Genetic Correlations Analysis of Seed, Cytoplasm and Maternal Plant for Nutrient Quality in indica Rice

SHI Chunhai[1], YU Yonggui[2], XUE Jianming[2], YANG Xiao'e[2], ZHU Jun[1]
([1] *Department of Agronomy*, [2] *Department of Soil Science and Agricultural Chemistry, Zhejiang Agricultural University, Hangzhou* 310029)

籼稻稻米营养品质性状的种子、细胞质和母体遗传相关分析

石春海[1] 余永贵[2] 薛建明[2] 杨肖娥[2] 朱 军[1]
([1]浙江农业大学农学系,浙江农业大学土化系,杭州 310029)

摘 要:利用9个籼型不育系和5个籼型恢复系进行不完全双列杂交,同时分析了早籼稻米蛋白质含量、蛋白质指数、赖氨酸含量、赖氨酸指数以及赖氨酸含量与蛋白质含量的比值等营养品质成对性状间种子、细胞质和母体等多种遗传相关。结果证实蛋白质含量与蛋白质指数等多数成对性状间的种子加性和显性相关、细胞质相关以及母体加性和显性相关系数均为显著正值,对这些性状进行间接改良有效。但赖氨酸含量与蛋白质含量的比值同蛋白质性状的关系则以显著负相关为主,表明选择高蛋白质含量或蛋白质指数的单株将会显著降低该比值。正向的种子和母体显性相关以及细胞质相关可以同时显著提高杂交稻组合中赖氨酸含量和赖氨酸指数以及赖氨酸含量与蛋白质含量比值。对于主要受加性相关控制的成对性状进行间接选择具有较好的效果,而杂交稻育种中则以利用显性相关为主。

关键词:遗传相关;营养品质;籼稻

Abstract: Nine cytoplasmic male sterile lines and five restoring lines were used in an incomplete diallel cross for analyzing genetic correlations of nutrient quality traits (protein content, protein index, lysine content, lysine index and the ratio of lysine content to protein content) of milled rice in indica rice (*Oryza sativa* L.). The results indicated that the genetic correlations of seed, cytoplasm and/or maternal plant are responsible for genetic correlations of most pairwise nutrient quality traits. The seed additive and dominance correlations, cytoplasmic correlations, maternal additive and dominance correlations for most pairwise traits studied were significantly positive. Some of the pairwise traits had negative genetic correlations especially for the traits between nutrient quality traits and the ratio of lysine content to protein content. Indirect selection for those traits with additive correlations was better than with dominance correlations. But the dominance correlations could be effectively used in hybrid rice breeding. The cytoplasmic correlations could be applied in both conventional crossing breeding and hybrid rice breeding.

Key words: genetic correlations; indica rice; nutrient quality

For breeding a new rice variety, breeders are more concerned with the combination of multiple traits in selection process. The relationship among some traits in rice has been studied in terms of phenotypic, genetic or environment correlation. Significant relationship was found for some traits and correlation studies have provides a general perspective of the genetic associations among rice traits. Shen[2], Kuo and Hsien[3] studied genetic and environmental correlations of agronomy traits of rice. Li and Yang found additive correlation coefficients were from

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−0.773 to 0.993 for some flower traits in rice[4]. Yu found that additive correlation was significant for some traits in barley[9]. Shi and Zhu pointed out that additive correlations were more important than dominance correlations between rice exterior quality traits and other milling, cooking or nutrient quality traits[6]. Up to now, little information is available about genetic correlation components of seed additive and dominance effects, cytoplasmic effects, and maternal additive and dominance effects for nutrient quality traits of milled rice. In this paper the mixed model approaches were used for estimating genetic variances and covariances to determine the genetic correlations among traits of nutrient quality of milled rice.

1 Materials and Methods

Nine females (Zhenshan 97A, etc.) were crossed to each of five males (Cezao 2-2, etc.) of indica rice in an incomplete diallel cross (9×5). The seeds of parents and F_1's were sown on 28 March and single plant per hill was transplanted to the paddy field at Zhejiang Agricultural University on 29 April in 1994. There were 24 plants in a plot at space of 20 cm×20 cm with three replications. Seed samples of parents or F_2s in F_1's plants were drawn at maturity from eight plants in the middle part of the plot. The F_1 seeds used for analyzing were obtained by crossing CMS lines to restoring lines at flowering during the early season. Quantitative traits evaluated by three replications for each sample were protein content determined by Semi-Micro Kjeldahl method (PC, %)[1], protein index (milligrams of protein per milled rice, PI), lysine content determined by using the method of Yuan *et al.* (LC, %)[8], lysine index (milligrams of lysine per milled rice, LI) and the ratio of lysine content to protein content (RLP) of milled rice.

Analysis of genetic correlations was conducted for nutrient quality traits in indica rice by using a genetic model for endosperm traits of cereal crops[10,11]. MINQUE (0/1) method were used to obtain estimated variances of traits and covariances for pairwise traits. The genetic correlation components analyzed were seed direct additive correlation (r_A), seed direct dominance correlation (r_D), cytoplasmic correlation (r_C), maternal additive correlation (r_{Am}), maternal dominance correlation (r_{Dm}), and residual correlation (r_e).

The Jackknife method was used to derive the standard errors of estimated components of correlation coefficients[5]. All data were analyzed on an IBM PC computer by programs written in C.

2 Results

Total genetic correlations include components of r_A, r_D, r_C, r_{Am} and r_{Dm}. The estimates of the genetic correlation components and r_e among nutrient quality traits in milled rice are presented in Table 1.

2.1 Estimation of correlations for seed direct genetic effects

The seed direct genetic correlations included r_A and r_D. Significantly positive additive correlations (r_A) were detected between PC and PI, PC and LC, and PI and LI. Negative additive correlations were found between RLP and other nutrient quality traits. The seed dominance correlations (r_D) between PC and RLP, and PI and RLP were significantly negative, while other pairwise traits studied were highly significantly positive.

2.2 Estimation of correlations for cytoplasmic genetic effects

The cytoplasmic genetic effects of organelles such as chloroplast and chondriosome were not negligible in rice breeding. The effects of cytoplasm could be inherited by females. So it is important to understand the correlations of cytoplasm (r_C) between two traits. Positive cytoplasmic correlations between most of the nutrient quality traits studied were detected except for the pairwise traits of PC and PI, PC and LC, and PC and LI.

2.3 Estimation of correlations for maternal genetic effects

Seeds are the offspring grown on their maternal plants which provide the nutrients in endosperm. There were significant maternal effects on nutrient quality traits of milled rice[7]. Maternal genetic correlations were found to be important for all nutrient

Table 1. Genetic correlation components among nutrient quality traits in indica rice

	Traits	r_A	r_D	r_C	r_{Am}	r_{Dm}	r_e
PC &	PI	0.398**	0.718**	−0.455**	0.473**	0.488**	0.746**
	LC	0.394**	0.442**	−0.523**	0.292**	0.285**	0.117*
	LI	0.055	0.360**	−0.065	0.141**	0.219**	0.211**
	RLP	−0.393**	−0.176**	0.196**	−0.318**	−0.035	−0.586**
PI &	LC	0.382**	0.325**	0.247**	0.337**	0.165**	0.002
	LI	0.157**	0.305**	0.413**	0.268**	0.251**	0.584**
	RLP	−0.235**	−0.203**	0.246**	−0.132*	−0.054	−0.468**
LC &	LI	0.096	0.561**	0.220**	0.090	0.695**	0.731**
	RLP	−0.309**	0.400**	0.097*	−0.323**	0.632**	0.736**
LI &	RLP	−0.103*	0.355**	0.201**	−0.155**	0.594**	0.431**

* and** at 5% and 1% significant level, respectively. PC=protein content, PI=protein index, LC=lysine content, LI =lysine index, and RLP=the ratio of lysine content to protein content.

quality traits. maternal additive correlations (r_{Am}) were significantly positive for most pairwise traits except for the relationship between RLP and other nutrient quality traits. Maternal dominance correlation (r_{Dm}) were all significantly positive among nutrient quality traits except for PC and RLP or PI and RLP. Therefore, the performance of correlations for maternal genetic effects were similar to those of seed direct effects.

2.4 Analysis of correlations for pairwise traits

The r_A, r_D, r_C, r_{Am} and r_{Dm} of the pairwise traits seem mostly to be significantly positive (Table 1). Some genetic correlations were negative for the pairwise traits especially for RLP and other nutrient quality traits. The correlation coefficients (r_A, r_D, r_C, r_{Am} and r_{Dm}) between PI and LC, and between PI and LI were significantly positive. Such association may suggest that genetic materials or hybrid rice with higher PI might have good rice increasing PI, LC and more LI. Possibility of simultaneously increasing PI, LC and LI was expected in rice breeding for improving these nutrient quality traits. The indirect selection in early generations could be influenced by r_D and r_{Dm}. Although seed and maternal additive correlations (r_A and r_{Am}) were not significant between LC and LI, the seed dominance correlation (r_D), cytoplasmic correlation (r_C) and maternal dominance correlation (r_{DM}) were 0.561**, 0.220** and 0.695** respectively. It was suggested that high LC with more LI in indica hybrid crosses was possible. Since r_A and r_{Am} were not significant between LC and LI, the offsprings with high LC and LI might still be obtained by using indirect selection in later generations. Although r_A, r_D, r_{Am} and r_{Dm} were all positive for the pairwise traits of PC and LI, PC and LC, PC and LI, r_C was negative and might reduce the selective effects for these pairwise traits. The r_A, r_D, r_{Am} and r_{Dm} in pairwise traits of RLP and PC or PI were negative except for r_C. It was difficult to select the plant and/or crosses with high RLP and PC and PI in rice breeding. Since there were positive additive correlation (r_A and r_{Am}) between LC and PC, when we selected the plants with high LC and LI, RLP in milled rice could be still decreased because of the negative r_A and r_{Am} between LC and RLP or LI and RLP. Therefore, it was difficult to increase both RLP and LC and/or LI by indirect selection for rice breeding. But positive r_D, r_C and r_{Dm} suggested the possibility of improving these pairwise traits could be obtained for indica hybrids.

Since most residual correlations (r_e) were most significant, so the relationships of nutrient quality traits of milled rice were also influenced by sampling errors.

3 Discussion

Content of protein and lysine of milled rice is related to nutrient quality of food. Selecting good quality of rice is one of the major breeding aims and breeders are now paying much more attention to it. Although rice quality can be affected by environments,

there is a large amount of variation among varieties. *It is possible to increase rice quality by breeding approaches.*

Indirect selection can be efficiently used in rice breeding according to the magnitude of genetic correlation components. When one trait can not be easily measured, it is better to indirectly select other traits with highly additive correlation (r_A and/or r_{Am}) and cytoplasmic correlation (r_C) to it, such as the pairwise traits of PI and LC or PI and LI. On the other hand, if the relationship between two traits was mainly controlled by dominance correlations such as the pairwise traits of LC and LI, breeding hybrid rice could be used to improve the quality of milled rice for related traits at the same time. Otherwise, the cytoplasmic correlations could be applied in both conventional crossing breeding and hybrid rice breeding. It is helpful for breeders to understand the genetic mechanism of quantitative traits in milled rice by analysis of genetic components of correlation. The analysis results of genetic correlation in this experiment could be used in rice nutrient quality breeding and the analysis method for genetic correlations could also be applied in other cereal crops.

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