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Combining Ability Analysis for Yield and its Related Traits in Pearl Millet

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A 10×10 half diallel excluding reciprocals was evaluated in 3 environments to study the combing ability and gene action involved in respect of yield and its attributers in pearl millet. The environment wise combining ability analysis revealed significant differences for GCA (general combining ability) and SCA (specific combining ability) variances for characters *viz.* days to 50% flowering, days to maturity, productive tillers/plant, plant height, panicle length, panicle girth, biological yield/plant, dry fodder yield/plant, grain yield/plant, harvest index, test weight and protein content in all the three environments, except GCA for productive tillers per plant in E_2 and panicle girth in E_3 and SCA for panicle girth in E_3, indicating the importance of both additive and non-additive gene effects for the genetic control of all the characters studied. The estimates of GCA effects indicated that the parents 71-75 and 76-80 emerged as good general combiners for grain yield and its components in the entire environment. Out of 45 crosses combinations only seven combinations such as 26-30 x 71-75, 26-30×RIB-135-144, 31-40×76-80, 31-40×RIB-135-144, 31-40×101-105, 41-50×RIB-20 and RIB-20×71-75 showed significant and positive SCA effects in all the three environment for grain yield and other yield attributing characters. These parents and crosses have immense potential for pearl millet improvement and may be utilized in multiple crossing programme.

Key Words: Combining ability, Environments, GCA, Gene action, SCA

Introduction

Pearl millet (*Pennisetum glaucum* L.) is the world's sixth important and widely grown potential cereal crop. In India pearl millet is the fourth most important food grain after rice, wheat and sorghum. Pearl millet is highly cross pollinated crop with the advantages of huge genetic variability, protogyny and availability of efficient cytoplasmic genetic male sterility system. These characteristics, offer great possibilities of crop improvement through hybridization. Selection of suitable parent is an important step in a crop improvement programme.

Materials and Methods

Ten inbred lines *viz.* 26-30, 31-40, 41-50, RIB-20, 61-70, 71-75, 75-80, 51-60, RIB-135-144 and 101-105 were crossed in a diallel fashion excluding reciprocals during *kharif* season 2011. These 10 parents and their $45F_1$'s were evaluated in randomized block design with three replications under three environments at Agronomy Research Farm, Jobner (Jaipur) during *kharif* season, 2012. Environment created by dates of sowing viz. 2 July, 2012 {first date of sowing (E_1)}, 14 July, 2012 {second date of sowing (E_2) and 28 July, 2012 {third date of sowing (E_3)}. Each entry was sown in a two row of 3.0 m length with row-to-row and plant-to-plant distances of 50 cm and 15 cm, respectively. The observation were recorded on five randomly selected plants from each replication and environment, for the characters namely; days to 50% flowering, days to maturity, productive tillers/plant, plant height, panicle length, panicle girth, biological yield/plant, dry fodder yield/plant, grain yield /plant, harvest index, test weight and protein content while, days to 50% flowering and days to maturity were recorded on plot basis. The combining ability analysis was done according to Griffing (1956) Method-2, Model-1 using SAS 2005 package from Zhang *et al.* (2005).

Results and Discussion

The general combining ability (GCA) and specific combining ability (SCA) variances were highly significant for days to 50% flowering, days to maturity, productive tillers/plant, plant height, panicle length, panicle girth, biological yield/plant, dry fodder yield/plant, grain yield/plant, harvest index, test weight and protein content in all the three environments, except GCA for productive tillers per plant in E_2 and panicle girth in E_3 and SCA for panicle girth in E_3, indicating the importance of both additive and non-additive gene effects for the genetic control of all the characters studied. However, GCA: SCA variance ratio being less than the unity showed that the non-additive gene action was more important for all the characters in three environments (Table 1).

These findings were supported by Vagadiya *et al*. (2010), Jethva *et al*. (2011), Yadav *et al*. (2012) and Parmar *et al*. (2013).

Nature and magnitude of combining ability effects provide an idea about the relative role of fixable and non- fixable gene effects in the inheritance of different characters. Thus, it helps in identifying suitable parents for crossing programme. In the present study, out of 10 parents only two parents such as 71-75 and 76-80 showed significant and positive general combining ability (GCA) effects in all the three environments for grain yield and other yield attributing characters. While parent 31-40 was found to be uniformly undesirable parent across the environment with high negative effects (Tables 2 and 3). These parents may be used in a multiple crossing programme to synthesize a dynamic population with most of the favourable genes accumulated (Griffing, 1956). In pearl millet, parents having good GCA have been reported by Shanmuganathan and Gopalan (2006), Rohitashwa *et al*. (2006), Dangaria *et al*. (2009) and Chaudhary *et al*. (2012).

There was no consistency over environment for the ranks of crosses with high SCA effects. Furthermore, a number of crosses exhibited changes in the magnitude and direction of SCA effects in different environments, which might be consequence of high SCA x environment interaction. Out of 45 crosses combinations only seven combinations such as 26-30×1-75, 26-30×RIB-135-144, 31-40×76-80, 31-40×RIB-135-144, 31-40×101-105, 41-50×RIB-20 and RIB-20×71-75 showed significant and positive specific combining ability (SCA) effects in all the three environment for grain yield and other yield attributing characters (Tables 2 and 3) These crosses have immense potential for pearl millet improvement, they may be utilized in multiple crossing programme and crosses 76-80×51-60, 31-40×101-105 and 41-50×RIB-135-144 in E_1, 26-30×41-50, 61-70×71-75 and RIB-20×71-75 in E_2 and 31-40×101-105, 41-50×RIB-20 and 31-40×76-80 in E_3 were identified on the basis of high SCA effects for specific environment for grain yield per plant and related traits (Table 4). These finding were corroborative with the results obtained by Rasal and Patil (2003), Bhanderi *et al*. (2007) and Chotaliya *et al*. (2010). These crosses offer good promise for improvement of respective component trait and ultimately grain yield in respective environment.

Conclusion

This study concludes that the SCA variance was greater than the GCA variance for most of the traits among the pearl millet population, indicating non-additive genetic effects as the most important in control of the studied traits. Since non-additive gene action was more important for grain yield, simple recurrent selection that emphasises selection for SCA could be employed in the breeding

Table 1. Analysis of variance for combining ability in individual environment in pearl millet

Source of variance	d.f.	Env.	Mean sum of square											
			Days to 50% flowering	Days to maturity	Productive tillers/ plant	Plant height (cm)	Panical length (cm)	Panical girth (cm)	Biological yield/ plant (g)	Dry fodder yield/ plant (g)	Grain yield/ plant (g)	Harvest index (%)	Test weight (g)	Protein content (%)
GCA		E_1	33.858**	42.823**	0.432**	258.517**	5.555**	0.893**	2391.863**	972.834**	14.434**	9.201**	2.515**	1.304**
		E_2	5.700**	15.555**	0.085**	524.367**	5.452**	2.447**	345.647**	452.764**	5.475**	2.022*	3.294**	0.771**
	9	E_3	14.106**	7.931**	0.005	676.653**	8.457*	0.535	132.082**	75.494*	3.1627**	102.617*	2.907**	1.042**
SCA		E_1	27.159**	31.279**	0.523**	1029.576**	17.496**	1.622**	4563.391**	3915.447**	15.864**	14.468**	1.643**	2.406**
		E_2	10.557**	19.218**	0.072**	413.973**	9.738**	1.928**	763.663**	762.552**	7.291**	5.979**	2.173**	2.152**
	45	E_3	9.695**	14.900**	0.010*	392.611**	9.367**	0.568	65.694*	46.862*	6.495**	926.338**	1.582**	2.200**
Error		E_1	0.565	1.128	0.017	1.388	0.488	0.028	525.240	155.629	0.632	0.979	0.353	0.091
		E_2	0.614	1.248	0.015	3.259	0.190	0.008	40.770	7.606	0.381	0.689	0.007	0.055
	105	E_3	0.438	2.139	0.006	3.888	2.557	0.107	34.339	24.620	0.703	445.227	0.004	0.024
GCA/SCA		E_1	0.104	0.115	0.068	0.020	0.024	0.045	0.038	0.018	0.075	0.050	0.139	0.043
		E_2	0.042	0.066	0.102	0.105	0.045	0.105	0.035	0.049	0.061	0.021	0.126	0.028
		E_3	0.123	0.037	-0.039	0.144	0.072	0.077	0.259	0.190	0.035	0.036	0.153	0.038

*and**significant at 5% and 1% level of significance, respectively

Table 2 Estimate of GCA and SCA effects of some promising parents and crosses for grain yield/plant in all the three environment

Parents/Crosses	Days to 50% flowering			Days to maturity			Productive tillers/plant			Plant height (cm)			Panicle length (cm)			Panicle girth (cm)		
	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3
71-75	0.083	0.011	0.922**	-0.556	-0.933**	0.633	0.039	0.110**	-0.010	-1.895**	-4.248**	-3.206**	0.006	-0.218	-1.633**	0.366**	0.182**	0.398**
76-80	-0.306	0.344	-0.828**	-1.056**	0.928**	-0.506	-0.094*	0.038	0.029	4.561**	16.277**	16.522**	-0.184	0.853**	1.091*	0.216**	0.011	-0.008
SEgi	0.215	0.224	0.189	0.304	0.320	0.418	0.038	0.036	0.023	0.337	0.516	0.564	0.200	0.125	0.457	0.048	0.026	0.094
26-30 X 71-75	-6.306**	-5.311**	-0.636	-7.601**	-5.467**	-4.578**	-1.103**	-0.243*	-0.079	-22.934**	-21.017**	3.306	-2.459**	-4.443**	-2.460	-1.255**	0.537**	0.400
26-30 X RIB-135-144	1.111	-1.311	1.558*	2.593**	-3.384**	1.811	-0.247*	0.223	0.038	59.938**	17.297**	2.334	-2.752**	0.691	3.613*	0.091	-0.270**	-0.032
31-40 X 76-80	4.222**	0.967	-1.081	4.538**	-0.384	-2.217	0.447**	-0.038	-0.068	-12.829**	31.936**	-8.449**	-1.250	-2.927**	-1.391	1.551**	1.164**	0.321
31-40 X RIB-135-144	-6.417**	1.634*	-2.636**	-8.101**	0.894	-2.634	-0.297*	-0.043	0.021	-4.768**	2.608	6.039**	1.794**	0.703	1.002	-0.986**	-0.557**	0.243
31-40 X 101-105	-2.944**	-3.449**	-2.497**	-1.351	-3.134**	-4.912**	0.825**	-0.016	0.049	5.749**	3.014	19.706**	1.061	-0.205	0.794	1.051**	0.023	-0.767*
41-50 X RIB-20	4.028**	-0.422	0.086	0.955	3.477**	2.394	-0.897**	-0.160	-0.040	9.330**	0.306	10.517**	-3.262**	3.917**	1.552	-0.159	-1.825**	0.526
RIB-20 X 71-75	-4.083**	0.939	1.503*	-3.851**	-1.995	-0.162	-0.319*	-0.182	-0.029	27.293**	22.347**	2.517	6.496**	-0.754	-3.933**	2.238**	2.218**	-0.450
SEsij	0.693	0.722	0.610	0.978	1.029	1.347	0.123	0.115	0.075	1.085	1.663	1.817	0.644	0.402	1.473	0.155	0.083	0.302

*=Significant at 5%level of significance, **=Significant at 1%level of significance

Table 3 Estimate of GCA and SCA effects of some promising parents and crosses for grain yield/plant in all the three environment

Parents/Crosses	Biological yield/plant (g)			Dry fodder yield/plant (g)			Grain yield/plant (g)			Harvest index (%)			Test weight (g)			Protein content (%)		
	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3
71-75	7.508	6.017**	-1.642	0.384	6.091**	-1.551	1.852**	1.259**	0.777**	1.136**	0.548*	2.041**	-0.301	-0.284**	-0.343**	0.040	-0.034	-0.124**
76-80	11.241	5.784**	6.677**	4.798	4.420**	3.871**	1.337**	0.856**	1.019**	0.641*	-0.087	-0.298	-0.430*	-0.312**	-0.477**	-0.321**	-0.244**	-0.219**
SEgi	6.555	1.826	1.676	3.568	0.789	1.419	0.227	0.177	0.240	0.283	0.238	0.581	0.170	0.024	0.020	0.086	0.068	0.044
26-30 X 71-75	-84.992**	-15.222*	0.247	-39.419**	-21.954**	0.227	2.499**	2.318**	2.164**	10.706**	3.325**	2.975	0.230	-0.150	0.260**	1.334**	1.189**	0.958**
26-30 X RIB-135-144	68.414**	40.114**	-3.467	65.841**	36.711**	-8.648	3.545**	3.628**	3.929**	-1.600	-0.269	9.004**	1.332*	2.756**	1.961**	0.394	1.024**	0.629**
31-40 X 76-80	-33.883	30.300**	1.089	-37.764**	34.529**	-1.711	4.970**	2.427**	3.992**	5.472**	-1.110	6.878**	0.866	0.674**	0.364**	2.443**	1.501**	2.293**
31-40 X RIB-135-144	-30.484	20.236**	2.628	-42.629**	6.857**	-0.630	3.015**	1.840**	3.725**	4.144**	-0.839	6.924**	-0.054	0.660**	0.213**	-0.678*	-1.269**	-0.895**
31-40 X 101-105	38.340	14.134*	-1.384	29.740*	0.935	-4.458	6.504**	3.968**	4.765**	0.729	1.564*	9.952**	0.005	-0.097	0.121	-0.088	0.302	0.450**
41-50 X RIB-20	3.661	22.677**	6.125	-53.739**	13.202**	1.070	2.551**	2.939**	4.539**	1.075	0.227	5.865**	-1.141**	-1.744**	-1.841**	-0.813**	-0.559*	-0.470**
RIB-20 X 71-75	51.251*	18.069**	-0.986	57.052**	8.780**	-1.261	5.639**	4.120**	2.343**	-0.990	1.301	5.804**	-0.129	-0.212**	-0.060	-2.962**	-2.786**	-3.415**
SEsij	21.111	5.882	5.398	11.491	2.540	4.571	0.732	0.569	0.773	0.912	0.765	1.870	0.548	0.077	0.065	0.278	0.217	0.142

*=Significant at 5%level of significance, **=Significant at 1%level of significance

Table 4. Top three parents and crosses for grain yield/plant on the basis of high GCA and SCA effects

Characters	Environments	GCA	SCA
Grain yield/plant	E_1	71-75, 76-80 and 41-50	76-80×51-60, 31-40×101-105 and 41-50×RIB-135-144
	E_2	71-75, 76-80 and 61-70	26-30×41-50, 61-70×71-75 and RIB-20×71-75
	E_3	76-80 and 71-75	31-40×101-105, 41-50×RIB-20 and 31-40×76-80

programme. The study also concludes that an astounding level of variability existed in the population because of the enormous level of high SCA among the hybrids, indicating the possibility of getting better combinations from segregating generations of these crosses.

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