables, Rx-1 = inverse matrix Rx

Ci = cross coefficient vector which shown the direct influence of any free variable that standarded to the non-free variable

Ry = vector coefficient of correlation between free variables Xi = (i = 1,2, ... p)

RESULTS AND DISCUSSION

Correlations between Yield and Yield Components Characters

The correlation relationships between crop characters crucially chose the right selected character. Pattern of relationships between the yield characters and yields known from the correlation value. The correlation between the characters presented in Table 1. The plant height positively correlated with the filled grain (0.32) and positively correlated with the empty grain number (0.43), and inversely proportional to productive tiller number (-0.24) and harvest age (-0.23). This data shown that the increase of crop height increased the filled grain number, but higher increase rate of the plant height precisely caused the empty seeds. The limited fotosintat that fills the seeds due to most of the photosynthate partitioned for vegetative parts. Although the higher the plant height significantly and positively correlated with filled seeds per panicle, the selection based on the necessarily plant high character due to the plant height related to the plant lodges which limited the yield.

The total tiller number positively correlated and closed to 1 with the productive tiller numbers (0.95) indicated that the observed total tiller nearly meant productive tillers, accorded to the desired criteria of new types of upland rice which tiller numbers meant productive tiller numbers (Khush, 2013). The productive tiller numbers positively correlated with panicle length (0.29), flowering age (0.35), harvest age (0.31), and significantly affected the grain weight per hill (0.64). The panicle length positively correlated with both the number of empty grains and the flowering age. However, the panicle length negatively correlated with the 1000 grain weights. The increased of filled grain number per panicle significantly increased yields per hill. The results of this research shown in the other research of Yang et al. (2007) on new types of upland rice. In contrast, the increased empty grain per panicle decreased the yield per hill with negative correlation value (-0.08). The higher the grain number per panicle followed by higher filled grain number per panicles increased yield per hill. Panda et al. (2015) has reported that the sucrose synthetasic (SUS3) enzyme actively involved in the seed filling period, increased spikelets density of panicles affected *SUS3* expressions in the basal spikelets.

The characters such total tiller numbers, productive tiller numbers, and filled grain numbers positively correlated to the grain weight per hill, and the panicle length, flowering age and 1000 grain weight. Thus, all five characters could be used as selected criteria to increase grain yield. According to Gomez and Gomez (2002) and Matchik and Sumertajaya (2002), the correlation value between two characters approached -1 or +1, closer relationship between two characters. The more positively correlation coefficient indicated that the greater the value of the variable the greater the yield. In contrast, the smaller the value the lower the yield with some drought stress conditions. The negatively correlation coefficient value showed the greater the value the lower the yield.

The increased of 1,000 grain weights followed by increased of yield per hill, shown by the positive correlation value. The 1,000 grain weight related to the grain both size and filledness such larger and filled grain would higher the 1000 grain weight. Overall, the increased yield per hill obtained by increased total tiller number, productive tiller numbers, panicle length, filled grain number per panicle, and 1000 grain weight, but inversely related with both plant height and empty grain number (Table 1).

The higher the flowering age the longer the harvest age, indicated by the positive correlation value of (0.58). The plant character determined by the flowering age due to the plant growth determined by vegetative phase. While, the reproductive phase of rice crops in the tropics actually 65 days consisted of a 35-day generative phase and a 30-day maturation phase (IRR, 2008)

Path Analysis to Distinguish Influential Variables on Yields

Characters correlated with the yields (Table 1) used as a selected character for new-type upland rice. Path analysis could determine which characters either directly or indirectly influenced the yield (Singh and Chaudhary, 2010). So, the path analysis aimed to find out the correlation coefficients into the path analysis coefficient components measured both direct and indirect effects. Based on the path analysis (Table 2), plant height, total tillers, productive tiller numbers, panicle length, filled grain weight per panicle, and the 1000 grains weight directly and positively affected the grain weight per hill. Productive tiller numbers, filled grain number per hill, and the 1000 grain weight greatly and positively impacted the of grain weight per panicle respectively 0.59, 0.42, and 0.26. The data suggested that three variables substantially contributed to the yield per hill.

The path analysis created a path diagram with one-way causal model. Based on the path analysis results in Table 2, the path diagram of characters influenced the yields. In the case of characters lowered on the direct effect coefficient on the yield, so the value of the character's indirectly influenced the yield through other characters (Singh and Chaudhary, 2010). Characters with no effect on yields through other character, chose characters with indirected effect coefficient values of > 0.09.

The plant height character indirected and negatively affected the productive tiller numbers with the coefficient value of -0.14. This data shown that increasingly higher crops decreased the productive tiller numbers. However, the plant height variables increased the filled grain number per panicle of 0.14 (Figure 1).

The total tiller number affected the productive tiller numbers with the coefficient of 0.56 which indicated that almost all of the planted tillers in the genotypes produced panicles which meant the character of the new-type rice with the tiller number above 12, which all meant productive tillers (Herawati et al., 2010; Khush, 2013). The productive tiller numbers per hill has become a character that could be used as a selected criterion in order to improve yield on new-type rice. According to Peng et al. (2008) to increase 10% yield potential in wetland rice then at least 330 productive tillers per m^2 (10-14 crops per hill)

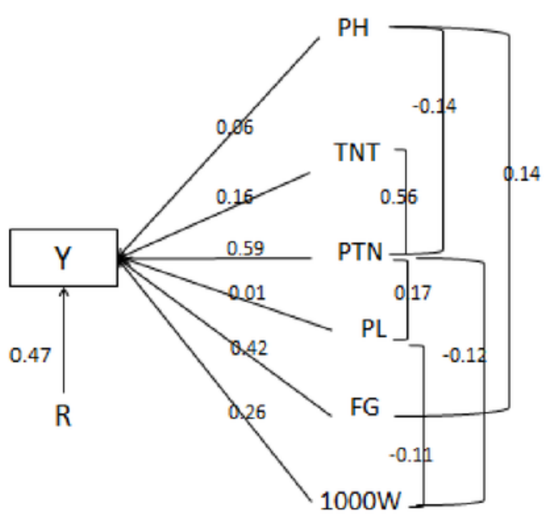

Figure 1. Path Analysis of Some Characters Which Directly and Indirectly Affected the Yields of Rice Crops

The increased productive tiller number affected by the flowering age and indirectedly by harvest age respectively of 0.21 and 0.18. This figure shown that the longer the plant life led to the longer the vegetative period and the higher the tiller number per hill. However, the tiller numbers depended on the plant ability to produce photosynthate. Khush (2013) revealed that in order to increase the yield potential, the rice increased the biomass production which the harvest index responsive to nitrogen fertilization, resistant to falling, and photosynthate partition.

The panicle length showed negative coefficient value to the 1000 grain weights. The data shown that the longer the panicle led to the smaller the grain the lower the grain yield per hill. Dea et al. (2018) revealed that grain filling in compact-panicle rice poorly subjected to the expression of recessive allele for high ethylene production, but the allele being amenable for suppression with corresponded dominant allele in a genetic breeding. Based on the path analysis, the residual of 0.47 indicated that presented other effect on the grain yield which could not explained in this research of 47 percent. Further researches being required in order to explain the relationship between grain yield and morpho-physiological properties such as leaf angle, and selections of drought and resistance to blast disease.

Determination of New-Type Upland Rice Selection Characteristics

Correlationships between any characters were used as an indirect selection for the main characters, so that the information obtained from this research referred to determine the selection character for new-type upland rice (Table 3). This research found that the new-type upland rice yield predicted several characters directed the effect on plant yield such plant height, productive tiller numbers, panicle length, grain number per panicle, and grain weight per hill. Herawati et al. (2010) developed criteria for new-type upland rice by modified the characters in new-type rice, big panicle (> 150 grain per panicle), all productive tillers (> 6), filled seed > 70%, plant height lower than 150 cm, short harvest age (less than 130 days), 10^0-15^0 flag leaf corner, the second and third leaves slightly drooped to allow the plant canopy to be wider, stem diameter > 0.7 cm. The character of new-type rice presented in the selected genotype as Table 3.

Table 3. Determination of Selection Characters of Rice Genotype for New Type Upland Rice

Characters	Genotype	Range	Mean
Plant Height (cm)	G29, G50, G49, G38, G46, G25, G44, G45	110-125	120.2
Productive tillers number	G23, G24, G22, G40, G14, G28, G48, G25, G44, G17, G33, G9, G28, G45, G21, G36, G7	12-18	13.9
Panicle length (cm)	G25. G21, G42, G17, G14, G3, G28, G22, G1, G44, G23, G35, G50, G36, G12, G31, G18, G13, G46, G9, G19, G39, G47, G41, G16, G2, G4, G7, G6, G11, G24	30-36	30.87
Number of fill grains	G5, G11, G3, G10, G14, G15, G20, G36, G4, G19, G24, G13, G40	160-200	171.2
Grains Weight per tiller (g)	G14, G24, G40, G10, G44, G23, G29, G28, G45, G25, G33	25-38	29.5

Plant height and productive tillers have been substantial agronomic character as spesific identity of a genotype. The standard of plant height which IRRI specified in the new-type rice was at least 100 cm (Peng et al., 2008), while the characteristics of the ideal plant according to Ma et al. (2006) at plant height was 115-120 cm. Based on these criteria prepared 8 selected genotypes with plant height close to ideal on new-type rice (110-125 cm). Productive tiller numbers > 12 with opportunity to produce filled grain in higher yields. The data showed the direct effect on the productive tiller numbers as 0.59 to the grain weight per hill (Table 2). According to Peng et al. (2008) in order to increase 10% of yield potential in wetland rice then the number of productive tillers met at least 330 tillers per m^2 (10-14 tillers per hill).

The panicle length ranged of 30-36 cm presented in 31 selected genotypes (Table 3). Although the panicle length directed effects with a value of 0.01, it was considered the indirect effect on the productive tillers of 0.17 (Figure 1). Longer panicles allowed more formed panicles. However, insufficient supply of photosynthates from leaves higher the formed empty grains. Kobata and Iida (2004) showed that lower filled seed in new-type rice attributed to the lower efficiency of the asymilate partition from the leaf to the seed. Virk et al. (2004) developed a new-type rice strategy on panicle length and 150 grains per panicle. Furtherly, Peng et al. (2008) confirmed that the number of panicles per m^2, the percentage of seed filling, the total biomass and the harvest index required for new-type rice. Moreover, Khush (2013) reported that poor grain filling NPT line was attributed to lack of apical dominance within a panicle, compact arrangement of spikelets and limited number of large vascular bundles for assimilate transport to grains. Increased seed fillings after the seed disposal done with high photosynthetic rates, increased biomass production, deferred aging of leaf and root (Wei et al., 2016).

Based on the information obtained from path analysis, the filled grain number per panicle highly direct the effect on yield as 0.42 (Figure 1). The filled grain number per panicle became one of the important characters to be used as a selected criterion in relation to higher grain yield per hill. Selected genotypes with the filled grain numbers per panicle of 160-200 and grain weight of 25-38 gram per hill (Table 3). Zhengjin et al. (2005) developed an ideal rice with the criteria of the grain numbers per panicle of more than 160 grains, while Virk et al. (2004) developed new-types rice with the character of filled grain of 150 grains per panicle. The selected genotypes in this F4 generation expected to produce new-superior genotypes on the next generation.

CONCLUSION

The character of productive tiller numbers positively correlated with panicle length (0.29), flowering age (0.35), harvest age (0.31), and highly-significant affected the grain weight per hill (0.64). The character of the total tiller numbers, the productive tiller numbers, and the filled grain numbers positively correlated and the grain weight per hill, and positively correlated with the panicle length, flowering age and the 1000 grain weight. Characteristic of plant height, total tiller numbers, productive tiller numbers, panicle length, filled grain numbers per panicle, and the 1000 grain weights directly and positively impacted on grain weight per hill, which closely related to the yields. Characteristic of plant height, productive tiller numbers, panicle length, filled grain number per panicle, and filled grain weight per hill used as selected criteria for new-type upland rice.

ACKNOWLEDGMENT

Acknowledgments and appreciations to the Indonesian Ministry of Research, Technology and Higher Education which funded this research through the National Strategic Research, year of 2018 budget (Contract number ....).

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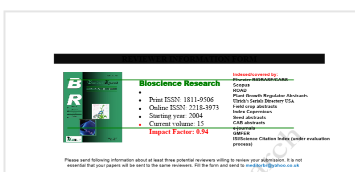

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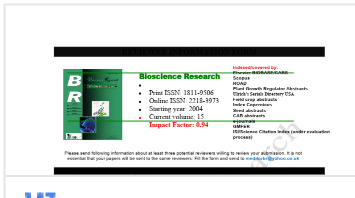

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- Print ISSN: 1811-9506
- Online ISSN: 2218-3973
- Starting year: 2004
- Current volume: 15
- **Impact Factor: 0.94**

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Reviewer # 2	
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Affiliation & Position healed	Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India
Specialization	Plant Breeding
Email (**compulsory**)	mraoiari@gmail.com

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RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2019 16(2): 000-000. **OPEN ACCESS**

Correlations and path analysis to determine the selection characters for developing new-type of upland rice

Reny Herawati*[1], Masdar[1], and Alnopri[1]

[1]Department of Agroecotechnology, Faculty of Agriculture, University of Bengkulu, Bengkulu, **Indonesia**. 38371.

***Correspondence:** reny.herawati@unib.ac.id **Accepted:** 13 Dec. 2018 **Published online:** 00 April. 2019

Correlation between growth characters and yields substantially efforted to determine the right character selection. Another method called path analysis could be used to identify essential traits, either directly or indirectly, to the crop yield. This research aimed to determine the selection criterion in agronomic characters of several genotypes in new-type upland rice. The experiment was laid out in a Randomized Block Design with three replications. The rice seed used was 50 rice genotypes derived from the recurrent selection. Growth character observed were plant height, total tillers number, number of productive tillers, panicle length, number of fill grain, number of empty grain, flowering age, harvest age, the 1000 grains weight, and grain weight per hill. The results showed that the characters of the total number of tillers, productive tillers number, and fill grains number had a positive correlation and very significant on grain weight per hill were 0.58, 0.64, 0.53 respectively and significant positive correlation with time flowering and 1000-grains weight were 0.23 and 0.29 respectively. Other characters such as plant height (0.06), total number of tillers (0.16), productive tillers number (0.59), panicle length (0.01), fill grains number (0.42), and 1000 grains weight (0.26) all directly and positively influenced the grain weight per hill, which character closely related to the yields. Plant characters such as plant height, productive tiller numbers, panicle length, filled grain number, and filled grain weight per hill was applied as selection criteria for developing of new-type of upland rice.

Keywords: correlation, path analysis, characters, new-type, upland rice

INTRODUCTION

Upland rice is a prospective crop as a supporting plant of national production, which has been dominated by lowland rice. In other words, upland rice cultivation is an effort to increase domestic rice production, due to many difficulties in lowland rice extensification. The development of upland rice cultivation has done through suboptimal land utilization, where more than 11 million hectares could develop as upland rice fields in Indonesia. The national productivity of upland rice has been only 3.2 tons/ha, which has been lower than the productivity of lowland rice of 5.3 tons/ha (Statistics Indonesia, 2017). Lower productivity of upland rice being caused by varying climatic and soil conditions, applying more inferior cultivation technology in varieties, fertilization and blast disease control. Applying high adapted varieties has been one of the efforts for the national production.

Plant breeding in the effort of upland rice variety assemblings, in this case, using the elder plant pool of wild rice relatives, which have tolerant genetic diversities to both abiotic and biotic stress. Sources of importantly plant breeding, selection, and evaluation techniques yield new, improved varieties (Hairmansis et al., 2016). There have been several genetic resources to improve upland rice. Importantly, tolerance to both abiotic and biotic stresses, most of the agronomic quality of rice obtained from the gene pool of local varieties.

A superior variety of rice types ideally expected to increase the upland rice yield. New-type of upland rice has been assembled through anther culture technique (Herawati et al., 2010), but the criteria for determining the desired character limited due to limited of the selected another. Modified agro-morphological characters in upland rice have been developed through conventional breeding of recurrent selection (Herawati et al., 2017). Necessarily, to modify the characteristics in order to assemble the new-type of upland rice, such as the panicle density above 150 filled grain per panicle, productive tiller numbers above 6, grain filling above 70 percent, plant hight below 150 cm, maturity age below 130 days, 10^0-15^0 flag leaf angle, the second and third leaves slightly drooped for more extensive canopy, stem diameter above 0.7 cm (Herawati et al., 2010). Improved varieties of upland rice in dispensed these characteristics to increase plant yields and upland rice area.

The diversity of plant morphological characters has been crucial in determining the best method to improve the yield. These morphological characters are significantly important in relations to the yield potential that being used as an indirect selection criterion or a to enhance/magnify the variety in the new population. The genetic diversity plays an essential aspect in which breeders always work (Gowane et al., 2013; Herawati et al., 2019; Osundare et al., 2017; Pachauri et al., 2017).

The yield potential character means the complex trait that strongly influenced by both growth and yield component (Zhou et al., 2018; Ikeda et al., 2013). Both yield potential and yield component controlled by many genes, which are strongly affected by environmental factors. Sravan et al. (2012) revealed that the system of breeding programs involved genetic diversity, and selected genotypes to develop prospective breeding lines. Plant breeders who assemble high yield plants rarely interested in just one character. So, learning about the relationship between yield and many other characters have been necessary (Agyei et al., 2012).

Several types of researches to examine relationships between characters by correlation illustrate the closeness of two traits (Aryana et al., 2011; Gupta et al., 2015; Osundare et al., 2017). The simple correlations coefficient is used to evaluate the relationship between each character. The correlation coefficient value ranged between -1 and 1 (Krualee et al., 2013). The positive correlation value between each character means the character increases yield with the rise of other character value. In contrast, a negative correlation value means the increased character value decreases other traits. Hussein and Hugo (2011), stated that path analysis helps to measure the indirect effect of one variable on other variables, through the separated correlation coefficient of both, directly and indirectly, influential variables. According to Zare et al. (2012), the yield potential means complex character derived from several components in both positive and negative influences on the trait. Accordingly, significant contributions of each element significantly contributed to the yield potential. This research aims to determine the selected agronomic characteristic criteria for developing of new-types of upland rice genotypes through both correlation and path analysis.

MATERIALS AND METHODS

This research had been conducted from July to October 2017 in Rawa Makmur, Bengkulu, as well as in Crop Production Laboratory, Faculty of Agriculture, University of Bengkulu, Indonesia. The experiments arranged in a Randomized Block Design (RBD) with three replications. The experiments used 50 rice genotypes derived from the recurrent selection in the F3 generation, and early-stage screened to tolerate drought stress (Herawati et al., 2017b). Rice grain from 50 lines sown in plastic containers. After 21 days, the seedlings transplanted in the rice fields. Each genotype number planted in two rows, 20 seedlings in each row. Plants fertilized with 200 kg ha^{-1} Urea, 100 kg ha^{-1} SP36, and 100 kg ha^{-1} KCl. The observation of agronomic characters are plant height (cm), total tiller numbers, productive tiller number per hill (stem), flowering age (day after planting), maturity age (day after planting), grain numbers per panicle (grain), filled grain numbers per panicle (grain), 1.000 grain weight (g), and weight of filled grain per hill (g). The effects of agronomic character on grain weight per hill analyzed by both correlation and path analysis. Genotypic correlations calculated by the formula as:

$$r_{g(xixj)} = \frac{cov.g(xixj)}{\sqrt{\sigma^2_{g(xi)} \cdot \sigma^2_{g(xj)}}}$$

cov.g(xixj) = genotypic covariance between i and j,

$\sigma^2_{g(xi)}$ = genotypic variance of character i,
$\sigma^2_{g(xj)}$ = genotypic variance of character j.

The significance of the correlation value between each character used t-test according to Singh and Chaudhary (2010), as follows:
$t = r\,[(n-2):(1-r^2)]^{1/2}$ where, t = obtained value compared with t student, df=degree of freedom (n-2), r = replication, n = observed population. Path coefficient analysis to determine the direct and indirect effects of agronomic characters, based on the following equation (Singh and Chaudary 2010):

$$\begin{bmatrix} r_{11}\ r_{12}\ldots r_{1p} \\ r_{21}\ r_{22}\ldots r_{2p} \\ \ldots\ldots\ldots\ldots \\ r_{p1}\ r_{p2}\ldots r_{pp} \end{bmatrix} \begin{bmatrix} c_1 \\ c_2 \\ \ldots \\ c_p \end{bmatrix} = \begin{bmatrix} r_{1y} \\ r_{2y} \\ \ldots \\ r_{py} \end{bmatrix}$$

Rx Ci Ry

Based on the above equation, the C_i value (directed influence) calculated by the formula:
$C_i = R_x$-1.R_y, where;
R_x = correlation matrix between independent variables,
$R_{x\text{-}1}$ = inverse matrix Rx
C_i = cross coefficient vector which shows the direct influence of any free variable that standard to the non-free variable
R_y = vector coefficient of correlation between free variables X_i = (i = 1,2, ... p)

RESULTS AND DISCUSSION

Correlation Between Yield and Yield Components

The association between plant characters chose the rightly selected trait. The pattern of relationships between the yield characters and yields known from the value of the correlation. The correlation between each character presented in Table 1. The plant height positively correlated to the filled grain (0.32) and positively correlated to the empty grain number (0.43), but inversely proportional to both productive tiller number (-0.24) and maturity age (-0.23). The data shows that the increased plant height will increase the fill grain number, but the higher the plant height higher the empty grains. Limited photosynthate for grain filling due to most of the photosynthates partitioned for the vegetative plant. Although the higher the plant height positively correlated with filled grains per panicle, the selection based on the plant high character needs to consider due to the plant height related to the plant lodges which limited the yield. Peng et al. (2008) reported that plant height and leaf width are the characters associated with lodge resistance, nutrient content and, the efficiency of photosynthetic.

Total tiller number positively correlates to the productive tiller numbers (0.95) indicates the observed whole productive tillers, according to the desired criteria of new types of upland rice which tiller numbers are all productive (Khush, 2013). The productive tiller numbers positively correlated to panicle length (0.29), flowering age (0.35), maturity age (0.31), and significantly affected the grain weight per hill (0.64). The panicle length positively correlated to both the empty grain numbers and the flowering age. However, the panicle length negatively related to the 1000 grain weights. Increasing the number of filled grains per panicle will significantly increase grain yield per hill. The results of this study are also shown in the study of Yang et al. (2007) and Herawati et al. (2019) on a new type of upland rice.

On the contrary, increased un-fill grains per panicle can decrease grain yield per hill which indicated the negative correlation value (-0.08). A large number of grains per panicle followed by filling grain at a long panicle will increase grain yield. Panda et al. (2015) have reported that the sucrose synthase (SUS3) enzyme actively involved in the seed filling period, increased spikelets density of panicle affected SUS3 expressions in the basal spikelets.

The characters such total tiller numbers, productive tiller numbers, and filled grain numbers positively correlated to the grain weight per hill, and the panicle length, flowering age and 1000 grain weight. Thus, all five characters could be used as selected criteria to increase grain yield. According to Gomez and Gomez (2002) and Matchik and Sumertajaya (2002), the correlation value between the two characters approached -1 or +1, closer relationship between two characters. The more positively correlation coefficient indicated that, the higher the value of the variable the more significant the yield. In contrast, the smaller the value, the lower the yield in drought stress conditions. The negative correlation coefficient value showed the higher the value, the lower the yield of grains obtained.

The increased 1,000-grain weights followed by the increased yield per hill shows by the value of the positive correlation. The 1,000-grain weight relates to the grain both size and level of un-filled such the more extensive the filled grain would, the higher the 1000 grain weight. Overall, increased yield per hill obtained by increased total tiller number, productive tiller numbers, panicle length, filled grain number per panicle, and 1000 grain weight, but inversely related to both plant height and empty grain number (Table 1).

The higher the flowering age, the longer the maturity age, indicating the value of the positive correlation (0.58). The plant characteristics determine the flowering age due to plant growth determines the vegetative phase. Reproductive phase of rice in the tropics 65 days consisted of a 35-day generative period and a 30-day maturation phase (IRRI, 2008).

Path Analysis to Determine the Effect of Characters on Yields

Characters correlated to the yields (Table 1) used as a selected character for new-types of upland rice. Path analysis determines growth characters, either directly or indirectly, influenced the yield (Singh and Chaudhary, 2010). So, the path analysis aims to find out the correlation coefficients of either direct or indirect effects. Based on the path analysis (Table 2), plant height, the total number of tillers, productive tiller numbers, panicle length, filled grain weight per panicle, and the 1000 grains weight directly and positively affected the grain weight per hill. Productive tiller numbers, fill grain number per hill, and the 1000 grain weight profoundly and positively influences the grain weight per panicle respectively 0.59, 0.42, and 0.26. This result shows that the three variables contribute significantly to the yield.

The path analysis creates a path diagram with the one-way causal model. Based on the path analysis results in Table 2, the path diagram of characters influences the yields. If the character that has a direct influence coefficient is low on yield, it is essential to attend to the value of the character's influence on the yield indirectly through other characters (Singh and Chaudhary, 2010). Characters that do not affect yields through other traits chosen which have an indirect effect coefficient above 0.09.

The plant height character indirectly and negatively affected the productive tiller numbers with the coefficient value of -0.14. This data has shown that the higher the plant height variable will reduce the formation of productive tillers. However, precisely the plant height increases the filled grain number per panicle by 0.14 (Figure 1).

The total number of tillers affected the productive tiller numbers with a coefficient of 0.56. The coefficient value indicated that almost all of the planted tillers in the genotypes produced panicles. The character of new-type rice clearly with the tiller number more than 12, which were all productive (Herawati et al., 2010; Khush, 2013). The prolific tiller numbers per hill have become a character that used as a selected criterion to improve the yield of new-type rice. Reference Peng et al. (2008) at least 330 productive tillers per m^2 (10-14 crops per hill) to increase 10% yield potential in wetland rice.

The high productive tiller number affected by the flowering age and indirectly by maturity age respectively of 0.21 and 0.18. The figure shows that the higher the plant maturity age led to the more prolonged the vegetative period and the chance to form more tillers. However, the tiller numbers depended on the plant ability to produce photosynthate. Khush (2013) revealed that increasing the yield potential; the rice increased the biomass production with the harvest index that responsive to nitrogen fertilization, resistant to lodge, and photosynthate partition.

The panicle length showed a negative coefficient value to the 1000 grain weights. The data shows that the more extended the panicle led to the smaller the grain and the lower the grain yield per hill. This data indicates that the longer panicle led to smaller the grain size which causes a decrease in grain yield per hill. Das et al. (2018) revealed that poorly grain filling subjected to the expression of the recessive allele for high ethylene production, but the allele being amenable for suppression to the dominant allele in genetic breeding. Based on the path analysis, the residual of 0.47 indicated that other effect on the grain yield could not be explained through this research. Further, researches required to describe the relationship between grain yield and morpho-physiological properties such as leaf angle, and selections to drought and resistance to blast disease.

Determination of Selection Characters of Rice Genotype for Developing of New Type of Upland Rice

Correlation between any characters was used as an indirect selection for the main characters so that some information obtained from this research determines the selection character for new-type of upland rice (Table 3).

Table 1. The Coefficient Correlations of Agronomical Characters of Upland Rice Lines

Characters	PH	TNT	PTN	PL	FG	UFG	TF	TH	1000W	GWH
PH	1	-0.25*	-0.24*	0.14	0.32*	0.43**	0.04	-0.23*	-0.03	-0.06
TNT		1	0.95**	0.28*	0.03	0.15	0.34*	0.35*	-0.25*	0.58**
PTN			1	0.29*	0.09	0.19	0.35*	0.31*	-0.2*	0.64**
PL				1	-0.00	0.37*	0.27*	0.12	-0.43**	0.03*
FG					1	0.09	0.21*	0.07	0.24*	0.53**
UFG						1	0.04	0.05	-0.31*	-0.08
TF							1	0.58**	-0.1	0.23*
TH								1	-0.48**	0.01
1000W									1	0.29*
GWH										1

PH = Plant Height; TNT=Total Number of Tillers; PTN = Productive Tiller Number; PL = Panicle Length; FG = Filled Grain per Panicle; UFG = Unfilled Grains per Panicle; TF=Time of Flowering; TH = Time of Harvest; 1000W = 1,000 Grain Weight; GWH= Grain Weight per Hill, * and ** = significantly different at P < 0.05 and P < 0.01

Table 2. The Direct and Indirect Effect of Some Agronomic Characters on the Yield

Charac Ters	Direct effects	Indirect effects								
		PH	TNT	PTN	PL	FG	UFG	TF	TH	1000W
PH	0.06	-	-0.02	-0.01	0.01	0.02	0.03	0.00	-0.01	-0.002
TNT	0.16	-0.04	-	0.15	0.05	0.00	0.02	0.05	0.06	-0.04
PTN	0.59	-0.14	0.56	-	0.17	0.06	0.11	0.21	0.18	-0.12
PL	0.01	0.001	0.003	0.003	-	-0.00	0.004	0.003	0.001	-0.004
FG	0.42	0.14	0.01	0.04	-0.001	-	0.04	0.08	0.03	0.09
UFG	-019	-0.09	-0.03	-0.04	-0.07	-0.02	-	-0.007	-0.01	0.06
TF	-0.05	-0.002	-0.017	-0.02	-0.01	-0.01	-0.002	-	-0.03	0.005
TH	-0.08	0.02	-0.03	-0.02	-0.01	-0.01	-0.004	-0.04	-	0.04
1000W	0.26	-0.01	-0.07	-0.05	-0.11	0.06	-0.08	-0.03	-0.13	-

PH = Plant Height; TNT=Total Number of Tillers; PTN = Productive Tiller Number; PL = Panicle Length; FG = Filled Grain per Panicle; UFG = Un-filled Grains per Panicle; TF=Time of Flowering; TH = Time of Harvesting; 1000W = 1,000 Grain Weight

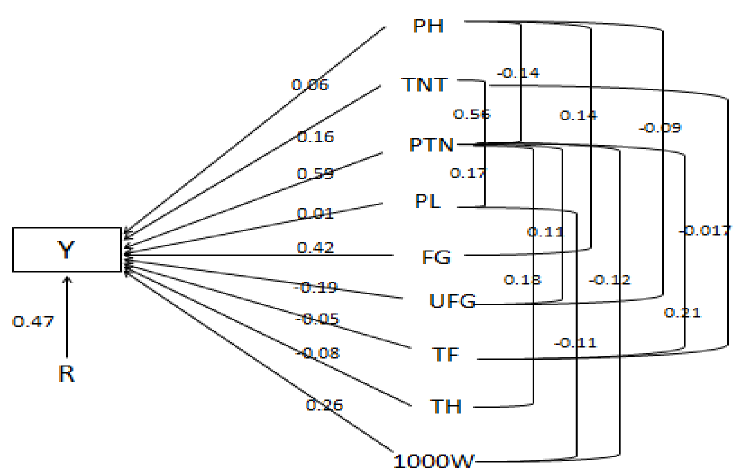

Figure 1. Path Analysis of Some Characters which Directly and Indirectly Affected the Yields

Table 3. Determination of Selection Characters of Rice Genotype for New Type of Upland Rice

Characters	Genotype	Range	Mean
Plant Height (cm)	G29, G50, G49, G38, G46, G25, G44, G45	110-125	120.2
Productive tillers number	G23, G24, G22, G40, G14, G28, G48, G25, G44, G17, G33, G9, G28, G45, G21, G36, G7	12-18	13.9
Panicle length (cm)	G25. G21, G42, G17, G14, G3, G28, G22, G1, G44, G23, G35, G50, G36, G12, G31, G18, G13, G46, G9, G19, G39, G47, G41, G16, G2, G4, G7, G6, G11, G24	30-36	30.87
Number of fill grains	G5, G11, G3, G10, G14, G15, G20, G36, G4, G19, G24, G13, G40	160-200	171.2
Grains Weight per tiller (g)	G14, G24, G40, G10, G44, G23, G29, G28, G45, G25, G33	25-38	29.5

This research found that the yield of new-type of upland rice predicted several characters effect on plant yield such plant height, productive tiller numbers, panicle length, grain number per panicle, and grain weight per hill. Herawati et al. (2010) developed some criteria for new-type of upland rice by modified the characters of new-type rice, big panicle (> 150 grain per panicle), productive tillers (> 6), filled grain > 70%, plant height below 150 cm, short maturity age (less than 130 days), 10^0-15^0 flag leaf angle, the second and third leaves slightly drooped to allow the plant canopy broader, stem diameter > 0.7 cm. The characteristics of new-type upland rice presented in the selected genotype as Table 3.

Plant height and productive tillers have been an agronomic character as a specific identity of a genotype. The standard of plant height, which IRRI specified in the new-type rice has been at least 100 cm (Peng et al., 2008). While the characteristics of the ideal plant according to Ma et al. (2006) was a plant height of 115-120 cm. These criteria prepared eight selected genotypes with plant height close to ideal for new-type rice (110-125 cm). Productive tiller numbers, which > 12 filled grain clearly with opportunity for higher yields, this could be seen from the direct effect of the number of fertile tillers of 0.59 on the grain weight per hill (Table 2). According to Peng et al. (2008) the number of productive tillers at least 330 tillers per m^2 (10-14 tillers per hill) to increase 10% of yield potential in lowland rice.

The panicle length ranges between 30-36 cm presented 31 selected genotypes (Table 3). Although the panicle length effects with a value of 0.01, however, it is necessary to consider indirect effects through productive tillers of 0.17 (Figure 1). Long panicles allow the formation of many panicles, but insufficient supply of photosynthates from leaves increases the empty grains. Kobata and Iida (2004) showed that lower filled grains in new-type rice attributed to lower efficiency of the assimilate partition from the plant leaf to the grains. Virk et al. (2004) developed a new-type rice strategy on panicle length for 150 grains per panicle. Furtherly, Peng et al. (2008) confirmed that the number of panicles per m^2, the percentage of grain filling, total biomass and harvest index required for new-type rice. Moreover, Khush (2013) reported that poor grain filling of new plant type line attributed to lack of apical dominance within a panicle, compact arrangement of spikelets and a limited number of large vascular bundles for assimilating transport to grains. Increased grain fillings after the grain disposal prepared with high photosynthetic rates, increased biomass production, aging of leaf and root (Wei et al., 2016).

Based on the information from path analysis, the fill grain number per panicle highly direct the effect on grain yield as 0.42 (Figure 1). The fill grain number per panicle became one of the significant characters to be used as a selected criterion concerning higher grain yield. Selected genotypes filled grain numbers per panicle of 160-200 and grain weight of 25-38 gram per hill (Table 3). Zhengjin et al. (2005) developed the ideal rice, which criteria of the grain numbers per panicle higher than 160 grains, while Virk et al. (2004) developed new-types rice, which character of the filled grain of 150 grains per panicle. The selected genotypes in this F4 generation expected to produce new-superior genotypes on the next generation.

CONCLUSION

The characters of the total number of tillers, productive tillers number, and fill grains number had a positive correlation and very significant on grain weight per hill were 0.58, 0.64, 0.53 respectively and significant positive correlation with time flowering and 1000 grains weight were 0.23 and 0.29 respectively. Other characters such as plant height (0.06), total number of tillers (0.16), productive tillers number (0.59), panicle length (0.01), fill grains number (0.42), and 1000 grains weight (0.26) all directly and positively influenced the grain weight per hill, which character closely related to the yields. Plant characters such as plant height, productive tiller numbers, panicle length, filled grain number, and filled grain weight per hill was applied as selection criteria for developing of new-type of upland rice.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest”.

ACKNOWLEGEMENT

Acknowledgments and appreciations to the Ministry of Research, Technology and Higher Education of Republic of Indonesia, through Directorate for Research and Community Service which funded through Applied Research in the 2019 budget year (Contract number 165/SP2H /LT/DRPM/ 2019).

AUTHOR CONTRIBUTIONS

All authors contributed equally in all parts of this research.

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