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Original article

Regression and Correlation Analysis of Some Morphological and Agronomic Characters in F_2 Generation of Rice (*Oryza sativa* L.)

Afifuddin Latif Adiredjo [a, *], Damanhuri Damanhuri [a], Nandariyah Nandariyah [b] & Taryono Taryono [c]

[a] Faculty of Agriculture, Brawijaya University, Jl. Veteran, Malang 65145, Indonesia
[b] Faculty of Agriculture, Sebelas Maret University, Jl. Ir. Sutami No.36A, Kota Surakarta 57126, Indonesia
[c] Faculty of Agriculture, Gadjah Mada University, Bulaksumur, Yogyakarta, Indonesia

Abstract

Rice is a cereal plant and staple food for most Indonesian people. One of the causes of the problem is decrease of wetland and lowland area which have impact on national level production. One of the efforts to increase rice production is selection to get desired trait. Regression and correlation analysis to determined the relationship among characters that can be used as a consideration for selection criterion. The purpose of this study is to know the relationships between morphological and agronomic characters in rice plant of F2 generation. This study was conducted at the Experimental Faculty of Agriculture, University of Brawijaya, Jatimulyo Village, Malang, between June and August 2018. Planting materials were population of F2 generation (SBCH, SBCB, TWCH dan TWCB). All of the populations planted in area 25 m x 3 m with spacing 60 cm x 60 cm. Based on the result, all of the populations showed that there was positif linear relationship between plant height and panicle length, number of tiller, and number of productif tiller. TWCH population showed strong and significant positive correlation in leaf length and number of tiller. Very strong and significant positive correlation showed by all of F2 generation in plant height with panicle length and number of productive tillers with number of tillers.

Keywords: Rice, F2 Generations, Regression, Correlation.

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* **Corresponding author:**

Afifuddin Latif Adiredjo, Faculty of Agriculture, Brawijaya University, Jl. Veteran, Malang 65145, Indonesia.
Email: al.adiredjo@gmail.com

INTRODUCTION

Rice is a cereal plants and staple food that consumed by more than 95% of Indonesian people. However, rice production in 2012 to 2018 does not stable. One of the causes is the decrease of wetland area function which has an impact on national level of rice production. The area of paddy fields in 2014 was 8,111,593 ha and decreased in 2015 to 8,092,906 ha (Ministry of Agriculture of Republic Indonesia, 2017).

Efforts to increase production can be done by selection to get the desired superior varieties. To obtain desirable traits, it is necessary to select the segregated generation and then proceed with self-pollination of 6-10 generations to obtain pure homozygous strains (Safitri et al., 2011). This causes the assembly of rice varieties to take a long time so that the selection efficiency is needed.

Selection will be more effective if the appropriate character is used. Morphological and agronomic characters are characteristics that can affect plant productivity. Aryana (2009) states that a character can be used as a selection criterion if there is a real relationship between these characters and the intended character. In this study, the value of regression and correlation is important to know the relationship between characters which can later be used as a consideration in making a selection.

Material and Methods

This research was conducted at the Experimental Garden of the Faculty of Agriculture, Brawijaya University, Jatimulyo Village, Lowokwaru District, Malang. In April to August 2018. The material used in this study is rice seed from the results of research by Yanuar (2017) and Hazmy et al., 2018, namely 4 generations of rice generation F2 (SBCH, SBCB, TWCH and TWCB), compost, urea, SP36 , KCl and insecticides. In this study all populations were planted in an area of 25 m x 3 m with a spacing of 60 cm x 60 cm. Total number of plants is 140 and total sample is 100 plants. Variables observed included plant height, leaf length, leaf width, panicle length, number of tillers, number of productive tillers and day to flowering. Data analysis used regression and correlation analysis. As follows:

$Y = a + bX$

Where Y is dependent variable, a is intercept, b is linear regression coefficient and x is independent variable.

Correlation formula:

$$r = \frac{\sum xy - \{(\sum x)(\sum y)\}/n}{\sqrt{[\sum x^2 - (\sum x)^2/n\ ]\,[\sum y^2 - (\sum y)^2/n\ ]}}$$

Where N is Number of data pairs X and Y, Σx is Total number of variables X, Σy is Total number of variables Y, Σx^2 is Total number of squares of variable X, Σy^2 is The total number of squared variables Y, Σxy is Total number of multiplications of XY variables.

Correlation categories are:

Coefficient Interval	Relationship Level
0.00 – 0.19	Very Weak
0.20 – 0.39	Weak
0.40 – 0.59	Moderate
0.60 – 0.79	Strong
0.80 – 1.00	Very Strong

Results and Discussion

Based on the results of regression analysis, in the fourth generation F2 rice population has a different regression function. The regression function in F2 generation rice plants is shown in Tables 1, 2, 3 and 4.

Table 1. Linear regression function of SBCH population

No	Independent variable (X)	Dependent variable (Y)	Function	R^2
1	Plant Height	Leaf Length	Y= 8.103+0.375 X	0.334
		Leaf Width	Y= 0.322+0.011 X	0.282
		Panicle Length	Y= 2.604+0.276 X	0.693
		Number of Tillers	Y= 59.222+0.077X	0.001
		Number of Productive Tillers	Y=35.660+0.254 X	0.007
		Days to Flowering	Y=92.224–0.098X	0.055
2	Leaf Length	Plant Height	Y=38.796+0.891 X	0.334
		Leaf Width	Y= 0.456 +0.018 X	0.330
		Panicle Length	Y=13.998+0.225 X	0.195
		Number of Tillers	Y= 73.594–0.266 X	0.003
		Number of Productive Tillers	Y= 68.173–0.439 X	0.009
		Days to Flowering	Y= 90.473–0.147 X	0.052
3	Leaf Width	Plant Height	Y=41.167+26.116X	0.282
		Leaf Length	Y=14.414+18.325X	0.330
		Panicle Length	Y=14.869+6.358 X	0.152
		Number of Tillers	Y=125.122-56.664X	0.115
		Number of Productive Tillers	Y=111.054-54.093X	0.133
		Days to Flowering	Y=80.477–4.681X	0.052
4	Panicle Length	Plant Height	Y=14.649+2.513X	0.693
		Leaf Length	Y=15.278+0.864X	0.195
		Leaf Width	Y=0.549+0.024X	0.152
		Number of Tillers	Y=29.167+1.634X	0.025
		Number of Productive Tillers	Y=23.228+1.385X	0.023
		Days to Flowering	Y=95.160–0.447X	0.162
5	Number of Tillers	Plant Height	Y=68.650+0.007X	0.127
		Leaf Length	Y=34.622–0.010X	0.003
		Leaf Width	Y=1.199–0.002X	0.115
		Panicle Length	Y=20.666+0.015X	0.025
		Number of Productive Tillers	Y= -0.979+0.840X	0.896
		Days to Flowering	Y=88.435–0.046X	0.140
6	Number of Productive Tillers	Plant Height	Y=67.597+0.028X	0.007
		Leaf Length	Y=35.077–0.020X	0.009
		Leaf Width	Y=1.199–0.002X	0.133
		Panicle Length	Y=20.778+0.017X	0.023
		Number of Tillers	Y=7.784+1.066X	0.896
		Days to Flowering	Y=88.191–0.051X	0.137
7	Days to Flowering	Plant Height	Y=117.269–0.564X	0.055
		Leaf Length	Y= 64.508–0.357 X	0.052
		Leaf Width	Y= 0.112–0.011 X	0.052
		Panicle Length	Y= 45.883–0.283 X	0.127
		Number of Tillers	Y=326.676-3.066X	0.140
		Number of Productive Tillers	Y=282.946–2.687X	0.137

Table 2. Linear regression function of SBCB population

No	Independent variable (X)	Dependent variable (Y)	Function	R^2
1	Plant Height	Leaf Length	Y=9.151+0.365X	0.128
		Leaf Width	Y=0.941+0.004X	0.009
		Panicle Length	Y=0.092+0.310X	0.491
		Number of Tillers	Y=249.170–2.766X	0.266
		Number of Productive Tillers	Y=193.379–2.104X	0.235
		Days to Flowering	Y=77.575+0.142X	0.026
2	Leaf Length	Plant Height	Y=56.508+0.350X	0.128
		Leaf Width	Y=0.830+0.010X	0.077
		Panicle Length	Y=19.044+0.066X	0.023
		Number of Tillers	Y=119.371–1.747X	0.110
		Number of Productive Tillers	Y=102.762–1.566X	0.135
		Days to Flowering	Y= 80.803+0.190X	0.049
3	Leaf Width	Plant Height	Y=65.542+2.452X	0.009
		Leaf Length	Y=25.255+7.469X	0.077
		Panicle Length	Y=19.136+1.834X	0.025
		Number of Tillers	Y=-23.701+70.677X	0.249
		Number of Productive Tillers	Y=-12.995+52.788X	0.212
		Days to Flowering	Y=96.542–7.836X	0.116
4	Panicle Length	Plant Height	Y=34.667+1.585X	0.491
		Leaf Length	Y=26.564+0.353X	0.023
		Leaf Width	Y=0.895+0.013X	0.025
		Number of Tillers	Y=106.017–2.168X	0.032
		Number of Productive Tillers	Y=87.672–1.796X	0.033
		Days to Flowering	Y=89.321+0.145X	0.018
5	Number of Tillers	Plant Height	Y=74.189–0.096X	0.266
		Leaf Length	Y=37.861–0.063X	0.110
		Leaf Width	Y=0.971–0.004X	0.249
		Panicle Length	Y=22.185–0.015X	0.032
		Number of Productive Tillers	Y=1.570+0.799X	0.976
		Days to Flowering	Y=91.020–0.063X	0.148
6	Number of Productive	Plant Height	Y=73.951-0.112X	0.235
	Tillers	Leaf Length	Y=38.352–0.086X	0.135
		Leaf Width	Y=0.983+0.004X	0.212
		Panicle Length	Y=22.224–0.019X	0.033
		Number of Tillers	Y=0.456+1.221X	0.976
		Days to Flowering	Y=91.001–0.075X	0.140
7	Days to Flowering	Plant Height	Y=52.211+0.186X	0.026
		Leaf Length	Y=11.450+0.259X	0.049

	Leaf Width	Y=2.471-0.015X	0.116
	Panicle Length	Y=15.353+0.068X	0.018
	Number of Tillers	Y=265.853–2.360X	0.148
	Number of Productive Tillers	Y=211.990–0.961X	0.140

Table 3. Linear regression function of TWCH population

No	Independent variable (X)	Dependent variable (Y)	Function	R^2
1	Plant Height	Leaf Length	Y= 27.558+0.095 X	0.009
		Leaf Width	Y= -0.003+0.016 X	0.177
		Panicle Length	Y=-15.065+0.527X	0.711
		Number of Tillers	Y= 16.695+0.956 X	0.100
		Number of Productive Tillers	Y= -8.818+1.117 X	0.136
		Days to Flowering	Y= 56.211+0.380 X	0.164
2	Leaf Length	Plant Height	Y= 64.169+0.093 X	0.009
		Leaf Width	Y = 1.008+0.003 X	0.005
		Panicle Length	Y= 17.234+0.094 X	0.023
		Number of Tillers	Y=108.547–0.809X	0.073
		Number of Productive Tillers	Y=94.592–0.830X	0.077
		Days to Flowering	Y=72.811+0.264 X	0.081
3	Leaf Width	Plant Height	Y=55.414+10.778X	0.177
		Leaf Length	Y=31.857+1.902X	0.005
		Panicle Length	Y=11.596+7.999X	0.249
		Number of Tillers	Y=43.599+33.962X	0.193
		Number of Productive Tillers	Y=24.444+38.017X	0.241
		Days to Flowering	Y=80.816+0.855X	0.001
4	Panicle Length	Plant Height	Y=39.786+1.348X	0.711
		Leaf Length	Y=28.931+0.246X	0.023
		Leaf Width	Y=0.467+0.031X	0.249
		Number of Tillers	Y=41.430+1.1941X	0.162
		Number of Productive Tillers	Y=26.448+1.956X	0.164
		Days to Flowering	Y=89.720+0.590X	0.155
5	Number of Tillers	Plant Height	Y=58.818+0.105X	0.100
		Leaf Length	Y=41.320-0.091X	0.033
		Leaf Width	Y=0.644+0.006X	0.193
		Panicle Length	Y=13.676+0.083X	0.162
		Number of Productive Tillers	Y=-2.208+0.846X	0.714
		Days to Flowering	Y=86.638-0.060X	0.038
6	Number of Productive Tillers	Plant Height	Y=59.231+0.122X	0.136
		Leaf Length	Y=40.126–0.093X	0.077
		Leaf Width	Y=0.683+0.006 X	0.241

		Panicle Length	Y=14.874+0.084X	0.164
		Number of Tillers	Y=25.077+0.843 X	0.714
		Days to Flowering	Y=84.697–0.041 X	0.018
7	Days to Flowering	Plant Height	Y=32.017+0.432 X	0.164
		Leaf Length	Y=8.849+0.307X	0.081
		Leaf Width	Y=0.982+0.001X	0.001
		Panicle Length	Y=-1.019+0.262 X	0.155
		Number of Tillers	Y=132.127–0.624X	0.038
		Number of Productive Tillers	Y=101.490–0.429X	0.018

Table 4. Linear regression function of TWCB population

No	**Independent Variable (X)**	**Dependent Variable (Y)**	**Function**	**R^2**
1	Plant Height	Leaf Length	Y= 26.532–0.065X	0.008
		Leaf Width	Y = 0.549+0.008X	0.239
		Panicle Length	Y= 12.291+0.128X	0.438
		Number of Tillers	Y= 36.885+0.628X	0.103
		Number of Productive Tillers	Y= 17.556+0.685X	0.123
		Days to Flowering	Y= 99.877–0.206X	0.075
2	Leaf Length	Plant Height	Y= 67.433+0.127X	0.008
		Leaf Width	Y = 1.043+0002X	0.007
		Panicle Length	Y= 20.002+0.047X	0.029
		Number of Tillers	Y= 73.979–0.247X	0.008
		Number of Productive Tillers	Y= 44.706+0.699X	0.065
		Days to Flowering	Y= 71.940+0.426X	0.152
3	Leaf Width	Plant Height	Y=37.284+31.060X	0.239
		Leaf Length	Y= 27.12+3.651X	0.007
		Panicle Length	Y= 14.220+6.588X	0.286
		Number of Tillers	Y=-0.090+74.444X	0.360
		Number of Productive Tillers	Y=-13.662+72.962X	0.345
		Days to Flowering	Y=102.984-16.228X	0.115
4	Panicle Length	Plant Height	Y=-1.744+3.409X	0.438
		Leaf Length	Y=17.662+0.628X	0.029
		Leaf Width	Y= 0.168+0.043X	0.286
		Number of Tillers	Y=-23.885+4.920X	0.239
		Number of Productive Tillers	Y=-42.704+5.089X	0.255
		Days to Flowering	Y=98.405–0.617X	0.025
5	Number of Tillers	Plant Height	Y= 57.961+0.165X	0.103
		Leaf Length	Y= 28.458+0.033X	0.008
		Leaf Width	Y= 0.703+0.005X	0.360
		Panicle Length	Y= 17.490+0.049X	0.239

		Number of Productive Tillers	Y= -6.200+0.890X	0.789
		Days to Flowering	Y= 93.535–0.103X	0.071
6	Number of Productive	Plant Height	Y= 69.505+0.179X	0.123
	Tillers	Leaf Length	Y= 24.990+0.083X	0.065
		Leaf Width	Y= 0.784+0.005X	0.345
		Panicle Length	Y= 18.129+0.050X	0.255
		Number of Tillers	Y= 22.738+0.887X	0.789
		Days to Flowering	Y= 89.011–0.058X	0.023
7	Days to Flowering	Plant Height	Y=102.301–0.363X	0.075
		Leaf Length	Y=0.605+0.357X	0.152
		Leaf Width	Y= 1.701–0.007X	0.115
		Panicle Length	Y=24.941–0.041X	0.025
		Number of Tillers	Y=140.330-0.689X	0.071
		Number of Productive Tillers	Y=99.736–0.391X	0.023

Table 5. Correlation coefficient of SBCH population

	PH	**LL**	**LW**	**PL**	**NT**	**NPT**	**DF**
PH							
LL	0.578**						
LW	0.531**	0.575**					
PL	0.833**	0.441*	0.390 ns				
NT	0.023 ns	-0.051 ns	-0.339 ns	0.159 ns			
NPT	0.084 ns	-0.094 ns	-0.364 ns	0.152 ns	0.946**		
DF	-0.235 ns	-0.229 ns	-0.229 ns	-0.356 ns	-0.375 ns	-0.370 ns	

(PH) Plant Height. (LL) Leaf Length. (LW) Leaf Width. (PL) Panicle Length. (NT) Number of Tillers. (NPT) Number of Productive Tillers). DF (Days to Flowering) (ns) Not Significant. (*) Significant at p<5%. (**) Significant at p<1%

Table 6. Correlation coefficient of SBCB Population

	PH	**LL**	**LW**	**PL**	**NT**	**NPT**	**DF**
PH							
LL	0.357 ns						
LW	0.093 ns	0.278 ns					
PL	0.701**	0.153 ns	0.157 ns				
NT	-0.516**	-0.332 ns	0.499*	-0.179 ns			
NPT	-0.484*	-0.368 ns	0.461*	-0.183 ns	0.988**		
DF	0.162 ns	0.222 ns	-0.340 ns	0.135 ns	-0.384 ns	-0.375 ns	

(PH) Plant Height. (LL) Leaf Length. (LW) Leaf Width. (PL) Panicle Length. (NT) Number of Tillers. (NPT) Number of Productive Tillers). DF (Days to Flowering) (ns) Not Significant. (*) Significant at p<5%. (**) Significant at p<1%

Table 7. Correlation coefficient of TWCH population

	PH	**LL**	**LW**	**PL**	**NT**	**NPT**	**DF**
PH							
LL	0.094 ns						
LW	0.421*	0.073 ns					
PL	0.843**	0.152 ns	0.499*				
NT	0.317 ns	-0.271 ns	0.439*	0.402*			
NPT	0.369 ns	-0.278 ns	0.490*	0.404*	0.845**		
DF	0.405*	0.284 ns	0.036 ns	0.393 ns	-0.194 ns	-0.133 ns	

(PH) Plant Height. (LL) Leaf Length. (LW) Leaf Width. (PL) Panicle Length. (NT) Number of Tillers. (NPT) Number of Productive Tillers). DF (Days to Flowering) (ns) Not Significant. (*) Significant at p<5%. (**) Significant at p<1%

Table 8. Correlation coefficient of TWCB population

	PH	**LL**	**LW**	**PL**	**NT**	**NPT**	**DF**
PH							
LL	0.074 ns						
LW	0.489*	0.081 ns					
PL	0.662**	0.171 ns	0.534**				
NT	0.321 ns	0.090 ns	0.600**	0.489*			
NPT	0.350 ns	0.254 ns	0.587**	0.505*	0.888**		
DF	-0.273 ns	0.390 ns	-0.339 ns	-0.159 ns	-0.266 ns	-0.150 ns	

(PH) Plant Height. (LL) Leaf Length. (LW) Leaf Width. (PL) Panicle Length. (NT) Number of Tillers. (NPT) Number of Productive Tillers). DF (Days to Flowering) (ns) Not Significant. (*) Significant at p<5%. (**) Significant at p<1%

Based on Tables 5, 6, 7 and 8 shows that character of plant height has a positive and significant correlation with the character of leaf length, leaf width, panicle length and days to flowering. The degree of closeness of the relationship between plant height and leaf length. leaf width and days to flowering is classified as moderate. While with the panicle length is classified as strong and very strong. Regression analysis (Table 1) showed linear line between plant height and panicle length with the equation Y = 2.604 + 0.276X and $R^2 = 0.693$. It's mean, each addition of plant height then panicle length will increase by 0.276 cm.

Donggulo et al. (2017) states that plants height will use asymylate more for stem and leaf formation than the formation of number of tillers. This is indicated by the character of plant height which has a real negative correlation with the character of the number of tillers and the number of productive tillers. Regression analysis showed that the SBCB population (Table 2) has a regression function Y = 193.379 - 2.104X. The same results were also obtained from the research of Babu et al. (2012) and Venkanna et al. (2014) that there is a real negative relationship between plant height and the number of productive tillers.

The population of SBCH showed the character of leaf length has a positive and significant correlation with plant height. leaf width and panicle length. The character of leaf length with the character of plant height, leaf width and panicle length are classified as having a moderate relationship. Guru et al. (2017) states the character length. width and angle determine the shape and size of leaves. Long leaves are associated with droopy leaves, while short and small leaves tend to be associated with erect leaves.

Based on observations of leaf morphology, the four F_2 populations have leaf characters in the short to medium category and erect leaf angles. Whereas in leaf width characters are in the medium category. Putri (2017) states that short and upright leaves cause the leaf surface to get more sunlight so photosynthesis will be more optimal. This results in the photosynthate produced being used for the growth process such as elongation of the stem. The lengthening of the stem will determine the height of the plant. The same results were also obtained by the study of Francis et al. (2018) showed that leaf length was significantly positively correlated with the character of leaf width, plant height, panicle length and maturation.

Leaf width showed positive and significant correlation with number of tillers and the number of productive tillers. This is shown in the populations of SBCH. TWCH and TWCB. Leaves are the main source of assimilate-producing plants. The assimilation results are then spread throughout the plant parts for the process of growth and development. The shape of the leaves greatly affects the interception of sunlight radiation and its spread in the canopy. The wider the leaf. the greater the absorption of the sun's intensity will be indicated by the increase in the number of tillers and the number of productive tillers (Saidah et al., 2015).

The panicle length has positive and significant correlation with the number of tillers and the number of productive tillers. This is indicated by the population of TWCH and TWCB which has a moderate level of relationship. The same thing is also showed by the research of Rajeswari and Nadarajan (2004) that there is a positive and real relationship to the number of productive tillers and panicle length.

The number of tillers showed a positive and significant correlation value with the character of leaf width and number of productive tillers. This is shown in the TWCB population with a degree of closeness between the number of tillers and the leaves width classified as moderate. The number of productive tillers has positive and significant correlation with the number of tillers. This is shown in all F_2 populations having a very strong closeness between the number of productive tillers and the number of tillers.

This shows that the increasing number of tillers will be followed by an increase in leaf area so that the increase in sun absorption will also be greater as indicated by an increase in the number of

productive tillers (Saidah et al., 2015). The same results were also showed by the study of Muthuvijayaragavan and Murugan (2017) stating the number of tillers had a real positive correlation value with the character of the number of productive tillers.

Days to Flowering have positive and significant correlation with plant height. this is shown in the SBCH population. That is, the longer of days to flowering, the plant height will have a higher tendency. The same results were also shown by Riyanto et al. (2012) that plant height has positive and significant correlation with the percentage of grain content per panicles, days to flowering and age of harvest.

All of F_2 generations showed different results. This is presumably because each population has different genetic, morphological and physiological properties. This causes differences in the appearance of plants. In accordance with Alavan et al. (2015) which states that the high and low growth and yield of plants, besides being influenced by the environment are also influenced by genetic factors such as plant age, plant morphology, food reserve capacity and disease resistance.

Conclusion

The fourth generation of F2 rice population showed a positive linear relationship between plant height with panicle length and character of the number of tillers with the number of productive tillers. The SBCB population showed negative and significant correlation with moderate closeness, namely the character of plant height with the number of tillers and the number of productive tillers. The population of TWCH has a positive and significant correlation with strong closeness which is the character of leaf width with the number of tillers. The positive correlation with closeness is very strong shown by the four populations, namely the character of plant height with panicle length and the character of the number of productive tillers with the number of tillers.

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