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Genetic Diversity and Combining Ability of Maize Landraces from China's Sichuan Basin

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Maize landraces are adapted to the specific environmental conditions of their habitats and selection by humans. It is important to systemically evaluate landraces for desired traits and to maintain this genetic diversity for future plant breeding. The objective of this research was to characterize the agronomic and quality traits of 22 maize landraces and select the landraces with important traits and the most potential for future breeding programs.

The 22 landraces selected, on the basis of their origin, agronomic performance and other important characteristics as determined by The Institute of Variety Resources Research, CAAS (1988), for this study included:. Hanyuanhongbaogu, Baibaogu, Jinhuanghou, Wenchuanerbai, Rongzhaiyumi, Nuoyumi, Dadudu, Yuzuibaogu, Qiuzi, Daguangyuan, Lengfengwu, Dabaimaya, Junlianhongbaogu, Wuer, Xuesi, Dahuang, Xiaobai, Dababai, Dazhaibaogu, Dabanya, Ganzierbai, and Dazihuang.

In the fall of 2006, the 22 landraces were planted in Yuanjiang, Yunnan. Data was recorded on plant height, ear height, total leaf number, ear length, barren-tip length， number of rows per ear, kernels per row, kernel depth, grain yield, kernel weight, oil composition, protein and starch content. During flowering, 13 of these races with medium to late maturity ratings and five testers (478, Mo17, 48-2, 9636 and Huangzao4) were chosen to create a diallel cross to examine combining abilities. For each of the landraces, pollen was combined from 30 plants and used to pollinate the five testers in the diallel method of North Carolina Design II (NCII). In the spring of 2007, the resulting 65 F_1 crosses were evaluated in Duoying, Ya'an, and grain yield per plant was recorded.

Analysis of variance (ANOVA) was carried out by the DPS2000 method (http://www.chinadps.net). Coefficient of variation (CV) was analyzed among populations by using Microsoft Excel (2003) to determine which had significantly different traits. The CV was computed as: $CV(\%) = \frac{s}{\bar{x}} \times 100$, where $\bar{x}$ was mean of a trait, 's' was standard deviation. General combining ability (GCA) and specific combining ability (SCA) of grain yield in the 13 landraces were calculated by using the incomplete diallel cross model (Ming et al. 1994; Rong et al. 2003). Heterosis was investigated by analyzing the SCA for grain yield per plant.

ANOVA revealed that significant genotypic variation existed among the 22 landraces for many of the agronomic and quality traits measured (Table 1). CV of the 12 agronomic traits measured ranged from 5.59% to 32.42%, with an average of 15.78%. Grain yield per plant and traits directly related with grain yield, such as rows per ear, kernels per row, kernel depth etc., had some of the highest CVs, indicating that the landraces differed more on these traits rather than others such as plant height, leaf number and flowering time. In contrast, the CV of the three quality traits (oil, protein and starch ratio) ranged from 0.91% to 5.64%, with an average of 4.06%, which suggested that variation for quality traits was lower than that for agronomic traits. For each trait, we determined which landrace had the most desired or optimum data for that trait (Table 1). Three landraces, Dazhaibaogu, Dahuang and Yuzuibaogu, exhibited the best agronomic performance while another three, Nuoyumi, Rongzhaiyumi and Dadudu, had highest oil, protein and starch content, respectively.

Individual ANOVA for grain yield of 65 crosses between 13 landraces and five testers showed that differences in grain yield per plant were significant. The results of the combining ability analysis showed that GCA and SCA effects on grain yield per plant were highly significant among landraces as well as among crosses (Table 2). Five landraces (Hanyuanhongbaogu, Dabaimaya, Xuesi, Dahuang and Dazhaibaogu) had the highest GCA effects (Table 2), which suggested that these landraces had the greatest potential for future breeding. The CV of GCA effects on grain yield per plant was 48.85%, which indicated that there are more selecting options in future breeding. Several SCA effects on grain yield per plant were also significant (Table 2). The SCA effects ranged from -18.21 (Dabanya×478) to 27.41 (Xuesi×9636).

In conclusion, Dazhaibaogu, Dahuang, Yuzuibaogu, Xuesi and Dabaimaya were the landraces determined to have the most promising characteristics for further use in maize breeding programs.

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Table 1 The mean, standard deviation (SD), minimum-maximum (Min-Max), coefficient of variation (CV), and optimum landrace for 12 agronomic and three quality traits measured on 22 maize landraces from the Sichuan Basin of China

Trait	Mean	SD	Min-Max	CV (%)	Optimum landrace
Plant height (cm)	258.54	22.51	213.23-305.65	8.71	Ganzierbai
Ear height (cm)	132.69	23.11	82.46-178.24	17.42	Rongzhaiyumi
Total leaf number	19.94	1.83	14.00-24.00	9.18	Wuer
Growing period (d)	127.27	7.21	117.00-142.00	5.59	Daguangyuan
Ear length (cm)	12.47	1.46	8.40-15.18	11.71	Lengfengwu
Barren-tip length	1.11	0.36	0.30-1.80	32.42	Dazhaibaogu
Rows per ear	12.54	1.80	8.70-17.05	14.36	Dazhaibaogu
Kernels per row	22.56	3.27	16.70-31.39	14.49	Dahuang
Kernel depth (cm)	1.52	0.23	0.79-1.84	15.15	Dahuang
Grain yield per plant	74.99	19.05	26.57-108.91	25.40	Yuzuibaogu
100-kernel weight	20.87	4.08	9.00-27.93	19.55	Qiuzi
Test weight (g/L)	632.79	97.57	245.00-705.00	15.42	Baibaogu
Oil ratio (%)	5.16	0.29	4.47-5.86	5.63	Nuoyumi
Protein ratio (%)	11.00	0.62	9.34-12.11	5.64	Rongzhaiyumi
Starch ratio (%)	69.37	0.63	67.74-70.60	0.91	Dadudu

Table 2 General combining ability (GCA) and specific combining ability (SCA) effects on grain yield per plant based on the analysis of combining ability data of 13 maize landraces from the Sichuan Basin of China and five testers

Landrace	GCA effects	SCA effects				
		478	Mo17	48-2	9636	Huangzao4
Hanyuanhongbaogu	6.75**	15.51**	-3.34	-1.78	-10.48**	0.09
Nuoyumi	-11.45**	-2.24	-0.92	8.31**	2.41	-7.56**
Dadudu	-2.59	-10.69**	13.98**	1.77	-15.31**	10.25**
Yuzuibaogu	-5.87*	5.79*	-10.54**	5.70*	-5.18*	4.23
Lengfengwu	-6.86**	0.22	-9.21**	4.12	7.37**	-2.50
Dabaimaya	5.29*	17.91**	-6.03*	-11.13**	11.38**	-12.13**
Wuer	-6.02*	-17.95**	9.67**	10.91**	-1.07	-1.56
Xuesi	5.42*	-5.86*	-10.02**	-15.83**	27.41**	4.31
Dahuang	10.95**	0.30	-4.39	8.50**	4.87*	-9.27**
Xiaobai	0.89	2.71	10.41**	3.66	-13.66**	-3.11
Dazhaibaogu	8.22**	7.52**	-3.90	8.74**	-14.79**	2.43
Dabanya	-2.92	-18.21**	-7.99**	-9.22**	20.50**	14.92**
Dazihuang	0.00	4.99*	22.29**	-13.75**	-13.45**	-0.08

*, **Significant at the 0.05 and 0.01 probability levels, respectively