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Studies on variability, character association and genetic diversity in b-lines of pearl millet

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Abstract

A field study conducted with 150 B-lines of pearl millet revealed significant differences in the germplasm for all 12 quantitative traits studied. Characters like biological yield per plant, flag leaf width, tillers per plant and seed yield per plant showed high PCV along with high genetic advance as percent of mean and moderate heritability and GCV. Seed yield had significant and positive correlation with biological yield, tillers per plant, plant height and flag leaf width. The direct and indirect effects of component characters like biological yield per plant, leaves per plant, flag leaf length, flag leaf width, panicle length, panicle diameter, plant height and tillers per plant were found positive on seed yield. Therefore, selection based on these component characters would result in improvement of seed yield also. Genotypes were grouped into 18 diversified clusters. The contribution of seed yield (27.58%) was found highest towards total divergence followed by biological yield (23.84%), days to maturity (21.20%) and days to flowering (7.36%), respectively.

Nineteen genotypes were found superior for seed yield and other related traits in early and medium maturity group of genotypes. Out of them three genotypes namely B-1116, B-1133 and B-1003 were substantially better in both seed yield and biological yield besides other related attributes. Therefore, these genotypes may be used in the breeding programme for developing the dual purpose hybrids for arid zone.

Keywords: variability, character association, genetic diversity, pearl millet

Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] commonly known as “Bajra”, is a coarse cereal belongs to family Poaceae. This is the most important food grain crop mainly cultivated under rainfed situation in arid zone. The C₄ pathway of pearl millet enhances photosynthetic efficiency and ability to produce higher biomass under hot and dry environment. Pearl millet is well adapted to the production system characterized by low and erratic rainfall, frequent drought, high temperature and poor soil conditions. It is widely cultivated as sole crop or mixed crop with legumes and intercropped with woody perennials. It is also cultivated exclusively for green fodder during summer and *Kharif* season (Sharma, 2013a) [6]. Its grains have high protein content (11.5%) with balanced amino acid profile and high level of iron, zinc and insoluble dietary fiber. These adaptive and nutritional features combined with high yield potential make pearl millet an important cereal crop that can effectively address the emerging challenges of global warming, water shortages, land degradation and food related health issues (Khairwal *et al.*, 2007) [3].

Utilization of different kinds of germplasm and breeding material is very critical in the diversification of cultivars. Hybrid parental lines are developed with considerable morphological diversity. In the development of A-lines, African germplasm has largely been used whereas locally adapted material has been utilized in R-line breeding programmes in India to achieve adequate adaptation of hybrids to different agro-ecologies (Yadav *et al.*, 2012) [8]. In the breeding of seed parents, high grain yield potential of A-lines, both as lines *per se* as well as in hybrids is the most important consideration. Thus, high yield potential is the first target trait for which selection is made. High yield, however, is achieved in combination with other agronomic and farmers' preferred traits. Most of these agronomic traits have high heritability for which visual selection during generation advance is fairly effective.

The present experiment has been conducted to determine the magnitude of genetic variability, character association and genetic diversity in B-lines of pearl millet. So that, promising inbred lines could be identified for the development of superior hybrids of pearl millet in arid zone.

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Materials and Methods

A field study was conducted during *Kharif* 2016 at the experimental farm, College of Agriculture, SKRAU, Bikaner. The site is situated at 28.01°N latitude and 73.22°E longitude at an altitude of 234.70 meters and has a tropical arid climate with mean annual rainfall of 263 mm. The soil of the experimental field was loamy sand in texture and slightly alkaline in reaction, poor in organic carbon, low in available nitrogen and medium in phosphorus but high in available potassium.

A total of 150 B-lines of pearl millet received from ICRISAT, Patancheru were evaluated in a randomized block design with two replications. Sowing was done on 5th July, 2016 accommodating 4 m long 2 rows per plot at 50 cm row distance as per standard seed rate of 4.0 kg ha⁻¹. A fertilizer dose of 60 kg N and 30 kg P ha⁻¹ was provided to the crop. A half dose of N and full dose of P were applied at the time of sowing, in the form of urea and DAP. The remaining half dose of the N was top dressed in the form of urea at 25 days after sowing. Additional foliar spray of 1% soluble NPK (18:18:18) was also applied to the crop at 40 and 55 days after sowing. Total 5 sprinkler irrigations were applied according to requirement of the crop. Two hand weeding were carried out at 18-20 and 32-35 days after sowing to have crop free from weeds.

Observations recorded for 12 characters *viz.* days to 50 percent flowering, days to maturity, plant height, number of tillers per plant, number of leaves per plant, flag leaf length, flag leaf width, panicle length, panicle width, biological yield per plant, seed yield per plant and harvest index were analyzed to study the variability, character association and genetic diversity in B-lines of pearl millet.

Results and Discussion

Analysis of variance revealed significant differences among B-lines of pearl millet for all 12 characters indicating that the material had adequate genetic variability to support the breeding programme for improving seed and biological yield of pearl millet (Table-1). In early and medium maturity group of parental lines, nineteen genotypes were found superior for seed yield and other related traits. Out of them, three genotypes namely B-1116, B-1133 and B-1003 were found substantially better for both seed yield and biological yield along with other attributes (Table-2). These three genotypes were also found early in flowering and maturity, which is the fundamental requirement of rainfed situation in arid zone. Therefore, these genotypes may be used in the breeding programme for developing the dual purpose hybrids in arid zone. High and significant variability for seed and biological yield in pearl millet has been reported by Unnikrishnan *et al.* (2004) [7], Nagar *et al.* (2006) [4], Shanmuganathan *et al.* (2006) [5] and Bhoite *et al.* (2008) [1].

Estimates of genetic variability parameters for different characters in B-lines of pearl millet revealed that characters like biological yield per plant, flag leaf width, tillers per plant and seed yield showed high PCV along with high genetic advance as percent of mean and moderate heritability and GCV, which indicates that these characters were under the control of additive gene action (Table 3). Therefore, selection of the male sterile line based on these component traits could be utilized for crossing to exploit genetic potential of the genotype.

Seed yield had significant and positive correlation with biological yield, tillers per plant, plant height and flag leaf width at phenotypic level (Table 4). Therefore, emphasis should be given to these characters while selecting parental lines of pearl millet for breeding programme. The direct and indirect effects of component characters like biological yield per plant, leaves per plant, flag leaf length, flag leaf width, panicle length, panicle diameter, plant height and tillers per plant were found positive on seed yield (Table 5). Therefore, selection based on these component characters would result in improvement of seed yield also. The magnitude of residual effect was medium which indicated that major portion of contribution towards seed yield may be explained on the basis of characters included in the study. Similar findings in pearl millet have been reported by Chaudhry *et al.* (2003) [2] and Yadav *et al.* (2004) [9].

D² analysis proved to be a very useful technique in isolating diverse genotypes from the material under study. On the basis of D² statistic, 150 B-lines were grouped into 18 clusters. The cluster I was the largest and consists of 80 genotypes followed by cluster II with 54 genotypes, and rest of clusters had solitary genotype (Table 6). This grouping indicated considerable diversity among pearl millet genotypes. The maximum intra cluster distance was recorded for cluster I followed by cluster II and the highest inter cluster distance was observed between cluster XVI and cluster XVII (Table 7). Thus, the crossing between genotypes of these two clusters hold good promise as parents for obtaining potential hybrids and thereby of creating large variability for superior hybrids in pearl millet. The contribution of seed yield (27.58%) was found highest towards total divergence followed by biological yield (23.84%), days to maturity (21.20%) and days to flowering (7.36%), respectively; however, least contribution was recorded for leaves per plant (Table 8).

It is therefore inferred from the study that parental lines have adequate genetic variability to support the breeding programme of pearl millet in arid zone and characters like biological yield, flag leaf width, tillers per plant and seed yield were positively correlated and controlled by additive gene action. Therefore, these component traits may be taken into consideration for pearl millet improvement programme.

Table 1

	D.F.	Days to 50% flowering	Days to maturity	Plant height	Tillers/ plant	Leaves/ plant	Flag leaf length	Flag leaf width	Panicle length	Panicle diameter	Biological yield/plant	Seed yield/ plant
Replication	1	10.083	0.27	4.1677	0.504	28.854**	40.553*	3.199**	6.843	0.03	241.795	1.33
Treatments	149	75.058**	59.254**	759.358**	0.3971**	1.942*	41.724**	.457**	19.36**	0.287**	1454.85**	452.74**
Error	149	5.459	2.351	205.297	0.138	1.435	10.163	0.122	4.055	0.100	96.607	28.783

*Significant at P = 0.05

** Significant at P = 0.01

Table 2: Yield and related traits in superior genotypes of pearl millet

Genotypes	Days to 50% flowering	Days to maturity	Plant height (cm)	Tillers/plant	Leaves/plant	Flag leaf length (cm)	Flag leaf width (cm)	Panicle length (cm)	Panicle diameter (cm)	Biological yield (g)	Seed yield/plant (g)	Harvest Index (%)
B-1003	51	77	151.50	1.33	10.50	34.00	3.09	20.50	2.75	175.5	62.5	35.59
B-1008	54	80	90.00	3.17	9.00	35.50	3.10	15.25	2.87	123.5	52.5	42.55
B-1033	55.5	79	145.00	1.00	11.00	29.50	3.00	20.00	2.73	139.5	49.5	35.46
B-1038	53.5	78	120.50	1.17	12.00	27.50	2.38	15.58	2.02	103.5	51.5	49.78
B-1039	53	78.5	117.33	1.17	11.50	30.00	2.70	18.00	2.48	133.17	62.5	46.93
B-1049	55	82	111.33	1.17	10.50	33.00	2.77	18.50	2.55	145.17	52.5	36.22
B-1057	51.5	76.5	92.00	1.17	11.33	28.00	3.00	23.33	2.53	129.5	63	48.69
B-1062	58	81	146.50	2.67	10.00	28.50	3.28	21.50	3.13	143.5	68.5	47.76
B-1064	56.5	78	138.00	2.67	11.33	22.13	2.88	15.62	2.74	123.5	61.5	49.71
B-1069	54.5	81	109.00	1.33	10.17	27.50	2.48	16.67	2.33	138.33	67	48.41
B-1074	52	79	160.00	1.33	9.83	34.33	3.30	24.50	2.22	114.5	53.5	46.69
B-1078	54.5	81	110.33	1.50	10.00	26.50	2.57	18.67	2.37	124	58.5	47.17
B-1079	55	78.5	105.00	1.33	10.50	32.67	2.50	19.17	2.81	138.17	63	45.62
B-1088	56.5	79.5	122.00	1.00	8.50	31.75	4.30	26.58	3.57	136.5	65.5	48.03
B-1099	56.5	80	129.50	1.50	9.83	26.00	3.93	22.50	1.63	143.17	58	40.27
B-1116	45	69	180.50	2.00	7.17	25.67	2.90	15.68	1.81	140	49	35
B-1132	57.5	81	84.50	2.33	10.50	30.00	2.71	24.50	3.17	168	71	42.27
B-1133	49.5	75.5	126.50	1.33	9.00	25.50	2.48	21.23	2.48	156.5	71.5	45.72
B-1141	58.5	79	155.50	1.33	10.00	24.00	2.68	21.50	3.07	140	54.5	38.95

Table 3: Estimates of genetic variability parameters for different characters in B-lines of pearl millet

S. No.	Characters	Range	Mean	GCV	PCV	Heritability (%)	Genetic Advance	GA as % of mean
1	Days to 50% flowering	45 - 75.5	63.58	9.28	9.98	86	11.29	17.77
2	Days to maturity	69 - 97	86.89	6.14	6.39	92	10.56	12.15
3	Plant height (cm)	66.16 - 180.5	119.16	13.97	18.43	57	25.99	21.81
4	Tillers/plant	1 - 3.33	1.45	24.75	35.59	48	0.52	35.46
5	Leaves/plant	7.16 - 12.66	10.29	4.89	12.63	15	0.40	3.90
6	Flag leaf length (cm)	17.5 - 39.5	27.98	14.19	18.20	60.8	6.38	22.81
7	Flag leaf width (cm)	1.516 - 4.3	2.91	14.08	18.50	57.9	0.64	22.06
8	Panicle length (cm)	13.5 - 39.5	19.51	14.18	17.54	65.4	4.61	23.62
9	Panicle diameter (cm)	1.6 - 3.56	2.60	11.77	16.92	48	0.44	16.86
10	Biological yield/plant (g)	54.5 - 197.66	117.86	22.11	23.63	87	50.23	42.62
11	Seed yield/plant (g)	17.5 - 73.5	43.47	33.49	35.69	88	28.14	64.75

Table 4: Phenotypic and genotypic Correlation coefficient for different characters for B-lines in pearl millet

Characters	Days to 50% flowering	Days to maturity	Plant height	Tillers/plant	Leaves/plant	Flag leaf length	Flag leaf width	Panicle length	Panicle diameter	Biological yield	seed yield/plant	
Days to 50 % flowering	P	1	0.9390**	-0.2838**	-0.0359	0.0911	-0.1117	-0.1108	0.0410	0.0873	-0.3780	-0.6916**
	G	1	0.9517	-0.2578	-0.0627	0.1643	-0.1123	-0.1065	-0.0197	0.1425	-0.4450	-0.7902
Days to maturity	P	1	-0.2996**	-0.0279	0.0891	-0.1073	-0.1191*	0.0164	0.1038	-0.3769**	-0.6710**	
	G	1	-0.3063	-0.0726	0.1799	-0.1031	-0.1362	-0.0334	0.1647	-0.4296	-0.7496	
Plant Height	P	1	-0.0119	0.1330*	0.1429*	0.1291*	0.0891	-0.0920	0.2437**	0.2004**		
	G	1	-0.938	-0.0667	0.1631	0.1067	0.1707	-0.1857	0.3140	0.2700		
Tellers/ Plant	P	1	-0.1267*	0.0794	0.0449	-0.1738**	-0.0958	0.3369**	0.3546**			
	G	1	-0.1921	0.1226	0.0061	-0.2286	-0.1630	0.3513	0.2922			
Leaves/ Plant	P	1	0.0161	-0.1158*	0.1519**	0.1931**	-0.0309	-0.0678				
	G	1	0.1476	-0.5855	0.1921	-0.0223	-0.1932	-0.1627				
Flag leaf Length	P	1	0.3475**	0.2188**	0.0327	0.1419*	0.1103					
	G	1	0.3382	0.2546	0.0775	0.1899	0.1236					
Flag leaf Width	P	1	0.1849**	-0.0018	0.1235*	0.1655**						
	G	1	0.2475	-0.0141	0.1808	0.2066						
Head Length	P	1	0.0372	0.1650**	0.0294							
	G	1	0.08	0.2282	0.0791							
Head Diameter	P	1	-0.019	-0.0591								
	G	1	-0.0751	-0.0985								
Biological Yield	P	1	0.6900**									
	G	1	0.6921									
Seeds yield/plant	P	1										
	G	1										

Table 5: Phenotypic (P) and genotypic (G) path coefficient of various characters on seed yield in B-line of pearl millet

Characters		Days to 50% flowering	Days to maturity	Plant height	Tillers/plant	Leaves/plant	Flag leaf length	Flag leaf width	Panicle length	Panicle diameter	Biological yield	Seed yield/plant
Days to 50% flowering	P	-0.4266	-0.1163	0.0191	-0.0071	0.0032	0.0049	-0.0075	0.0004	0.0006	-0.1623	-0.6916**
	G	-0.7702	0.1246	-0.0155	-0.0128	0.0476	0.0220	-0.0343	0.0015	0.0134	-0.1664	-0.7902
Days to maturity	P	-0.4006	-0.1239	0.0202	-0.0055	0.0031	0.0047	-0.0081	0.0002	0.0007	-0.1618	0.6710**
	G	-0.733	0.1310	-0.0184	-0.0148	0.0521	0.0202	-0.0439	0.0025	0.0155	-0.1606	-0.7496
Plant height	P	0.1211	0.0371	-0.0675	-0.0023	0.0047	-0.0063	0.0088	0.0009	-0.0006	0.1046	0.2004**
	G	0.1986	-0.0401	0.0602	-0.0191	-0.0193	-0.0319	0.0344	-0.0126	-0.0175	0.1174	0.2700
Tillers/plant	P	0.0153	0.0035	0.0008	0.1976	-0.0045	-0.0035	0.0030	-0.0017	-0.0006	0.1447	0.3546**
	G	0.0483	-0.0095	-0.0057	0.2039	-0.0557	-0.0240	0.0020	0.0169	-0.0154	0.1313	0.2922
Leaves/plant	P	-0.0389	-0.0110	-0.0090	-0.0250	0.0353	-0.0007	-0.0079	0.0015	0.0012	-0.0133	-0.0678
	G	-0.1266	0.0236	-0.0040	-0.0392	0.2898	-0.0289	-0.1889	-0.0142	-0.0021	-0.0722	-0.1627
Flag leaf length	P	0.0477	0.0133	-0.0096	0.0157	0.0006	-0.0441	0.0236	0.0022	0.0002	0.0609	0.1103
	G	0.0865	-0.0135	0.0098	0.0250	0.0428	-0.1956	0.1091	-0.0188	0.0073	0.0710	0.1236
Flag leaf width	P	0.0473	0.0148	-0.0087	0.0089	-0.0041	-0.0153	0.0678	0.0018	0.0000	0.0530	0.1655**
	G	0.0820	-0.0178	0.0064	0.0012	-0.1697	-0.0661	0.3226	-0.0183	-0.0013	0.0676	0.2066
Panicle length	P	-0.0175	-0.0020	-0.0060	-0.0343	0.0054	-0.0097	0.0125	0.0100	0.0002	0.0708	0.0294
	G	0.0152	-0.0044	0.0103	-0.0466	0.0557	-0.0498	0.0798	-0.0740	0.0075	0.0853	0.0791
Panicle diameter	P	-0.0373	-0.0129	0.0062	-0.0189	0.0068	-0.0014	-0.0001	0.0004	0.0063	-0.0082	-0.0591
	G	-0.1098	0.0216	-0.0112	-0.0332	-0.0065	-0.0152	-0.0045	-0.0059	0.0943	-0.0281	-0.0985
Biological yield	P	0.1612	0.0467	-0.0164	0.0666	-0.0011	-0.0063	0.0084	0.0016	-0.001	0.4293	0.6900**
	G	0.3428	-0.0563	0.0189	0.0716	-0.056	-0.0371	0.0583	-0.0169	-0.0071	0.3739	0.6921

Table 6: Composition of clusters for B-lines of pearl millet

Clusters	Number of genotypes	Composition of clusters
I.	80	B-1039, B-1056, B-1078, B-1069, B-1079, B-1119, B-11041, B-1126, B-1052, B-1096, B-1087, B-1067, B-1043, B-1019, B-1010, B-1051, B-1065, B-1014, B-1071, B-1032, B-1013, B-1076, B-1011, B-1086, B-1098, B-1050, B-1012, B-1127, B-1100, B-1101, B-1020, B-1006, B-1048, B-1124, B-1143, B-1034, B-1044, B-1137, B-1061, B-1018, B-1121, B-1104, B-1054, B-1024, B-1055, B-1150, B-1033, B-1030, B-1005, B-1063, B-1089, B-1108, B-1074, B-1136, B-1015, B-1111, B-1123, B-1049, B-1002, B-1062, B-1023, B-1095, B-1112, B-1107, B-1135, B-1118, B-1004, B-1145, B-1146, B-1038, B-1103, B-1122, B-1141, B-1099, B-1009, B-1053, B-1148, B-1125, B-1140, B-1022
II.	54	B-1036, B-1059, B-1082, B-1084, B-1134, B-1029, B-1042, B-1083, B-1046, B-1085, B-1094, B-1097, B-1128, B-1092, B-1081, B-1027, B-1115, B-1025, B-1139, B-1131, B-1144, B-1129, B-1045, B-1080, B-1073, B-1070, B-1058, B-1142, B-1147, B-1077, B-1068, B-1066, B-1091, B-1138, B-1090, B-1017, B-1130, B-1114, B-1106, B-1075, B-1102, B-1149, B-1113, B-1035, B-1031, B-1021, B-1093, B-1037, B-1047, B-1060, B-1007, B-1028, B-1072, B-1105
III.	1	B-1016
IV.	1	B-1003
V.	1	B-1110
VI.	1	B-1040
VII.	1	B-1057
VIII.	1	B-1117
IX.	1	B-1064
X.	1	B-1133
XI.	1	B-1109
XII.	1	B-1001
XIII.	1	B-1132
XIV.	1	B-1088
XV.	1	B-1008
XVI.	1	B-1026
XVII.	1	B-1116
XVIII.	1	B-1120

Table 7: Average intra (in bold) and inter cluster D² value in B-lines of pearl millet

Clusters	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII
I	29.49	67.78	47.23	49.22	53.67	46.7	58.44	48.8	46.42	59.79	58.83	74.27	50.3	62.2	56.01	113.12	94.85	73.1
II	67.78	27.19	94.71	128.42	92.27	109.43	168.76	109.8	123.22	175.11	108.6	111.13	134.83	160.36	88.57	69.89	190.02	89.22
III	47.23	94.71	0	38.56	28.98	95.63	83.44	82.97	86.2	59.41	38.38	45.82	48.05	49.84	100.29	123.08	131.86	97.97
IV	49.22	128.42	38.56	0	27.22	56.36	39.73	63.28	59.66	21.72	18.15	28.55	24.47	48.66	67.41	190.27	51.32	89.17
V	53.67	92.27	28.98	27.22	0	83.7	88.54	98.15	108.4	62.42	28.02	24.45	61.22	88.97	99.65	104.49	121.4	88.43
VI	46.7	109.43	95.63	56.36	83.7	0	26.73	87.11	47.19	42.82	96.02	119.41	43	75.57	37.18	139.88	83.89	93.77
VII	58.44	168.76	83.44	39.73	88.54	26.73	0	70.16	40.17	13.41	83.75	103.34	20.27	39.62	69.25	221.46	70.52	101.62
VIII	48.8	109.8	82.97	63.28	98.15	87.11	70.16	0	31.4	69.6	69.29	93.04	74.5	75.2	85.85	218.85	54.23	102.25
IX	46.42	123.22	86.2	59.66	108.4	47.19	40.17	31.4	0	47.82	75.39	120.48	43.51	66.44	44.58	210.4	44.66	114.67
X	59.79	175.11	59.41	21.72	62.42	42.82	13.41	69.6	47.82	0	59.1	82.86	22.37	35.62	87.86	216.52	55.16	112.12
XI	58.83	108.6	38.38	18.15	28.02	96.02	83.75	69.29	75.39	59.1	0	14.86	39.83	77.39	68.16	188.27	66.74	83.97

XII	74.27	111.13	45.82	28.55	24.45	119.41	103.34	93.04	120.48	82.86	14.86	0	58.22	91.78	106.18	184.36	110.39	65.55
XIII	50.3	134.83	48.05	24.47	61.22	43	20.27	74.5	43.51	22.37	39.83	58.22	0	41.89	47.08	199.6	74.94	77.2
XIV	62.2	160.36	49.84	48.66	88.97	75.57	39.62	75.2	66.44	35.62	77.39	91.78	41.89	0	109.21	208.26	99.84	82.9
XV	56.01	88.57	100.29	67.41	99.65	37.18	69.25	85.85	44.58	87.86	68.16	106.18	47.08	109.21	0	172.62	83.3	108.56
XVI	113.12	69.89	123.08	190.27	104.49	139.88	221.46	218.85	210.4	216.52	188.27	184.36	199.6	208.26	172.62	0	313	148.2
XVII	94.85	190.02	121.86	51.32	121.4	83.89	70.52	54.23	44.66	55.16	66.74	110.39	74.94	99.84	83.3	313	0	145.37
XVIII	73.1	89.22	97.97	89.17	88.43	93.77	101.62	102.25	114.67	112.12	83.97	65.55	77.2	82.9	108.56	148.2	145.2	0

Table 8: Contribution of different characters towards total divergence

S. No.	Characters	Percent contribution
1.	Days to 50% flowering	7.36%
2.	Days to maturity	21.20%
3.	Plant height	4.68%
4.	Tellers/plant	2.81%
5.	Leaves/plant	0.43%
6.	Flag leaf length	3.32%
7.	Flag leaf width	3.45%
8.	Panicle length	3.73%
9.	Panicle diameter	1.60%
10.	Biological yield	23.84%
11.	Seed yield	27.58%

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