Indian J. Genet., 50 (3): 256–259 (1990)

GENE EFFECTS FOR THE ROOT CATION EXCHANGE CAPACITY OF *SORGHUM BICOLOR* (L.) MOENCH

A. R. DABHOLKAR AND SATISH VERULKAR

Sorghum Improvement Project, College of Agriculture
J. N. Krishi Vishwa Vidyalaya, Indore 452 001

(Received: January 7, 1988; accepted: August 11, 1989)

ABSTRACT

Six generations, viz., P_1, P_2, F_1, F_2, BC_1 and BC_2 of crosses SPV 346 x SPV 351, 2219 B x CS 3541 and Vidisha 60-1 x CS 3541 were grown at Indore. Significant differences were observed among the generation means for root CEC. Estimates of six components of generation means, viz., m, d, h, i, j and l were obtained for grain yield, 1000-grain weight, and root CEC. Additive gene effects alone were important for root CEC of the cross Vidisha 60-1 x CS 3541. On the other hand, nonadditive gene effects were predominant for root CEC in the remaining two crosses. Only additive gene effects governed the inheritance of grain yield in the cross SPV 346 x SPV 351. However, for the cross 2219 B x CS 3541, the estimate of h was many times higher than for other components. For 1000-grain weight, predominant gene effects were nonadditive.

Key words: Root CEC, gene effects, sorghum.

The concept of plant ideotype has proved valuable to the plant breeders while restructuring the high yielding plants of wheat, rice, sorghum, etc. This ideotype was confined mostly to the plant parts above the ground level. But roots play a crucial role in plant life by supplying nutrients and water from the soil. The process by which roots take up cations like Ca^{++}, Mg^{++} etc. from the soil is known as cation exchange. The ability of roots to bind cations at pH 7 or other suitable pH, depending on methods of estimation used, is known as cation exchange capacity (CEC). Positive correlation of root CEC with grain yield was reported by several workers [1–3]. The present investigation aims to understand the gene action for root CEC of sorghum.

MATERIALS AND METHODS

Genotypes SPV 346, SPV 351, CS 3541, 2219 B and Vidisha 60-1 of sorghum were used in the investigation. SPV 346 and SPV 351 are high yielding varieties released for general cultivation in India. Corss SPV 351 x SPV 346 was identified as superior combination on the basis of its sca effect [4]. Vidisha 60-1, an indigenous cultivar, was found to be a desirable general combiner for root CEC [4]. 2219 B is relatively early and dwarf, and is a very good combiner for yield.

Generations F_1, F_2, BC_1 and BC_2 of 3 crosses (SPV 346 x SPV 351, 2219 B x CS 3541, and Vidisha 60-1 x CS 3541) were developed in the rainy season of 1985 at Indore.

In the summer of 1986, seeds of six generations of each cross were sown in cement pots (10 cm in diameter and 45 cm high). The experimental design was completely randomized blocks with two replications. The number of pots assigned per replication in each generation of three crosses were: 3 for each parent and F_1, 10 for F_2, and 5 each for BC_1 and BC_2. For estimation of root CEC, samples of roots were taken when the plants were 60 days old, as root CEC is reported to be maximum at this age [5]. Root CEC was estimated following Drake [6].

Six generations of the crosses SPV 346 x SPV 351 and 2219 B x CS 3541 were planted in the field during the rainy season of 1986 at Indore. The experiment was completely randomized with two replications. Each plot comprised a single row, 3 m long, spaced 45 cm apart. The plots used per replication were: 1 each in P_1, P_2 and F_1, 6 in F_2, and 3 each in BC_1 and BC_2. The observations were recorded on five competitive plants in each plot for grain yield and 1000-grain weight.

The scaling tests A, B, C of Mather [7] were applied to generation means to test the adequacy of the additive–dominance model. Data for root CEC, grain yield and 1000-grain weight were analysed following the procedure recommended for completely randomized block design. When the generation means exhibited significant difference for the characters studied, the perfect fit solutions of Mather and Jinks [8] were employed to calculate the six components of generation means: m, d, h, i, j and l.

RESULTS AND DISCUSSION

Scaling tests indicated that the additive–dominance model was satisfactory for root CEC in the cross Vidisha 60-1 x CS 3541 (Table 1). On the other hand, the simple additive–dominance model was not adequate for the crosses SPV 346 x SPV 351 and 2219 B x CS 3541. Dabholkar and Saxena [4] reported that additive as well as nonadditive components of heritable variation were responsible for root CEC in sorghum. In the present study, only additive gene effects governed the inheritance of root CEC in cross Vidisha 60-1 x CS 3541, whereas the estimate of h, reflecting dominance gene effects, was relatively larger in magnitude for the crosses 2219 B x CS 3541 and SPV 346 x SPV 351. Negative sign of h suggested that genes with lower root CEC were in general dominant. Component l was also significant in both these crosses, which implied that dominance x dominance kind of digenic nonallelic interaction was also responsible for the inheritance of this trait. Additive x additive kind of fixable nonallelic interaction determined generation means of cross SPV 346 x SPV 351. The sign of i, however, was negative which reinforced the negative dominance gene effects.

For grain yield, it was observed that only additive effects of genes were important in the cross SPV 346 x SPV 351. On the other hand, components h, i, j and l were significant and larger in magnitude than d for the cross 2219 B x CS 3541 (Table 1). The sign of l was opposite to that of h, implying duplicate type of nonallelic interaction. Nonadditive gene effects were thus predominant for grain yield of this cross. This is contrary to the results reported earlier [9–11]. On the other hand, Liang and Walter [12] and Goyal and Joshi [13] reported dominance gene effects to be important for grain yield. Differences in gene effects for a given trait could arise due to differences in the history of origins of different genotypes.

Table 1. Scaling tests and the components of generation means for three characters of sorghum

Cross	Results of scaling tests			Estimates of					
	A	B	C	m	d	h	i	j	l
Root CEC									
SPV 346 x SPV 351	**	**	**	29.8 ± 3.7**	2.8 ± 0.4**	–3.49 ± 8.2**	–8.3 ± 3.7	0.7 ± 1.7	26..9**
2219 B x CS 3541	—	**	**	20.6 ± 1.2**	–0.5 ± 0.1**	–6.2 ± 2.9**	–2.9 ± 1.3	–0.3 ± 0.7	7.1**
Vidisha 60-1 x CS 3541	—	—	—	16.8 ± 1.7**	1.3 ± 0.2**	4.6 ± 4.1	2.3 ± 1.7	–0.3 ± 1.1	–3.5
Grain yield per plant									
SPV 346 x SPV 351	—	—	—	29.1 ± 14.4*	4.1 ± 1.5**	54.1 ± 37.6	21.0 ± 14.3	–1.9 ± 11.1	–20.2
2219 B x CS 3541	**	—	**	4.7 ± 7.2	1.7 ± 0.6*	80.6 ± 17.7**	35.3 ± 7.2**	17.3 ± 4.6**	–24.2*
1000-Grain weight									
SPV 346 x SPV 351	**	**	**	22.7 ± 1.0**	1.3 ± 0.1**	–7.3 ± 2.3**	–1.9 ± 1.1	–1.2 ± 0.4**	9.8**
2219 B x CS 3541	**	**	—	23.1 ± 0.4**	0.9 ± 0.0**	–2.8 ± 1.6	–1.5 ± 0.8	3.8 ± 0.2**	4.3**

*P = 0.05, **P = 0.01.

Predominant kind of gene effects for 1000-grain weight were nonadditive (Table 1) in case of both the crosses, viz., SPV 346 x SPV 351 and 2219 B x CS 3541. Although the estimate of d was significant for both crosses, it was relatively smaller in magnitude than the estimates of parameters specifying nonadditive gene effects. Opposite signs of h and l for SPV 346 x SPV 351 suggested duplicate type of digenic nonallelic gene interaction for this character.

Since only additive gene effects governed the inheritance of grain yield in the cross SPV 346 x SPV 351, pedigree method of handling the segregating material would be an efficient breeding procedure. Likewise, conventional breeding procedure would be appropriate for isolating segregates with high root CEC from the segregating material of cross Vidisha

60-1 x CS 3541. Because nonadditive gene effects predominated for the three characters in cross 2219 B x CS 3541, conventional breeding procedure would not be desirable to handle segregating population. Sorghum breeders in the country have already exploited the nonadditive kind of gene effects observed in this cross by releasing a high yielding hybrid, CSH 6 (2219 A x CS 3541).

REFERENCES

1. C. L. Mehrotra and V. P. Saxena. 1970. Cation exchange capacity of plant root as an index of fertility status of soil. Indian J. agric. Sci., **40**: 889–894.

2. R. C. Dakhore. 1983. Root CEC as a criterion for screening varieties of sorghum for their yielding potential. PKV Res. J., **7**: 220–222.

3. M. K. Saxena. 1985. Genetic Analysis of Root CEC, Grain Yield and Components of Yield in *Sorghum bicolor* (L.) Moench. M.Sc.(Ag) Thesis. Jawahar Lal Nehru Krishi Vishwa Vidyalaya, Jabalpur.

4. A. R. Dabholkar and Mukesh Saxena. 1987. Combining ability analysis for root cation and root anion exchange capacity in sorghum. Indian J. agric. Sci., **57**: 5–8.

5. P. R. Chhabda, M. V. Gajbe and S. D. More. 1978. Relationship between root CEC and N content in sorghum. Res. Bull. Marathwada Agril. Uni., **2**: 50–52.

6. M. Drake. 1965. Soil chemistry and plant nutrition. *In*: Chemistry of Soils (ed. F. E. Bear). Oxford and IBH Publishing Co., New Delhi: 402.

7. K. Mather. 1949. Biometrical Genetics (1st ed.). Methuen, London.

8. K. Mather and J. L. Jinks. 1982. Biometrical Genetics (3rd ed.). Chapman and Hall, London.

9. N. Y. Nayakar. 1973. Gene effects for seven quantitative characters in *Sorghum vulgare* Pers. Mysore J. agric. Sci., **7**: 535–538.

10. A. R. Dabholkar and S. S. Baghel. 1980. Gene action for resistance to grain mould, yield and yield components in sorghum. JNKVV Res. J., **14**: 7–14.

11. H. Patidar and A. R. Dabholkar. 1981. Gene effects for grain size and yield in sorghum. Indian J. Genet., **41**: 259–263.

12. G. H. L. Liang and J. L. Walter. 1968. Heritability estimates and gene effects for agronomic traits in grain sorghum, *Sorghum vulgare* Pers. Crop Sci., **8**: 77–81.

13. S. N. Goyal and P. Joshi. 1984. Genetics of yield and panicle components in grain sorghum hybrids. Indian J. Genet., **44**: 96–101.