Gene Action for Grain Zinc Content in Pearl Millet

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INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is a major coarse-grained cereal, grown primarily for grain production on 26 million ha in the arid and semi-arid tropical regions of Asia and Africa. It is an important source of dietary energy and nutritional security for millions of people in these regions. Research has shown that pearl millet is the cheapest source of Fe and Zn (Parthasarathy et al. 2006). A large variability has been found for these micronutrients in improved populations and breeding lines (Velu et al. 2006). The objective of this study was to understand the nature of gene action to develop effective breeding strategies for these micronutrients.

METHODS

Ten inbred lines with varying grain Zn content and 90 F_1 hybrids (including reciprocals) derived from diallel crosses were evaluated in a randomised complete block design with three replications in 2-row plots of 4 m length during the 2005 rainy and 2006 dry seasons in Patancheru, India. Sib-mated grains were analysed for Zn content using dry ashing and atomic absorption spectrophotometry (Jorhem 1993). The interaction of entry with season was significant but of negligible order. The reciprocal effect was non-significant. Thus, means over reciprocal crosses and seasons were subjected to half-diallel analysis following Griffing's Method 2, Model II (Griffing 1956) using software Genstat version 8.

RESULTS AND DISCUSSION

Large and significant differences ($P< 0.01$) were observed for grain Zn content among parents (28.8-51.4 mg/kg) and hybrids (26.4-52.5 mg/kg) (Table 1). Differences in general combining ability (GCA) among parents and in specific combining ability (SCA) among hybrids were also highly significant. The interaction of season with GCA was significant, and it was of smaller magnitude than the GCA variance. The predictability ratio (Baker 1978) measured by $2\sigma^2\text{gca}/(2\sigma^2\text{gca} + \sigma^2\text{sca})$ was 0.88, implying preponderance of additive gene action. Also, there was a highly significant positive correlation ($r = 0.81$; $P < 0.01$) between mid-parental values and mid-parent heterosis which was an additional indication of the predominant role of additive gene action for this trait. Predominantly additive gene action for grain Zn content has also been reported in maize (Long et al. 2004).

Mid-parent heterosis was significant in eleven of the forty five hybrids tested. Heterosis in positive direction (18.8 to 22.4% heterosis) was observed for three hybrids and heterosis in negative direction (-10.9 to –18.2% heterosis) was observed for eight hybrids. Five hybrids had Zn levels higher than 50 mg/kg, four of them with high Zn content in both parents, and one hybrid had parents with high and medium Zn levels. None of the hybrids exceeded the Zn levels of their parents. This showed that there would be little opportunity, if any, to exploit heterosis for this trait, and that high Zn levels would be required in both parental lines to breed hybrids with high Zn content.

The correlation between Zn content of inbred lines and their GCA for this trait was positive and highly significant ($r = 0.94$; $P < 0.01$). This indicates that the selection of lines with high Zn levels would be effective in selecting for a high GCA for this trait. Of the four hybrids with significantly positive SCA, three had 863 B in their parentage. Also, 863B parented the three hybrids with positive mid-parent heterosis. This could result from the high correlation observed between the performance of lines and their GCA since the former is a component in heterosis estimation and the latter is a SCA estimation component. Incidentally, 863B is a large-seeded and drought tolerant seed parent of three commercial hybrids in India, and it has remained highly resistant to multiple pathotypes of the most prevalent disease, downy mildew, caused by *Sclerospora graminicola* (Sacc.) Schroet.

Table 1. Average grain Zn content (mg/kg) of parents (diagonal) and hybrids (above diagonal), and general combing ability (GCA) and specific combining ability (SCA) (below diagonal) in a 10 × 10 diallel cross of pearl millet: Mean of 2005 rainy season and 2006 summer season, Patancheru.

S. No.	**Inbred line**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	863B	**45.9**	50.2	51.1	52.5	43.7	$52.9^{\dagger}$	39.9	$45.8^{\dagger}$	41.1	$47.6^{\dagger}$
2	ICMB 94111	2.1	**49.2**	$42.9^{\ddagger}$	$41.7^{\ddagger}$	40.0	$40.3^{\ddagger}$	$38.2^{\ddagger}$	36.7	$31.9^{\ddagger}$	$35.6^{\ddagger}$
3	ICMB 00888	0.4	-2.7	**50.2**	50.9	40.8	44.1	39.7	39.6	38.0	38.7
4	AIMP 92901 S_5	1.2	-4.6^{*}	2.1	**51.4**	43.1	$41.7^{\ddagger}$	40.9	41.5	38.6	39.6
5	ICMB 95222	-0.8	0.6	-1.1	0.6	**36.9**	$35.5^{\ddagger}$	40.0	30.7	32.9	30.7
6	ICMV 93074 S_6	5.2^{**}	-2.4	-1.1	-4.1^{*}	-3.4	**39.9**	40.4	34.8	36.5	37.6
7	MC 94 C2 S_5	-3.9^{*}	-0.5	-1.5	-1.0	5.1^{**}	2.2	**36.7**	30.2	28.9	31.6
8	81B	4.1^{*}	0.1	0.4	1.7	-2.2	-1.4	-2.1	**29.6**	30.4	29.3
9	ICMS 8511 S_6	0.7	-3.4	0.1	0.2	1.3	1.7	-2.0	1.5	**28.8**	26.4
10	ICMV 91059 S_7	5.7^{**}	-1.2	-0.7	-0.4	-2.5	1.2	-0.9	-1.1	-2.6	**31.9**
	gca effects	6.9^{**}	1.8^{*}	4.4^{**}	5.0^{**}	-1.9^{**}	1.4^{*}	-2.6^{**}	-4.6^{**}	-5.9^{**}	-4.4^{**}

*, ** Significant at 0. 05 and 0.01 probability, respectively; †, Positive significant mid-parent heterosis, ‡, Negative significant mid-parent heterosis

ACKNOWLEDGEMENT

The research reported here was funded by the HarvestPlus Challenge Program of the Consultative Group on International Agricultural Research (CGIAR).

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