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Correlation and Path Analysis for Grain Yield and Its Components of Lowland Rice Grown under Coastland Agroecosystem

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ABSTRACT

Growth traits and yield components of rice plants affect yield. The magnitude of this relationship is seen from the correlation value between characters, and the direct and indirect effects are seen from the cross-fingerprint value. The study aims to determine which characters have a correlation with rice plant yield and their direct and indirect effects. The study was conducted from July 2023 to February 2024. The research location was in the rice fields of SPA Hamlet, Rias Village, Toboali, South Bangka Regency. The study used an experimental method, with a Randomized Complete Block Design (RCBD). The study was divided into 4 experimental blocks. The treatments were 10 superior varieties consisting of 8 inbred varieties (Inpari 32 HDB, Inpari 33, Inpari 42 Agritan GSR, Inpari 49 Jembar, Ciherang, Siliwangi, Padjajaran Agritan, and Cakrabuana Agritan) and 2 hybrid varieties (Mapan P05 and Bridantara 8). Data analysis was using correlation analysis and path analysis with Excel and SPSS applications. The results of the correlation analysis showed that only leaf width correlated with grain dry weight. Leaf width, plant height and number of productive tillers had the highest direct influence on yield. Leaf width characters can be recommended as selection characters in rice breeding.

INTRODUCTION

Food availability is still an important concern for a region. Food sufficiency is related to the amount of rice production as a staple food with population growth. BPS (2021), noted that the population data for the Bangka Belitung Islands is around 1.46 million people. The Bangka Belitung Islands Province in 2022 has a rice production of 61,430 tons. The rice requirement for the Bangka Belitung community is estimated to reach 77,810 tons. This production figure has not been able to meet the food needs of the community, so that the Bangka Belitung Islands have not been able to meet their food needs independently. According to BPS (2022), the Bangka Belitung Islands have a prevalence of inadequate food consumption reaching 15.95%. Bangka Belitung Islands have not been able to be self-sufficient in rice

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so that the basic needs of their people still come from outside the region.

The staple food agriculture subsector in the form of rice continues to be developed, both dryland rice and lowland rice. The lack of food supply for the community in the Bangka Belitung Islands can be caused by the low productivity of food crops, especially lowland rice. The decline in rice productivity can occur due to climate conditions, soil fertility problems, and fertilizer use. According to Maulana and Wagiyana (2017), one of the factors is pest attacks. Farmers in the field also still use very few certified seeds, so this also causes plant productivity to decline (Noviyanti et al. 2020).

South Bangka Regency has a large contribution to regional rice production, so it is nicknamed the rice barn of Bangka. According to BPS BABEL (2022), 52% of the total rice production has been contributed by South Bangka Regency. The largest rice producing area in South Bangka is in Toboali District or precisely in Rias Village, with the main commodity being lowland rice. Farmers are generally still unfamiliar and do not know many new superior varieties that have been certified. Slow information received by farmers and the minimal adoption of technology have resulted in new certified superior varieties not being widely cultivated.

The use of new superior varieties of rice fields that have high yields, are responsive to fertilization, and are resistant to pests and diseases in an integrated management system can increase crop productivity, production efficiency, and food sufficiency (Noviyanti et al., 2020). The diversity new superior varieties of rice fields can be a crop rotation option for farmers. The varieties released have the potential for superior genetic characters according to their abiotic and biotic environments. The varieties Inpari 32, Inpari 42, and Ciherang were selected as comparative varieties for the characters of new superior varieties of rice fields. The selected new superior varieties, such as Inpari 33, Inpari 49, Siliwangi, Padjajaran, Cakrabuana, Mapan, and Bridantara, have superior characteristics, high yield potential, and a rice taste that is liking by the community.

The potential of rice yield has supported by the characteristics of the yield components. Positively related yield characteristics will have a direct effect on rice production. The relationship between characters can be seen from the results of the correlation analysis. According to Hamdani and Haryati (2021), the correlation value shows the relationship between growth components, yield components, and yield. The influence is arising from each character on yield potential can be seen using path analysis. Path analysis was also used to explain the relationship between quantitative characters and production.

Aryawati and Sutami (2019) stated that there is a correlation between panicle length and the number of grains with high grain yields. Long rice panicles will make plants tend to produce a lot of grain. Afa et al. (2021) stated that there is a positive correlation between the total panicle grain components with the weight of filled grain, the weight of grain in a clump and grain production. This correlation means that an increase in the total grain in panicle will be followed by an increase in the weight of grain in a clump and an increase in rice production. Safriyani et al. (2019) also stated that the more panicles in a clump produced, the more the number of filled grains in a clump, the weight of 1000 grains, the harvest index and the weight of grain in a clump. According to Krishna et al. (2022) the number of grains in panicle has a significant positive correlation with panicle length, 1000 grain weight, and the number of panicles in a plant. Okasa et al. (2021) stated that the number of panicles also has a positive correlation with the grain yield in a plant. The strength of the correlation between characters is seen from the value and direction of the relationship, namely positive or negative. The weakness and strength of the correlation between characters are seen from the range of numbers.

The direct influence of plant characteristics on yield potential will be seen from the results of the path analysis. Observations of the direct and indirect influences between these rice

characters have been carried out on several other varieties and different regions. The character of the number of in panicle grains has a significant contribution to the weight of grain in panicle. According to Kartina et al. (2016) the number of productive tillers and the total number of tillers have a direct positive effect on grain yield. Grain yield in a plant is also directly influenced by the character of the number of productive tillers and panicle length. According to Jeke et al. (2021) the character that has a direct influence on grain yield, this relationship is positive and not significant.

This is new observations in this ecosystem area will later be able to determine what characters have correlations and have direct and indirect influences on the results of paddy production. The information will be comprehensive data as a reference in optimizing the production of paddy varieties in Rias Village, Toboali District, South Bangka Regency.

MATERIALS AND METHODS

The research was conducted from July 2023 to February 2024. The research location was in SPA Hamlet, Rias Village, Toboali District, South Bangka Regency, Bangka Belitung Islands Province. The tools used in the study were, RHS color chart cultivator, tractor, combine, meter, sprayer, analytical balance, scissors, stationery. The materials used were 8 varieties of inbred rice (Inpari 32 HDB, Inpari 33, Inpari 42 Agritan GSR, Inpari 49 Jembar, Ciherang, Siliwangi, Padjajaran Agritan, and Cakrabuana Agritan) and 2 varieties of hybrid rice (Mapan P05 and Bridantara 8), plastic, labels, organic fertilizer, urea and NPK fertilizer, variety name tags, pesticides, lime and compost. This study was conducted using a field trial method. The experimental design was used a Randomized Block Design (RAK) with rice variety treatments consisting of 10 treatment levels. The experiment was divided into 4 blocks with a total of 40 experimental units, or each block consisted of 10 experimental units. The sample consisted of 20 clumps of rice plants per unit or 200 clumps of plants per block, so that the number of sample plants in all blocks was 800 clumps of paddy fields. The research work stages included seed procurement, land preparation, seed sowing, seed planting, fertilization, pest control, and harvesting. The observed characters included plant height, number of productive tillers, leaf length, leaf width, number of panicles, panicle length, number of grains per panicle, number of grains per panicle, dry grain weight, weight of 1000 grains. Observations on the yield components used harvested and dried grains. Data analysis was carried out using correlation analysis and path analysis using Excel and SPSS applications.

RESULTS AND DISCUSSION

The correlation coefficient value is very significant at the 1% level, the characters that are positively correlated are the number of annual grains with plant height (0.42933), the number of panicles with the number of productive tillers (0.51559), the number of annual grains with panicle length (0.40406), and the number of rice grains with the number of grains in the panicle (0.73388). The very significant negative correlation at the 1% level includes the character of plant production with leaf width (0.78862), the weight of 1000 grains with the number of grains per panicle (-0.49186), and the weight of 1000 grains with the number of full grains, namely (-0.43735). The characters that are significantly positively correlated at the 5% level are leaf length with plant height (0.33379), the number of productive tillers with leaf length (0.32257), and panicle length with plant height (0.34888). Characters that were significantly negatively correlated at the 5% level were 1000 grain weight and plant height (-0.32637) (Table 1).

The results of path analysis in Table 2 show that plant characters have the highest direct influence, namely leaf width (0.63699), plant height (0.08529), number of productive tillers (0.07890), number of full grains (0.03952), number of panicles (0.01461), leaf length (0.00590), weight of 1000 grains

Table 1. Results of correlation analysis of relationships among rice yield components

Characters	Plant height	Number of productive tillers	Leaf length	Leaf width	Number of panicles	Panicle length	Number of grains per panicle	Number of filled grains	Dry grain weight	Weight 1000 grains
Plant height	X									
Number of productive tillers	0.031	X								
Leaf length	**0.334** *	**0.323** *	X							
Leaf width	-0.219	-0.180	0.181	X						
Number of panicles	-0.074	**0.516** **	0.194	0.166	X					
Panicle length	**0.349** *	-0.105	0.056	0.231	-0.110	X				
Number of grains per panicle	**0.429** **	-0.101	0.297	-0.160	-0.233	**0.404** **	X			
Number of filled grains	0.270	-0.157	0.249	-0.100	-0.074	0.226	**0.733** **	X		
Dry grain weight	0.269	0.271	-0.097	**-0.789** **	-0.096	0.004	0.272	0.184	X	
Weight 1000 grains	**-0.326** *	0.230	-0.199	-0.058	0.044	0.024	**-0.492** **	**-0.437** **	-0.091	X

Information:
1. Numbers followed by the symbol "*" in the column indicate a real correlation at the 5% level, numbers followed by the symbol "**" in the column indicate a very real correlation at the 1% level.
2. The (-) sign at the beginning of the number indicates that the direction of the correlation between characters is negative or an inverse relationship, while the (+) sign at the beginning of the number indicates that the direction of the correlation between characters is positive or a linear relationship (in one direction).
3. Range of correlation relationship levels (r); 0.00 – 0.199 (very weak); 0.20 – 0.399 (weak); 0.40 – 0.599 (fair); 0.60 – 0.799 (strong); 0.80 – 1.00 (very strong).

(0.00505), panicle length (0.00183) and number of grains per panicle (0.00183). The characters with the highest indirect influence are leaf width and plant height on rice yield (0.05097). The residual value in the path analysis obtained R = 0.13008 (13%). The residual value means that the prediction data is sufficient to represent the direct and indirect influence between characters on yield characters in the field. The image of the characters that affect the results can be seen from the path diagram (Figure 1).

Correlation was analyzed using average data plant characters in each variety, in order to represent all variety data in general. Correlation between yield potential characters will be shown by the correlation coefficient value. The correlation test showed that the character of plant height was significantly positively correlated with leaf length. This result means that an increase in plant height will be followed by an increase in the character of leaf length. Plant height describes the large level of proportion of the plant canopy which acts as a source or organ of food distribution which is important in the process of photosynthesis. An increase in plant height that coincides with an increase in leaf length can trigger an increase in the amount of photosynthate and the formation of character components of rice plant yields. This is an added value of the character of plant height as a strategy for rice plant breeding. A real positive correlation relationship is also found in the character of plant height and panicle length. The photosynthate produced will then be distributed to the sink organ or food storage organ, namely grain. A very real correlation is shown by the character of plant height with the number of grains per panicle, so that it will indirectly play a role in increasing the yield of lowland rice plants. Plant height characteristics will be suitable if they become a strategy observed in plant breeding.

Leaf length has a significant positive correlation with the number of productive tillers. The very important role of leaves in the process of photosynthesis and distributing photosynthate is very influential in this case.

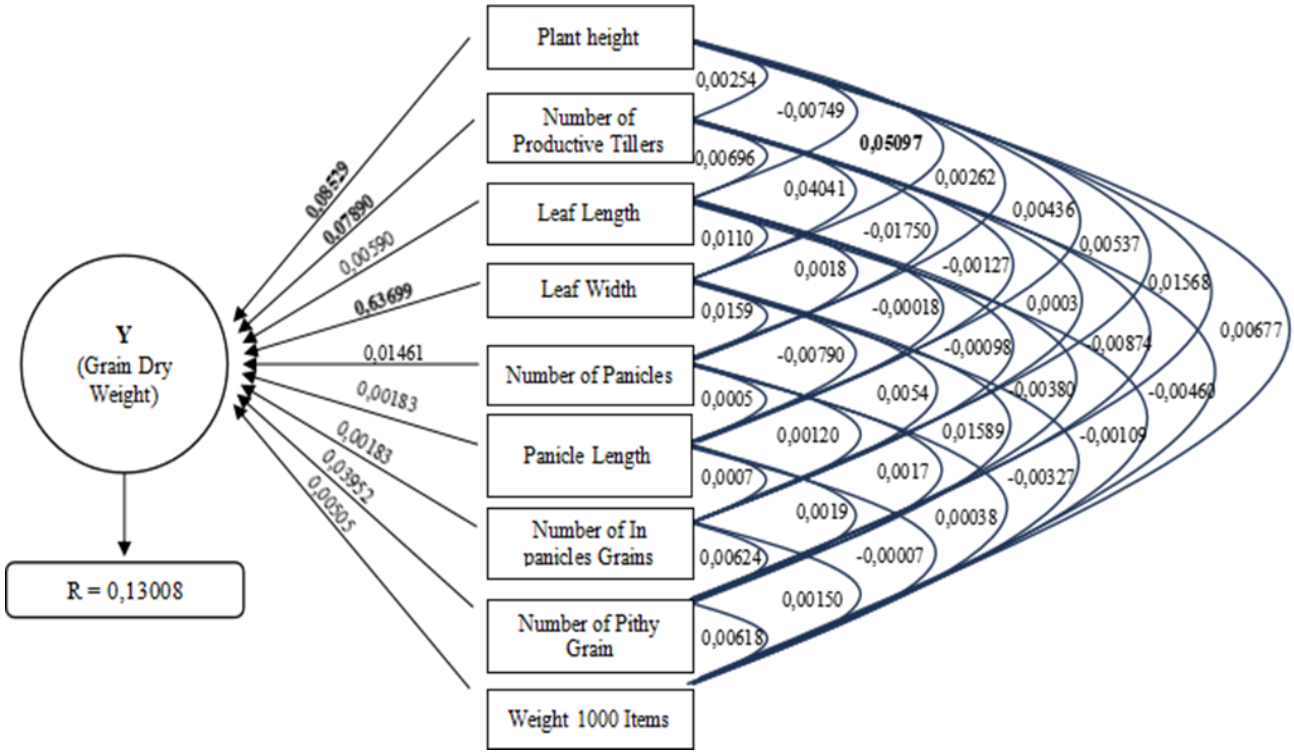

Figure 1. Path diagram of several variables that influence potential outcomes

The plants in their vegetative period prepare source organs that play a role in producing and distributing photosynthate, especially leaves, so that plants can maximize the formation of sink organs that receive photosynthate in their generative phase, namely rice grains.

The increase in the number of productive tillers has a very real positive correlation with the number of panicles. Plants with a large number of tillers will allow for many productive tillers, so that this can increase the number of panicles and the amount of grain in the plant. Wardana and Hariyati (2016) stated that the increasing number of rice tillers is directly proportional to the rice production results, so that the number of tillers does not rule out the possibility of increasing the production of lowland rice.

The panicle length character has a very real positive correlation value to the character of the number of grains per panicle. The correlation shown means that the length of the panicle can also increase the amount of grain produced. Panicles with long sizes can support the acquisition of a lot of rice grain (Kartina et al., 2016). This means that the longer a rice panicle, the more the plant biomass will increase, followed by an increase in the amount of grain and plant production. The length of the rice plant panicle is the result of differences in genotype rather than environmental influences (Nasution, 2010).

The number of grains in panicle shows the highest positive real correlation to the number of full grains so that the correlation relationship is classified as a strong level or closely related. The correlation coefficient value approaching 1 means that the two variables have a strong or perfect relationship. This positive correlation relationship indicates that the more the number of grains per panicle produced, the more full grains will be formed. This result is the same as the statement of Kartina et al. (2016) the number of filled grains per panicle with a positive correlation to the total number of grains and the percentage of seed filling (seed set). The increase in the number of filled grains will also be followed by an increase in panicle fertilization which will later support seed filling and seed production in a clump. If the correlation value is positive and significant in a character against other characters, it can be used as a selection index that determines the harvest yield (Armandoni et al. 2023).

A negative correlation relationship is also found in the character of plant height with a

Table 2. Results of direct and indirect effects of Path Analysis

Variables	Beta Coefficient	Direct Influence	Indirect Influence									Indirect Influence	Total Influence
			X1	X2	X3	X4	X5	X6	X7	X8	X10		
X1	0.29204	**0.08529**		0.00254	-0.00749	**0.05097**	0.00262	0.00436	0.00537	0.01568	0.00677	0.08082	0.16611
X2	0.28090	**0.07890**	0.00254		-0.00696	0.04041	-0.01750	-0.00127	-0.00121	-0.00874	-0.00460	0.00267	0.08157
X3	-0.07680	0.00590	-0.00749	-0.00696		0.01107	0.00180	-0.00086	-0.00098	-0.00380	-0.00109	-0.00830	-0.00241
X4	-0.79812	**0.63699**	**0.05097**	0.04041	0.01107		0.01598	-0.00790	0.00546	0.01589	-0.00327	**0.12861**	0.76560
X5	-0.12086	0.01461	0.00262	-0.01750	0.00180	0.01598		0.00057	0.00120	0.00177	0.00038	0.00681	0.02142
X6	0.04280	0.00183	0.00436	-0.00127	-0.00018	-0.00790	0.00057		0.00074	0.00192	-0.00007	-0.00183	0.00000
X7	0.04280	0.00183	0.00537	0.00033	-0.00098	0.00546	0.00120	0.00074		0.00624	0.00150	0.01986	0.02169
X8	0.19879	0.03952	0.01568	-0.00874	-0.00380	0.01589	0.00177	0.00192	0.00624		0.00618	0.03514	0.07466
X10	-0.07106	0.00505	0.00677	-0.00460	-0.00109	-0.00327	0.00038	-0.00007	0.00150	0.00618		0.00580	0.01085
Total	0.86992												
R	0.13008												

Note: X1 = plant height, X2 = number of productive tillers, X3 = leaf length, X4 = leaf width, X5 = number of panicles, X6 = panicle length, X7 = number of grains in panicle, X8 = number of full grains, X10 = weight of 1000 grains.

weight of 1000 grains. Widyaningtias et al. (2020) concluded the results of their study that agronomic and morphological characters such as plant height, flag leaf length, flag leaf width, productive tillers, and panicle length can reduce filled grain by 29.33%. This statement is also in line with the results of the study which showed that leaf width has a negative correlation with plant production. Morphological and agronomic characters in plant panicles can also cause emptiness, due to the low assimilates produced and insufficient to fill the grain so that there is a pseudo emptiness (Abdullah et al. (2008). The level of emptiness can also occur due to imperfect pollination and an imbalance between large receiving organs (sinks) and small sources of production (sources) . The emptiness of rice grains will be directly related to the grain quality which can determine the quality and quantity of lowland rice yields. Factors that also greatly affect the components of rice crop yields are external plant factors.

Pest and disease attacks can also cause empty grain. The main pests that attack include stem borers, grasshoppers, birds, snails and rats whose numbers are not too dominant. According Attacks by stem borers (*Scircophaga innotata*) in the imago and nymph phases on rice plants can damage leaf tissue, and at severe levels can cause crop failur Bed bug pests (*Leptocorisa oratorius* Fab.) That attack young rice will cause empty grain which is characterized by upright panicles without being filled (Manueke et al. 2017). The occurrence and level of disease attack also determine the level of rice health. The main disease of rice plants such as blast is caused by the fungus *Pyricularia orizae* Cav. namely symptoms of spots on the leaves, dry rot on the neck of the panicle so that the milk ripening infection makes most of the rice grains empty.

The weight of the rice grain produced can be influenced by the shape of the grain itself. The size and weight of rice grains can be influenced by rice genetics (Chen et al. 2021). The shape of round and large grains will have a relatively high weight compared to oval and flat grains. Safriyani et al. (2019) stated that the weight of 1000 grains in rice can describe the size and nutritional value of the grain. This statement interprets that a negative correlation between the number of grains in panicle and the number of nutritious grains to the weight of 1000 grains can occur if the panicle produces small grains of rice and low nutritional value. The lack of efficiency in the absorption of fertilizers given also affects the use of nutrients by plants in filling rice grains. Nutrients in fertilizers that are not utilized by plants indicate low plant efficiency in the use and absorption of fertilizers.

The harvest is the result of the expression of various other supporting characters. The high yield of a plant can be optimized by maximizing the characters that are closely related to the yield components. The correlation coefficient value indicates the magnitude of the linear relation-ship between the two variables. According to Kartina et al. (2016), longer panicles support grain yields.

Characters that correlate with yield will later become selection criteria in plant breeding. Knowledge on the relationship between yield and the component characters themselves can prove the efficiency of selection.

Information regarding the causal relationship between characters and results can be known from path analysis. Path analysis shows a causal relationship model to find the right path for an independent variable (X) to the dependent variable (Y). The results of the path analysis will later describe the magnitude of the direct and indirect influence of a character on the results or amount of dry grain harvested. According to Güneri et al. (2017) path analysis separates the correlation value into direct and indirect influences through other characters to facilitate good interpretation in determining the influence of a character on other characters.

The path value between the yield component characters shows that leaf width has the highest positive direct effect on the dry weight of grain, that is 0.63699. This result is in line with the correlation analysis, where leaf width has the highest correlation value with dry weight of grain.

The highest indirect effect is shown between the characteristics of leaf width and plant height on yield. This shows that the character of leaf width can affect yield together with plant height. The direct effect of character on dry weight of grain is stated as weak if the path coefficient value is less than 0.05. The strength of the path coefficient value is said to be low and considered insignificant if it has a number below 0.05. The characteristics of plant height and the number of productive tillers have a direct effect value that is still quite strong, namely 0.08529 and 0.07890. The number of panicles and the number of grains per panicle have a weak direct effect (<0.05) on dry weight of grain. The direct effect value of other characters which is very small can be said to have no real effect on dry weight of grain (0.00).

The direct influence of a character on the yield can also occur due to an indirect relationship with other yield component characters. Characters that have a direct influence on the weight of plant seeds cannot stand alone without a large contribution from other characters that also have an indirect influence. The weak path coefficient value in high correlation value occures due to the indirect effect of other variables. The results of the pathing analysis also showed that the highest indirect influence was the leaf width character on plant height.

The residual value is remaining value of the total direct influence or also called error. The residual value approaches zero which means that the parific analysis used is increasingly effective in explaining the causal relationship of the observed correlation and character values to explain the direct and indirect influence values. The residual of this study has an R value = 0.13008 or a probability of data interpretation error of 13%, this indicates that the value is good in representing the direct and indirect influence between the character of the result component and other supporting characters.

CONCLUSION

Characters that are significantly correlated are leaf length to plant height, number of productive tillers to leaf length, and panicle length to plant height. Highly significant correlation values were obtained in the characters of the number of grains in panicle to plant height, number of panicles to number of productive tillers, number of grains in panicle to panicle length, and number of full grains to number of grains in panicle. Characters that have a direct influence on yield are leaf width, number of productive tillers, plant height, number of panicles and number of full grains. Characters that have an indirect influence on yield are leaf width and plant height. The character that has the most direct influence on lowland rice yield based on path analysis results is leaf width.

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