CHAPTER 3

CORRELATION AND PATH COEFFICIENT ANALYSIS FOR AGRONOMIC CHARACTERISTICS, GRAIN YIELD AND TOTAL PHENOLIC CONTENT OF NATIVE PURPLE GLUTINOUS RICE

Abstract

This study aims to analyze correlation and path coefficient among agronomic characteristics, grain yield and grain total phenolic content. Study materials were 26 varieties of native purple glutinous rice. This study was conducted at Lamphun College of Agriculture and Technology during March – December 2007. Field data i.e. phenological development, grain yield and yield components as well as total phenolic content in grain were collected. Analysis results reveal that significant positive correlation were found among grain yield with panicle length and 1,000-grain weight. In contrast, number of days to heading and number of sterile grain per panicle show negative correlation with grain yield. It was also found that 1,000-grain weight and panicle length positively correlated with total phenolic content. Analysis of path coefficients clearly demonstrate that 1,000-grain weight show strongly total effect on grain yield (0.623). Moreover there was also showed indirect effect of 1,000-grain weight via panicle length (0.272) on grain yield are positive. Even though the direct effects of panicle length on grain yield were found negative (-0.072) but the coefficients of indirect effects of panicle length via 1,000-grain weight (0.327) were positive. Thus it produced positive correlation among panicle length and grain yield. Results from this study suggest that grain weight and panicle length were major factors that influenced both direct and indirect effect on grain yield. Hence improving grain yield and grain total phenolic content of native purple glutinous rice, plant breeder should pay priority attention on both factors.

3.1 Introduction

Purple glutinous rice is a native rice variety in which it has black or purple color grain. Normally purple glutinous rice varieties are photoperiod sensitive. Purple glutinous rice has specific phenotype in which the leaf and stem color are purple. The level of purple color vary among genotypes. The purple color found in leaf stem and grain is primarily due to its high in mixture of anthocyanins content which located in the aleurone layer (Hu *et al*., 2003). The mixture of anthocyanins are naturally occurring as compounds that belong to phenolic group which relate to the antioxidant.

Purple glutinous rice generally grown in the North and North eastern part of Thailand. This is because it has great ability to recover from drought condition which normally occur in the area. However, the purple glutinous rice is well adapted to the upland condition in which it produces lower yield as compare the lowland rice. Rice yield is the product of yield components i.e. number of panicle per area, number of fertile grain per panicle and grain weight. Yoshida (1981) stated that enhancing rice yield can be achieved by increasing each of yield components. However, increasing each yield components variable could decrease the others. This follow the law of compensation. Both environmental factors and genetic control the variation of yield components. Even though the correlation analysis among yield and yield components can express the relationship among them both positive and negative, however such analysis does not investigate the direct and indirect effect of one variable that may indirectly influence yield through another variables. The path coefficient analysis is a statistical procedure that can be use to analyze both direct and indirect effect of independent variables on dependent variable. Path coefficient analysis has been successfully analyzed relationship between yield and yield components of soybean (Pandey and Torrie, 1973), maize (Ivanovic and Rosic, 1985), sugarcane (Milligan *et al*., 1990; Gravois *et al*., 1991), rice (Sΰrek and Beser, 2003), cotton (Rauf *et al*., 2004) and pearl millet X elephant grass (Diz *et al*., 1994). This study aims to investigate relationship among agronomic characteristics of purple glutinous rice and yield as well as total phenolic content in grain using path coefficient analysis. Result of this study can be an essential information for purple glutinous rice variety selection and improvement for high yield and grain quality in terms of high antioxidant.

3.2 Materials and methods

Twenty six varieties of purple glutinous rice (Table 3.1) were planted in 3 x 5 meter plots with spacing of 30 x 25 centimeter at upland field experiment of Lamphun College of Agriculture and Technology, Mae Tha district, Lamphun province. Design of the experiment was randomized completed block design with 3 replications. Twenty one days after planting, nitrogen fertilizer (16-20-0) were apply at 156.25 kg/ha. Urea (46-0-0) were apply twice at tillering and panicle initiation stage at the rate of 156.25 and 62.5 kg/ha respectively. Water and pest management were treated at suitable level through out the growing period.

Phenological stage i.e. number of days to heading and physiological maturity stages were recorded. Plant height were recorded from ground level to panicle base at maturity. Panicle length was also recorded. Grain yield was collected from 1 m^2 area. Yield components i.e. number of panicle per hill, number of grain per panicle and grain weight were collected. Rice grains were sampling and dehulled to produce brownrice. Total phenolic content of brownrice was then analyze using Folin-Ciocalteu method (Nakornriab *et al*., 2007).

Pearson correlation were performed among variables collected. In addition, path coefficient analysis was used to investigate direct and indirect effect of collected variables related to agronomic characteristics on grain yield and total phenolic content using SPSS/AMOS as suggest by Garson (2010).

Table 3.1 Purple glutinous rice varieties used in this study.

No.	Variety name	Source
1	MHS 1	Mae Hong Son Province
2	Chiang Saen	Chiang Saen District, Chiang Rai Province
3	PGMHS 3	Mae Hong Son Rice Research Center
4	Kum Doi Sa Ket	Chiang Mai University
5	PGMHS 5	Mae Hong Son Rice Research Center
6	PGMHS 6	Mae Hong Son Rice Research Center
7	PGMHS 7	Mae Hong Son Rice Research Center
8	PGMHS 8	Mae Hong Son Rice Research Center

Table 3.1 (Continue)

No.	Variety name	Source
9	PGMHS 9	Mae Hong Son Rice Research Center
10	PGMHS 10	Mae Hong Son Rice Research Center
11	PGMHS 11	Mae Hong Son Rice Research Center
12	PGMHS 12	Mae Hong Son Rice Research Center
13	PGMHS 13	Mae Hong Son Rice Research Center
14	PGMHS 14	Mae Hong Son Rice Research Center
15	PGMHS 15	Mae Hong Son Rice Research Center
16	PGMHS 16	Mae Hong Son Rice Research Center
17	PGMHS 17	Mae Hong Son Rice Research Center
18	PGMHS 18	Mae Hong Son Rice Research Center
19	No.16815	Chiang Mai University
20	Samoeng No.1	Samoeng Rice Research Center, Chiang Mai
21	Samoeng No.2	Samoeng Rice Research Center, Chiang Mai
22	Samoeng No.3	Samoeng Rice Research Center, Chiang Mai
23	Samoeng No.4	Samoeng Rice Research Center, Chiang Mai
24	Samoeng No.7	Samoeng Rice Research Center, Chiang Mai
25	Samoeng No.8	Samoeng Rice Research Center, Chiang Mai
26	Nong Khao 2	Mae Hong Son Province

3.3 Results and Discussion

Correlation analysis result (Table 3.2) revealed that there was significant positive correlation among yield, panicle length and 1,000-grain weight. In contrast, grain yield has negative significant correlation with number of days from planting to heading and number of sterile grains per panicle. This analysis pointed out that grain yield of purple glutinous rice varieties in this study demonstrated relationship with grain weight which is the only one factor yield components. Number of panicles per hill and number of grains per panicle did not show significant correlation with grain yield. Thus grain weight is an essential factor for yield enhancement. However it was also found that plant height and number of grains per panicle has significant positive correlation. This probably because of the higher plant height related with greater leaf area. Sheehy *et al.* (2001) found that there was positive correlation among leaf area and number of grains per panicle. The leaf area is considered as the source for producing starch and sugar.

Table 3.2 Correlation coefficient among agronomic characteristics and grain yield of purple glutinous rice (n = 26).

	Day to Heading	Pan/hill	Duration	Grain-1000	Sterile	Pan Length	Height	No.grain/pan
Pan/hill	-0.6731**							
Duration								
Grain-1000	-0.4291*							
Sterile				-0.4316*				
Pan Length	-0.4415*	0.4700*		0.6047**				
Height		-0.4741*						
No.grain/pan	-0.3889*						0.4195*	
Yield	-0.5328**			0.6232**	-0.5371**	0.4404*		

* = Significant at 5% level of P, ** = Significant at 1% level of P, Day to Heading = No.of days to heading, Pan/hill = No. of Panicle per hill, Duration = Grain filling duration, Grain-1000 = 1,000 - grain weight, Sterile = No. of Sterile grain per panicle, Pan Length = Panicle length, Height = Plant height, No.grain/pan = No. of Grain per panicle, Yield = Grain yield

The pathways through which the agronomic characteristics operated to produce their genotypic association with grain yield reveal direct and indirect contributions (Table 3.3) and are demonstrated diagrammatically in figure 3.1. It was found that there was the negative total effect of number of days from planting to heading on grain yield (-0.533). This result suggested that the purple glutinous rice variety which has shorter period from planting to heading would produce greater yield than that of variety which has longer heading period. However the direct effect of number of days to heading on grain yield is positive (0.215). The reason for negative total effect found because of there were negative indirect effect among grain yield and grain filling duration (-0.132), number of panicles per hill (-0.197), number of grains per panicle (-0.194) and 1,000-grain weight (-0.325). Ram (1992) also reported similar result which indicated that grain yield was influenced by number of panicles per hill, number of grains per panicle and 1,000-grain weight.

The direct effect of panicle length through is negative but insignificant (-0.072). However the indirect effect of panicle length via 1,000-grain weight is positive and strong (0.327) thus result in the positive total effect which is 0.44.

The similar result also reported by Ibrahim et al. (1990) and Surek and Beser (2003) in which they found the positive correlation among grain yield and panicle length. In addition path coefficients (Table 3.3) suggested that rice variety with long panicle which produce high grain yield is associated with other factors such as 1,000-grain weight.

The total effect of sterile grain on grain yield was negative (-0.537). Similarly direct effect of sterile grain on grain yield was also negative (-0.414). From the analysis of path coefficients revealed that the indirect effect of 1,000-grain weight was stronger (-0.143) than the other indirect effect variable i.e. number of days to heading (-0.025), grain filling duration (0.025), plant height (0.009), number of panicles per hill (0.020), panicle length (-0.058) and number of grains per panicle (0.049).

The analysis of relationship among 1,000-grain weight and grain yield demonstrated that the direct effect was insignificant where the path coefficient is 0.074. However there was strong effect of the total effect (0.623). The strong total effect was a result of indirect effect of number of days to heading (0.162), panicle length (0.272) and number of sterile grain per panicle (0.219). All of these indirect effect showed positive effect on grain yield. This result indicated that 1,000-grain weight did not influence directly on grain yield but being influenced by indirect factors. Generally, rice varieties which have greater grain weight was associated with greater grain yield (Yang, 1986; Ram, 1992; Mehetre *et al*., 1994; Samonte *et al*., 1998 and Surek *et al*., 1998). Interestingly, it was found that direct effect of 1,000-grain weight showed positive correlation with number of sterile grains per panicle. It can be explained that having great number of sterile grains per panicle resulted in fewer number of fertile grains per panicle. Accordingly, the fertile grains would have better chance of gaining assimilate thus resulted in heavier grain weight.

Table 3.3 Direct and indirect effect of agronomic characteristics on grain yield.

Path ways of association	Direct effect	Indirect effect	(r)
1 Day to Heading			
(a) direct effect	0.215		
(b) indirect effect via			
Duration		-0.132	
Height		-0.019	
Pan/hill		-0.197	
Pan Length		0.196	
No.grain/pan		-0.194	
Sterile		-0.077	
Grain-1000		-0.325	
(c) Total effect			-0.533
2 Pan Length			
(a) direct effect	-0.072		
(b) indirect effect via			
Day to Heading		-0.118	
Duration		0.023	
Height		0.010	
Pan/hill		0.066	
No.grain/pan		0.098	
Sterile		0.106	
Grain-1000		0.327	
(c) Total effect			0.440
3 Sterile			
(a) direct effect	-0.414		
(b) indirect effect via			
Day to Heading		-0.025	
Duration		0.025	
Height		0.009	
Pan/hill		0.020	
Pan Length		-0.058	
No.grain/pan		0.049	
Grain-1000		-0.143	
(c) Total effect			-0.537

Table 3.3 (Continue)

	Path ways of association	Direct effect	Indirect effect	(r)
4	Grain-1000			
	(a) direct effect	0.074		
	(b) indirect effect via			
	Day to Heading		0.162	
	Duration		0.007	
	Height		-0.005	
	Pan/hill		-0.023	
	Pan Length		0.272	
	No.grain/pan		-0.083	
	Sterile		0.219	
	(c) Total effect			0.623

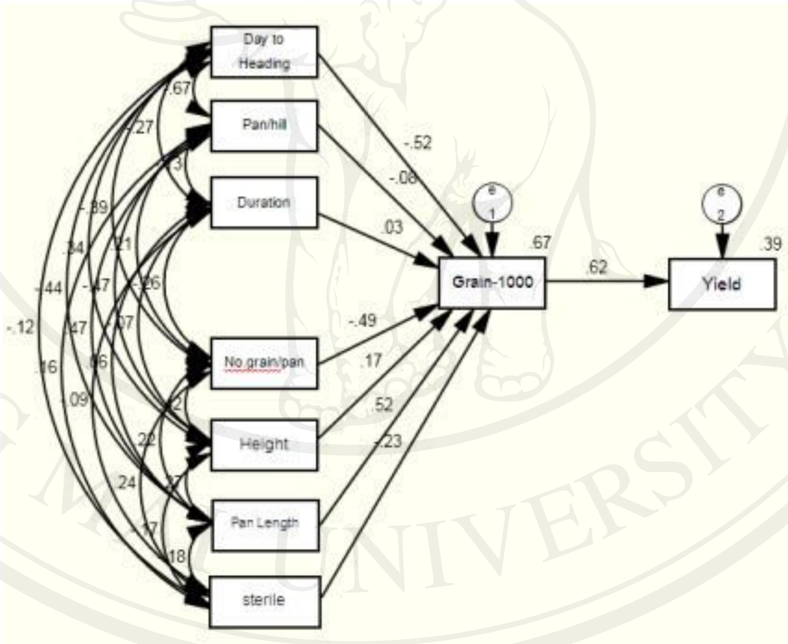

Figure 3.1 Diagrammatic representation of direct and indirect effect of agronomic characteristics on grain yield.

Simple correlation analysis of total phenolic content in brown rice grain and agronomic characteristics variables (Table 3.4) demonstrate the significant relationship of total phenolic content with panicle length and 1,000-grain weight. This result suggested that the larger grain may accumulate total phenolic content in the larger areulone layer this is because larger grain would have greater surface area and thicker areulone layer of the brown rice than the smaller grain. Chung *et al*. (2003)

also reported that pigment in rice grain including phenolic was significant associated with brown rice produced. Rice with the longer panicle may also have ability to produce phenolic and accumulate in rice grain than that of rice which have the shorter panicle.

Path coefficient analysis (Table 3.5) showed that there was moderate positive direct effect of panicle length on total phenolic content in grain (0.414). The indirect effect of panicle length via number of days to heading (0.087), 1,000-grain weight (0.131), grain yield (0.007) and percentage of bran (0.094) were all positive thus resulted in strong positive total effect (0.733). It was noticed that indirect effect of panicle length via 1,000-grain weight was greater than the others which suggested that 1,000-grain weight has stronger effect than the others variables in which Chung *et al*. (2003) also reported similar result.

The direct effect of 1,000-grain weight on grain phenolic content in brown rice grain was negative. However the total effect was found stronger and positive (0.515). This was the result of the indirect effect of 1,000-grain weight on number of days to heading (0.063), panicle length (0.264), grain yield (0.106) and percentage of bran (0.195) were all positive. It was also notice that the indirect effect of 1,000-grain weight via panicle length and percentage of bran were stronger than that of number of days to heading and grain yield.

Table 3.4 Correlation coefficient among agronomic characteristics and total phenolic content of purple glutinous rice.

	Day to Heading	Pan Length	Grain-1,000	Yield	Bran
Pan Length	-0.4415**				
Grain-1000	-0.4291**	0.6047**			
Yield	-0.5328**	0.4404**	0.6232**		
Bran			0.4107*		
Phenolic		0.7335**	0.5155**		

*= Significant at 5% level of P, ** = Significant at 1% level of P, Day to Heading = No.of days to heading, Pan Length = Panicle length, Grain-1,000 = 1,000 - grain weight, Yield = Grain yield, Bran = Percentage of bran, Phenolic = Total phenolic content

Table 3.5 Direct and indirect effect of agronomic characteristics on total phenolic content.

Path ways of association	Direct effect	Indirect effect	(r)
1 Pan Length			
(a) direct effect	0.414		
(b) indirect effect via			
Day to Heading		0.087	
Grain-1000		0.131	
yield		0.007	
Bran		0.094	
(c) Total effect			0.733
2 Grain-1000			
(a) direct effect	-0.113		
(b) indirect effect via			
Day to Heading		0.063	
Pan Length		0.264	
yield		0.106	
Bran		0.195	
(c) Total effect			0.515

3.4 Conclusion

Simple correlation analysis pointed out that number of days to heading, 1,000-grain weight, number of sterile grains per panicle and panicle length were correlated with grain yield. However the path coefficient analysis further magnified factors that influenced grain yield particularly 1,000-grain weight and panicle length. The path coefficient analysis demonstrated significant total effect of 1,000-grain weight on grain yield. Moreover the indirect effect of 1,000-grain weight via panicle length was also strong. Interestingly the direct effect of panicle length on grain yield was negative but the indirect effect of panicle length via 1,000-grain weight was great and positive with resulted in positive total effect. The simple correlation analysis also showed positive correlation among total phenolic content and panicle length thus the overall analysis showed the essential of 1,000-grain weight and panicle length in relation with both yield and grain phenolic content which indicated grain quality. So the improvement or selection of purple glutinous rice variety may give priority to both factors.