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DIVERGENCE AND HETEROSIS FOR FODDER ATTRIBUTES IN PEARL MILLET

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ABSTRACT

No relationship was observed between the geographical diversity and genetic divergence in the fifteen parental lines of fodder pearl millet. The clustering pattern was effected by environment and role of different characters varied with shift in season. The size of D^2 statistic had no effect on the magnitude of heterosis for the attributes studied.

Key words: Divergence, heterosis, pearl millet.

Hybrids of genetically diverse parents are generally expected to manifest heterosis. Hence the utility of topological distances in predicting genetic divergence [1] for fodder attributes in pearl millet is reported here.

MATERIALS AND METHODS

The experimental details were reported earlier [2]. Divergence among the parental lines was determined by Mahalanobis' multivariate (D^2) analysis and grouped by Tocher's method [3].

RESULTS AND DISCUSSION

DIVERGENCE IN PARENTAL LINES

The fifteen parental lines were grouped into five clusters during summer, seven in rainy season, and five in the pooled analysis (Table 1). No consistant pattern was observed in the distribution of indigenous and exotic strains over the clusters. The local collections from Rajasthan were distributed in different clusters combined with the exotics, revealing absence of any relationship between geographical diversity and genetic divergence. This contradicts the results of [4–6], but supports those of [7–10].

A marked variation was observed in the cluster means of several characters, which signifies their role in differentiation at intercluster level in pearl millet (Table 2). However, the role of different characters varied considerably in different seasons. In summer, the cluster means varied widely for stem thickness, regeneration capacity and protein content, while the variation among the clusters for these attributes was of much lower magnitude in rainy season. However, during this season, intercluster variation was much greater for plant height, tiller number, leaf breadth, green fodder yield and dry matter yield (Table 2). Such variation in character expression in different environments is responsible for varied clustering patterns in the two seasons.

Table 1. **Distribution of fifteen parental lines of fodder pearl millet in different clusters in two seasons and in pooled analysis**

Cluster	No. of strains	Name and code number*
		Summer
I	7	LCB 3 (P 1), K 677 (P 3), LCB 1-3 (P 6), L 72 (P 9), MPP 483-1 (P 10), D 1941 (P 11), D 2291 (P 12)
II	4	MPP 7112 (P 2), LCB 10 (P 4), L 74, (P 5) MPP 7513 (P 7)
III	2	LCB 2 (P 8), MPP 504 (P 13)
IV	1	DFB 21 (P 14)
V	1	DFB 2 (P 15)
		Rainy season
I	5	LCB 3, K 677, LCB 10, LCB 1-3, LCB 2
II	3	MPP 7513, D 1941, DFB 2
III	2	D 2291, MPP 504
IV	2	MPP 7112, DFB 21
V	1	L 74
VI	1	L 72
VII	1	MPP 483-1
		Pooled analysis
I	6	LCB 3, K 677, L 72, D 1941, D 2291, MPP 504
II	5	MPP 7112, LCB 10, L 74, MPP 7513, DFB 2
III	2	LCB 1-3, MPP 483-1
IV	1	LCB 2
V	1	DFB 21

Source: P 3, P 5, P 9, P 11, P 12—All-India Coordinated Research Programme; P 2, P 7, P 10, P 13—exotic collections; P 1, P 4, P 6, P 8—Rajasthan local collections; and P 14, P 15—selections from local varieties.

D^2 STATISTIC AND HETEROSIS

The characterwise results of the best heterotic crosses in summer and rainy season did not exhibit any relationship between the size of D^2 statistic and magnitude of heterosis for a particular attribute. This is clearly illustrated by the results on plant height, green fodder yield, and crude protein content (Table 3), which showed that the most heterotic crosses also involved parents grouped in the same cluster or in the clusters having close affinity. Similar results were reported by Singh et al. [11]. This point is further elucidated by a comparative study of D^2 values for the parents involved in the crosses showing heterosis for as many as 10–12 yield components with those heterotic for a lesser number of characters (Table 4). Here again, no relation was observed between heterosis in a particular cross and the topological distance between its parents. This means that it is not always

Table 2. Intracluster means of various fodder attributes in pearl millet

Cluster	Seedling dry weight (mg)	Days to flower	Plant height (cm)	Tiller number	Stem thick-ness (cm)	Leaf number	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm^2)	Leaf-stem ratio	Green fodder yield (g)	Dry matter yield (g)	Protein content (%)	Regene-ration (%)
							Summer							
I	355	78.0	184.8	4.4	1.1	10.5	55.1	3.2	126.2	0.4	331	96	4.5	54.2
II	507	88.7	179.1	5.2	1.2	10.2	60.6	3.4	164.7	0.4	276	71	5.2	33.2
III	309	78.2	173.4	4.8	1.0	10.6	61.6	3.4	152.6	0.4	300	85	4.9	39.8
IV	452	85.0	183.7	4.3	1.2	11.5	73.1	2.9	152.0	0.6	278	80	4.3	91.4
V	503	75.3	155.5	4.3	0.9	9.3	59.4	2.6	113.2	0.4	227	62	9.4	98.5
							Rainy season							
I	—	60.07	224.4	4.5	1.2	12.1	73.3	4.2	221.3	0.3	455	123	6.6	50.8
II	—	65.22	197.1	3.9	1.1	10.5	66.7	4.0	208.7	0.2	306	87	3.9	77.1
III	—	52.66	193.4	3.0	1.0	10.2	59.3	3.9	175.0	0.2	294	83	5.3	58.4
IV	—	67.33	236.9	5.6	1.3	12.0	63.8	4.6	223.4	0.2	337	112	6.1	70.3
V	—	64.00	150.1	3.0	1.0	10.0	73.7	4.3	229.2	0.3	236	89	3.0	48.7
VI	—	62.00	180.7	6.3	1.1	10.3	63.2	3.7	180.0	0.2	457	146	5.1	45.3
VII	—	67.33	163.2	4.0	1.4	12.7	76.33	3.5	289.7	0.3	537	153	5.2	43.0
							Pooled analysis							
I	—	67.87	195.9	4.5	1.1	10.6	61.88	3.6	168.0	0.3	375	107	4.8	52.2
II	—	74.57	186.2	4.6	1.2	10.3	65.49	3.8	186.9	0.3	301	84	5.1	56.7
III	—	76.08	186.0	4.0	1.3	11.7	66.68	3.3	186.7	0.3	366	109	4.4	47.8
IV	—	75.83	191.2	4.4	1.2	12.3	60.82	4.2	189.0	0.2	293	80	3.2	49.2
V	—	74.00	208.1	5.3	1.2	12.1	67.22	3.4	171.6	0.4	306	96	5.7	82.0

Table 3. Mean heterosis and clusters involved in the best crosses for plant height, green fodder yield and crude protein content

Rank	Summer					Rainy season				
	mean		heterosis (%)		clusters involved	mean		heterosis (%)		clusters involved
	cross	value	cross	value		cross	value	cross	value	
					Plant height (cm)					
1	P 2 x P 4	279.0	P 2 x P 14	55.6	II, IV	P 7 x P 11	288.2	P 5 x P 13	55.1	II, III
2	P 1 x P 4	269.8	P 2 x P 4	47.6	II, II	P 7 x P 8	277.2	P 5 x P 15	53.9	II, II
3	P 2 x P 14	267.8	P 2 x P 15	40.1	II, V	P 1 x P 7	275.2	P 10 x P 15	45.9	VII, II
4	P 4 x P 6	257.3	P 1 x P 2	34.5	I, II	P 1 x P 2	274.6	P 7 x P 10	42.8	III, VII
5	P 1 x P 2	252.0	P 2 x P 5	34.0	II, II	P 11 x P 15	272.5	P 9 x P 12	41.6	VI, III
6	P 1 x P 14	251.7	P 6 x P 11	33.9	I, I	P 8 x P 10	269.5	P 8 x P 10	40.5	I, VII
7	P 4 x P 14	251.1	P 5 x P 11	33.4	II, I	P 1 x P 4	268.4	P 13 x P15	38.7	III, II
8	P 4 x P 5	247.3	P 6 x P 12	32.8	I, I	P 3 x P 15	266.8	P 1 x P 7	37.6	I, II
9	P 4 x P 15	241.2	P 4 x P 6	30.5	II, I	P 1 x P 15	262.5	P 7 x P 11	37.1	II, II
10	P 6 x P 8	237.5	P 6 x P 9	30.0	I, I	P 1 x P 8	262.1	P 1 x P 10	36.5	I, VII
S.E. ±		4.0		3.4			7.8		6.5	
					Green fodder yield (g)					
1	P 1 x P 10	885	P 2 x P 14	221.3	II, IV	P 3 x P 4	761	P 7 x P 12	136.0	II, I
2	P 1 x P 3	871	P 6 x P 15	179.8	I, V	P 4 x P 15	758	P 12 x P 14	107.2	I, IV
3	P 2 x P 14	860	P 4 x P 15	169.2	I, V	P 4 x P 13	744	P 3 x P 12	106.8	I, I
4	P 1 x P 14	790	P 4 x P 13	149.8	I, III	P 1 x P 5	729	P 5 x P 10	106.5	V, VII
5	P 1 x P 6	758	P 13 x P 15	147.1	III, V	P 1 x P 2	710	P 2 x P 14	106.4	IV, IV
6	P 3 x P 5	749	P 2 x P 6	145.9	II, I	P 2 x P 7	698	P 11 x P 12	104.2	II, III
7	P 1 x P 5	708	P 9 x P 13	143.7	I, III	P 2 x P 14	696	P 9 x P 12	94.8	VI, III
8	P 11 x P 15	674	P 11 x P 15	138.0	I, V	P 8 x P11	664	P 12 x P 13	94.6	III, III
9	P 1 x P 15	667	P 8 x P 14	138.0	III, IV	P 3 x P 12	660	P 1 x P 5	92.2	I, V
10	P 9 x P 13	641	P 4 x P 8	134.2	I, III	P 9 x P 12	660	P 8 x P 12	90.8	I, I
S.E. ±		23.15		19.31			22.48		20.04	
					Crude protein content (%)					
1	P 9 x P 15	12.4	P 7 x P 15	122.4	II, I	P 11 x P 13	10.0	P 11 x P 13	147.9	I, III
2	P 2 x P 5	12.3	P 2 x P 5	119.6	II, II	P 5 x P 10	9.3	P 5 x P 10	128.6	V, VII
3	P 1 x P 5	9.7	P 8 x P 12	101.9	III, I	P 1 x P 10	9.0	P 5 x P 11	124.4	I, VII
4	P 10 x P 11	9.7	P 6 x P 14	96.6	I, IV	P 2 x P 14	8.7	P 1 x P 10	112.6	I, II
5	P 2 x P 15	9.4	P 9 x P 15	91.3	I, V	P 9 x P 15	8.5	P 11 x P 15	100.0	I, II
6	P 1 x P 15	9.0	P 8 x P 11	88.8	III, I	P 3 x P 7	7.7	P 1 x P 8	90.0	I, I
7	P 7 x P 12	8.9	P 6 x P 9	88.0	I, I	P 11 x P 15	7.6	P 3 x P 11	81.7	I, I
8	P 3 x P 5	8.8	P 10 x P 11	82.5	I, I	P 7 x P 9	7.5	P 6 x P 10	81.0	I, VII
9	P 8 x P 11	8.4	P 9 x P 12	72.2	I, I	P 8 x P 9	7.5	P 8 x P 9	77.9	I, VI
10	P 5 x P 14	8.4	P 9 x P 14	68.2	I, IV	P 10 x P 15	7.5	P 4 x P 5	76.7	I, V
S.E. ±		0.5		0.4			0.4		0.3	

Note. Parental codes as in Table 1. All values significant at 1% level.

Table 4. Genetic divergence (D^2) in the parents of ten crosses showing heterosis for variable number of yield components in 15 x 15 diallel of pearl millet

Heterotic for different number of characters							
10 to 12		7 to 9		4 to 6		1 to 3	
cross	D^2	cross	D^2	cross	D^2	cross	D^2
				Summer			
P 4 (II) x P 7 (II)	4796.3	P 1 (I) x P 3 (I)	3236.5	P 1 (I) x P 9 (I)	1994.2	P 3 (I) x P 7 (II)	46313.5
P 8 (II) x P 10 (I)	14569.1	P 1 (I) x P 7 (II)	2956.2	P 2 (II) x P 7 (II)	1860.4	P 3 (I) x P 12 (I)	1785.6
P 8 (III) x P 12 (I)	8800.4	P 2 (II) x P 14 (II)	4565.7	P 3 (I) x P 4 (II)	61350.2	P 11 (I) x P 14 (IV)	23072.2
P 2 (II) x P 10 (I)	30922.7	P 3 (I) x P 8 (I)	4436.6	P 3 (I) x P 13 (III)	598.5		
P 8 (III) x P 11 (I)	12269.4	P 4 (II) x P 11 (I)	50365.7	P 4 (II) x P 6 (I)	29945.7		
P 10 (I) x P 15 (V)	4754.3	P 4 (II) x P 14 (IV)	7934.1	P 5 (II) x P 7 (II)	4631.5		
P 12 (I) x P 14 (IV)	23329.1	P 7 (II) x P 10 (I)	22159.7	P 5 (II) x P 15 (V)	4459.1		
P 13 (III) x P 14 (IV)	38393.2	P 7 (I) x P 12 (I)	33522.7	P 6 (I) x P 10 (I)	550.7		
P 9 (I) x P 14 (IV)	31817.1	P 9 (I) x P 13 (III)	705.5	P 12 (I) x P 15 (V)	61301.2		
P 4 (I) x P 13 (IV)	66482.1	P 13 (III) x P 15 (V)	84850.7	P 14 (IV) x P 15 (V)	10924.9		
Mean	27892.3		21473.3		17760.7		23723.7
				Rainy season			
None		P 12 (I) x P 5 (V)	255.5	P 1 (I) x P 9 (VI)	331.0	P 2 (IV) x P 4 (IV)	564.8
		P 7 (II) x P 13 (III)	466.8	P 3 (I) x P 11 (II)	270.0	P 2 (IV) x P 6 (I)	341.2
		P 9 (VI) x P 12 (III)	840.9	P 4 (I) x P 5 (V)	452.0	P 2 (IV) x P 8 (I)	254.0
		P 11 (II) x P 12 (III)	530.1	P 5 (V) x P 11 (II)	476.0	P 2 (IV) x P 9 (VI)	427.9
		P 13 (III) x P 15 (II)	435.1	P 6 (I) x P 7 (II)	333.9	P 3 (I) x P 9 (VII)	197.1
None		P 1 (I) x P 3 (I)	148.4	P 6 (I) x P 9 (IV)	294.3	P 4 (I) x P 10 (VII)	411.8
		P 1 (I) x P 14 (IV)	613.7	P 6 (I) x P 13 (III)	344.5	P 7 (II) x P 14 (IV)	644.5
		P 3 (I) x P 7 (II)	287.9	P 7 (II) x P 10 (VII)	569.5	P 11 (I) x P 14 (IV)	634.9
		P 5 (V) x P 12 (III)	350.6	P 7 (II) x P 11(II)	204.1	P 6 (I) x P 14 (IV)	551.0
		P 7 (II) x P 12 (III)	560.7	P 8 (I) x P 9 (VI)	193.6	P 14 (IV) x P 15 (II)	616.3
Mean			448.9		346.8		464.3

Note. Parental code as in Table 1. Cluster number of the parent given in parentheses.
D^2 values for summer season based on fourteen fodder attributes and in rainy season on thirteen attributes.

possible to predict that the genetically most diverse lines will certainly be most productive for fixing transgressive segregates [12]. Many a times forces other than genetic divergence of parents operate in the segregating materials which may appear phenotypically similar in spite of different gene constellations. The overall D^2 values between such populations may be quite low and lead to misjudgement.

REFERENCES

1. A. B. Joshi. 1979. Breeding methodology for autogamous crops. Indian J. Genet., **39**: 567–579.

2. R. V. Dave and P. Joshi. 1990. Heterosis for fodder attributes in pearl millet. Unpublished results.

3. C. R. Rao. 1952. Advanced Statistical Methods in Biometric Research. John Willey and Sons, Inc., New York.

4. R. H. Moll, W. S. Sulhana and H. F. Robinson. 1962. Heterosis and combining ability in varietal crosses of maize. Crop Sci., **2**: 197–198.

5. A. B. Joshi and N. L. Dhawan. 1966. Genetic improvement in yield with special reference to self fertilizing crops. Indian J. Genet., **26A**: 101–113.

6. J. Ram and D. V. S. Panwar. 1970. Interspecific divergence in rice. Indian J. Genet., **30**: 1–10.

7. M. K. Upadhyay and B. R. Murty. 1971. Genetic divergence and combining ability in pearl millet. Indian J. Genet., **31**: 63–71.

8. S. Singh and P. K. Gupta. 1979. Genetic divergence in pearl millet. Indian J. genet., **39**: 210–215.

9. P. Mukherji, R. K. Agrawal and R. M. Singh. 1980. Genetics of yield and traits in dwarf pearl millet (*Pennisetum typhoides* S. & H.). Madras Agric. J., **67**: 281–287.

10. V. M. Raut, V. S. P. Rao, V. P. Patil and G. B. Deodikar. 1985. Genetic divergence in *Triticum durum*. Indian J. Genet., **45**(1): 141–151.

11. Y. P. Singh, A. Kumar and B. P. S. Chauhan. 1981. Genetic divergence in pearl millet. Indian J. Genet., **41**: 186–190.

12. P. L. N. Somayajulu, A. B. Joshi and B. R. Murty. 1970. Genetic divergence in wheat. Indian J. Genet., **30**: 47–58.