Madras Agric. J. 90 (4-6) : 224-227 April-June 2003

Genetic analysis of kernel quality traits in rice

MOHAN ANDRE SAVERY AND J. GANESAN
Dept. of Agrl. Botany, Faculty of Agriculture, Annamalai Univ., Annamalainagar-608 002, Tamil Nadu

Abstract: In rice, genetics of kernel quality traits *viz.* kernel length, kernel L/B ratio, kernel length after cooking, kernel elongation, and elongation index was studied in five crosses. All the quality traits were governed by additive, dominance and epistatic interactions of additive x additive, additive x dominance and dominance x dominance and duplicate type. Pedigree method of breeding followed by selection in later generations involving one or two cycles of intermating of selected segregant is suggested for improvement.

Key words : Basmati rice, Kernel quality, Gene action.

Introduction

Studies on the nature of gene action governing the yield and its component traits in rice are available in plenty while information on the genetics of kernel quality traits such as grain size, shape and elongation on cooking are limited. Hence, an attempt was made to unravel the genetic architecture of some of the kernel quality involving basmati and non-basmati rice varieties.

Materials and Methods

Five high yielding cosmopolitan rice varieties *viz.* ASD 19, ADT 38, ADT 39, CO 43 and improved White Ponni were crossed with Pusa Basmati 1 during summer 1996 at the Plant Breeding Farm, Department of Agricultural Botany, Faculty of Agriculture, Annamalai University, Annamalainagar. Five hybrids along with the parents were raised during the Kuruvai 1996 (May-Sept). The F1s were used as female and pollen from their corresponding parents were dusted separately to obtain the two back cross progenies *viz.* B_1 (F_1/P_1) and B_2 (F_1/P_2). Fresh crosses were also effected to obtain F_1 seeds. Selfing of parents and all F_1s was also done to obtain seeds of P_1, P_2 and F_2 generations.

All the six generations *viz.* P_1, P_2, F_1, F_2, B_1 and B_2 of each of the five crosses were raised in randomised block design with three replications during late Thaladi 1997 (Oct-Feb). The plot size for each cross was 6 x 3 m with a spacing of 30 x 20 cm. Ten plants in each of P_1, P_2 and F_1; 40 plants in each of B_1 and B_2 and 70 plants in F_2 generation per replication were randomly selected to record observations on the following traits *viz.* kernel length, kernel L/B ratio, kernel length after cooking, kernel elongation and elongation index.

Seeds hulled in McGill sample sheller were used to measure kernel length in mm with Mitutoyo micrometer. The ratio of kernel length to kernel breadth was computed as kernel L/B ratio. For cooking test, four months old samples were used for analysis. The hulled seeds were milled in KETT rice polisher uniformly for 40 seconds. The milled rice was cooked as per the method of Juliano and Perez (1984) Ten randomly selected whole milled kernels before and after cooking were measured in mm with a graduated card board (Pillaiyar and Mohandoss, 1981). The ratio of the mean length of cooked rice to mean length of milled rice was computed as kernel elongation. The elongation index was derived by dividing the mean L/B ratio of cooked rice with the mean L/B ratio of milled rice (Juliano and Perez, 1984).

The adequacy of additive-dominance model was studied by scaling test. In cases where the scales A or B or C or D significantly differed from zero, a digenic interaction model was assumed. Genetic components of generation

..ble 1. Generation means and estimates of gene effects

	ASD 19/Pusa Basmati 1	ADT 38/Pusa Basmati 1	ADT 39/Pusa Basmati 1	CO 43/Pusa Basmati 1	Improved White Ponni/Pusa Basmati 1
			Kernel length		
..eration					
	5.32 ± 0.025	6.29 ± 0.008	5.50 ± 0.012	5.47 ± 0.013	5.72 ± 0.016
	45 ± 0.019	7.45 ± 0.020	7.45 ± 0.020	7.45 ± 0.020	7.45 ± 0.020
	98 ± 0.043	6.27 ± 0.013	6.21 ± 0.013	6.17 ± 0.015	5.99 ± 0.017
	47 ± 0.006	6.34 ± 0.004	6.22 ± 0.005	6.11 ± 0.005	5.82 ± 0.005
	..12 ± 0.009	5.80 ± 0.006	5.66 ± 0.007	5.73 ± 0.034	6.37 ± 0.009
	6.12 ± 0.008	5.84 ± 0.008	6.50 ± 0.07	6.04 ± 0.034	6.75 ± 0.009
..ameter					
	5.79* ± 0.04	8.96* ± 0.03	7.04* ± 0.03	7.38* ± 0.10	3.62* ± 0.03
	-1.07* ± 0.02	-0.58* ± 0.01	-0.98* ± 0.01	-0.99* ± 0.01	-0.87* ± 0.01
	-1.46 ± 0.11	-7.78* ± 0.08	-2.44* ± 0.08	-3.85* ± 0.29	6.42* ± 0.10
	0.60* ± 0.03	-2.09* ± 0.03	-0.56* ± 0.03	-0.92* ± 0.10	2.96* ± 0.03
	0.07* ± 0.02	0.54* ± 0.01	0.14* ± 0.02	0.68* ± 0.05	0.49* ± 0.02
	1.65* ± 0.11	5.09* ± 0.06	1.61* ± 0.05	2.65* ± 0.20	-4.05* ± 0.07
			Kernel L/B ratio		
..eration					
	2.44 ± 0.014	3.33 ± 0.015	2.49 ± 0.017	2.46 ± 0.023	2.95 ± 0.019
	4.55 ± 0.035	4.55 ± 0.035	4.55 ± 0.035	4.55 ± 0.035	4.55 ± 0.035
	3.18 ± 0.023	3.41 ± 0.020	3.15 ± 0.018	3.08 ± 0.020	3.12 ± 0.030
	3.04 ± 0.010	3.43 ± 0.008	3.22 ± 0.009	2.98 ± 0.006	3.06 ± 0.009
	2.53 ± 0.008	3.01 ± 0.008	2.83 ± 0.009	2.63 ± 0.007	3.35 ± 0.015
	3.46 ± 0.014	3.11 ± 0.009	3.46 ± 0.011	3.08 ± 0.010	3.55 ± 0.012
..ameter					
	3.69* ± 0.05	5.43* ± 0.04	3.83* ± 0.05	4.02* ± 0.04	2.20* ± 0.06
	-1.06* ± 0.02	-0.61* ± 0.02	-1.03* ± 0.02	-1.04* ± 0.02	-0.80* ± 0.02
	-2.07* ± 0.14	-5.99* ± 0.11	-1.74* ± 0.13	-3.20* ± 0.11	2.52* ± 0.15
	-0.19* ± 0.05	-1.50* ± 0.04	-0.31* ± 0.04	-0.51* ± 0.04	1.55* ± 0.05
	0.12* ± 0.03	0.51* ± 0.02	0.40* ± 0.02	0.59* ± 0.02	0.59* ± 0.03
	1.57* ± 0.10	3.96* ± 0.08	1.07* ± 0.09	2.26* ± 0.08	-1.60* ± 0.11
			Kernel length after cooking		
..eneration					
	7.97 ± 0.035	8.40 ± 0.011	8.05 ± 0.017	8.18 ± 0.019	8.15 ± 0.023
	12.92 ± 0.034	12.92 ± 0.034	12.92 ± 0.034	12.92 ± 0.034	12.92 ± 0.034
	9.99 ± 0.072	10.84 ± 0.022	9.44 ± 0.308	9.63 ± 0.023	10.43 ± 0.032
	9.17 ± 0.009	10.89 ± 0.008	9.75 ± 0.070	10.75 ± 0.009	9.80 ± 0.009
	8.15 ± 0.014	9.80 ± 0.010	8.75 ± 0.068	8.95 ± 0.011	10.49 ± 0.015
	10.03 ± 0.013	9.52 ± 0.012	10.23 ± 0.011	10.66 ± 0.013	10.90 ± 0.014
..rameter					
	10.77* ± 0.06	17.02* ± 0.05	11.52* ± 0.14	14.34* ± 0.05	6.96* ± 0.06
	-2.48* ± 0.02	-2.26* ± 0.02	-2.44* ± 0.02	-2.37* ± 0.02	-2.39* ± 0.02
	-5.61* ± 0.17	-18.34* ± 0.13	-4.98* ± 0.52	-9.64* ± 0.14	7.89* ± 0.16
	-0.32* ± 0.05	-6.36* ± 0.04	-1.03* ± 0.14	-3.78* ± 0.05	3.58* ± 0.05
	0.60* ± 0.03	1.82* ± 0.03	0.96* ± 0.07	0.66* ± 0.03	1.98* ± 0.03
	4.84* ± 0.17	12.16* ± 0.09	2.90* ± 0.67	4.93* ± 0.10	-4.12* ± 0.12

*Significant at 5 per cent level.

Table 2. Generation means and estimates of gene effects

	ASD 19/Pusa Basmati 1	ADT 38/Pusa Basmati 1	ADT 39/Pusa Basmati 1	CO 43/Pusa Basmati 1	Improved Wh Ponni/Pus Basmati 1
			Kernel elongation		
Generation					
P_1	1.61 ± 0.010	1.37 ± 0.002	1.47 ± 0.003	1.51 ± 0.004	1.53 ± 0.0
P_2	2.10 ± 0.006	2.10 ± 0.006	2.10 ± 0.006	2.10 ± 0.006	2.10 ± 0.0
F_1	1.81 ± 0.014	1.86 ± 0.004	1.75 ± 0.004	1.74 ± 0.004	1.90 ± 0.0
F_2	1.80 ± 0.002	1.86 ± 0.001	1.78 ± 0.001	1.83 ± 0.002	1.82 ± 0.0
B_1	1.68 ± 0.003	1.66 ± 0.002	1.66 ± 0.002	1.67 ± 0.002	1.72 ± 0.0
B_2	1.75 ± 0.002	1.72 ± 0.002	1.76 ± 0.002	1.80 ± 0.002	1.78 ± 0.0
Parameter					
(m)	2.19* ± 0.01	2.42* ± 0.01	2.06* ± 0.01	2.19* ± 0.01	2.09* ± 0.0
(d)	-0.24* ± 0.01	-0.36* ± 0.003	-0.31* ± 0.003	-0.29* ± 0.004	-0.28* ± 0.0
(h)	-1.19* ± 0.03	-1.66* ± 0.02	-0.81* ± 0.02	-0.95* ± 0.02	-0.90* ± 0.
(i)	-0.34* ± 0.01	-0.68* ± 0.01	-0.28* ± 0.01	-0.38* ± 0.01	-0.28* ± 0.
(j)	0.17* ± 0.01	0.30* ± 0.004	0.21* ± 0.004	0.16* ± 0.005	0.22* ± 0.0
(l)	0.81* ± 0.03	1.11* ± 0.02	0.50* ± 0.02	0.47* ± 0.02	0.71* ± 0.
			Elongation index		
Generation					
P_1	1.10 ± 0.006	0.87 ± 0.005	0.93 ± 0.006	1.15 ± 0.009	0.95 ± 0.0
P_2	1.24 ± 0.010	1.24 ± 0.010	1.24 ± 0.010	1.24 ± 0.010	1.24 ± 0.01
F_1	1.10 ± 0.012	1.13 ± 0.008	1.18 ± 0.009	1.19 ± 0.010	1.16 ± 0.01
F_2	1.09 ± 0.009	1.14 ± 0.003	1.18 ± 0.003	1.33 ± 0.004	1.14 ± 0.00
B_1	1.05 ± 0.004	1.06 ± 0.011	1.13 ± 0.006	1.21 ± 0.004	1.10 ± 0.00
B_2	0.97 ± 0.004	1.03 ± 0.004	1.16 ± 0.005	1.14 ± 0.005	1.12 ± 0.00
Parameter					
(m)	1.49* ± 0.04	1.44* ± 0.03	1.21* ± -0.02	1.18* ± 0.02	1.21* ± 0.0
(d)	-1.07* ± 0.01	-0.19* ± 0.01	-0.15* ± 0.01	-0.04* ± 0.01	-0.14* ± 0.0
(h)	-1.20* ± 0.08	-0.89* ± 0.08	-0.09* ± 0.06	-0.30* ± 0.05	-0.24* ± 0.0
(i)	-1.31* ± 0.04	-0.39* ± 0.03	-0.12* ± 0.02	-0.61* ± 0.02	-0.12* ± 0.0
(j)	0.15* ± 0.01	0.21* ± 0.01	0.12* ± 0.01	0.12* ± 0.01	0.12* ± 0.01
(l)	0.82* ± 0.05	1.58* ± 0.05	0.06* ± 0.04	0.68* ± 0.04	0.19* ± 0.0

* Significant at 5 per cent level.

mean were estimated following six parameter model (Mather and Jinks, 1982).

Results and Discussion

Six varieties with diverse kernel characters were crossed to generate six generations involving five cross combinations. Means of each generation were calculated and scaling test was applied to test the adequacy of additive-dominance model. Based on scaling tests, a digenic epistatic model was assumed for all the traits studied. The mean value of kernel traits for six generations and estimates of gene effects are given in Table 1 and 2. The observed value of F_1 for all the kernel characters was intermediate between the two parental means.

Additive (d) and dominance (h) effects were negative and significant for kernel length. Murai and Kinoshita (1986) and Kato (1989) opined that grain size was governed by additive-dominance model. The additive x additive interaction effect was positive and significant in two crosses indicating enhancing effect. The additive x dominance and dominance x dominance

...fects were also significant and positive. The ...and 'l' effects recorded opposite signs for ...the kernel characters revealing the presence ...duplicate interaction. Additive, dominance ... epistatic interactions of all the three and ...licate type appear to govern kernel length.

The additive and dominance effects were ...ative and significant for kernel L/B ratio ... kernel length after cooking. Singh and ...charia (1977), Somrith *et al.* (1979), and ...gh and Singh (1985) reported that this was ...trolled by both additive and non-additive ...e actions, while Reddy and Nerkar (1991) ...rted the absence of epistasis for this trait. ...awgi *et al.* (1991) observed predominance ...non-additive component for kernel L/B ratio. ... additive x additive interaction effect was ...ificant and negative revealing a diminishing ...t. Both additive x dominance and dominance ...minance effects were positive and significant. ...ce additive, dominance and epistatic interactions ...all the three and duplicate type appear to ...uence kernel L/B ratio and kernel length ...r cooking.

The additive and dominance effects were ...ative and significant for kernel elongation ... elongation index. Siddiq (1980) reported ...kernel elongation was predominantly governed ... non-additive gene action. The additive x ...ditive interaction effect was negative and ...nificant while the additive x dominance and ...minance x dominance effect was positive ...d significant. Hence, additive, dominance and ...static gene actions of all the three and duplicate ...raction control kernel elongation and elongation ...ex. Tomar (1987) reported that additive and ...static reaction mainly of duplicate effects ...luenced kernel elongation.

The grain quality traits *viz.* kernel length, ...nel L/B ratio kernel length after cooking, ...nel elongation and elongation index were ...der the control of additive, dominance and ... the three kinds of epistatic interactions along ...h duplicate type.

As additivity was present for all the traits, ...digree method of breeding may be followed ... improvement of these traits. Since considerable ...ount of dominance effect was also present, selection has to be postponed to later generations until homozygosity is achieved. Since epistatic interactions of various kinds were also observed, one or two cycles of intermating of selected segregants will result in the improvement of kernel traits.

References

Juliano, B.O. and Perez, C.M. (1984). Results of a coroborative test on the measurement of grain elongation of milled rice during cooking. *J. Cereal Sci.* 281-292.

Kato, T. (1989). Inheritance of grain size in rice. *Japan J. Breed.* **39**: *Suppl.* **2**: 308-309.

Mather, K. and Jinks, J.L. (1982). *Biometrical Genetics*, New Fetterane, London.

Murai, M. and Konoshita, T. (1986). Diallel analysis of traits concerning yield of rice. *Japan J. Breed.* **36**: 7-15.

Pillaiyar, P. and Mohandoss, R. (1981). Cooking qualities of parboiled rices produced at low and high temperature. *J. Food Sci. Agric.* **32**: 115-120.

Reddy, C.D.R. and Nerkar, Y.S. (1991). Quantitative inheritance of panicle traits in Indica rice. *Crop Res.* **4**: 173-175.

Sarawgi, A.K., Srivastava, M.N. and Chowdhary, B.P. (1991). Partial diallel cross analysis of yield and its related characters in rice (*Oryza sativa* L.) under irrigated and rainfed situations. *Indian J. Genet.* **51**: 30-36.

Siddiq, E.A. (1980). High yielding basmati rice: problems, progress and prospects. *Research Bull.* **30**. Indian Agricultural Research Institute, New Delhi.

Singh, N.B. and Singh, H.G. (1985). Heterosis and combining ability for kernel size in rice. *Indian J. Genet.* **45**: 181-185.

Singh, R.S. and Richharia, A.K. (1977). Combining ability for grain dimensions and shape in unhusked rice. *Indian J. Agric. Sci.* **47**: 54-57.

Somrith, B., Chang, T.T. and Jackson, B.B. (1979). Genetic analysis of traits related to grain characteristics and quality in two crosses of rice. *IRRI Res. Pap. Ser.* **35**, International Rice Research Institute, Manila, Philippines.

Tomar, J.B. (1987). Analysis of genetic components of generation mean for some quality characters in rice. *Oryza*, **24**: 112-118.

(Received : August 2000 ; Revised : February 2003)