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DETERMINATION OF MATERNAL EFFECTS ON QPM INBREDS LINES

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ABSTRACT
Five UQPM inbreds were crossed as female parent to three testers as male parent to generate 15 F1 direct crosses and reciprocal crosses were made to generate another 15 F1 crosses. Totally 39 genotypes including hybrids along with their parents and check (COH (M) 5) were evaluated in randomized block design to estimate the maternal effects in QPM through SCA, and GCA analysis. In this study, we revealed that hybrids of female parent UQPM 15 and UQPM 11 possess higher grain tryptophan and grain lysine where as in reciprocal crosses *i.e*. when UQPM 15 and UQPM 11 used as male, quality characters do not show improvement to the level to which they are used as female parent, indicating that quality protein content depended on maternal parent. Also found to have desirable gca effects for the biometric traits.

KEYWORDS: UQPM, SCA, GCA, Maternal effects, Lysine and Tryptophan.

INTRODUCTION

Maize is important food crop next to wheat and rice. Maize is used as both food and fodder crop and also a poor man's nutricereal. Maize kernel contains 80 % carbohydrates, 10% protein, 4.5% oil, 3.5% fiber and 2% minerals (Jugenheimer, 1976). It is a good source of calcium and phosphorous. But maize is deficient for two essential amino acids such as lysine and tryptophan. The breakthrough in maize production is obtained after the discovery of opaque 2 mutant maize which alters the amino acid composition and enhances the grain tryptophan and lysine content in maize (Mertz *et al*., 1964). It promotes evolution of new quality protein maize composites such as rattna, sakthi and protina. Later on QPM production was affected due to its soft endosperm texture. Intensive breeding efforts had made in CIMMYT to release the hard texture endosperm QPM for commercial cultivation. The endosperm modification in QPM is quantitatively inherited and there is increased synthesis of zein (Vassal *et al*., 1993). Several report suggested preponderance of additive gene action in kernel modification. Favourable GCA of kernel vitreousness and kernel hardness was positively correlated with an accumulation of dominant kernel modifiers. In this study we evaluated the 30 hybrids derived from both direct and reciprocal crosses along with 8 parents and check (COH (M) 5) to understand the maternal effects of University Quality Protein Maize (UQPM) inbreds.

MATERIALS & METHODS

Eight inbreds listed in Table 1 obtained from Department of Millets, centre for Plant Breeding and Genetics (CPBG), Tamil Nadu Agricultural University (TNAU), Coimbatore formed the parent material of the present study. The parents numbered 1 to 5 (Table 1) were used as female parents (Lines) and 6 to 8 were used as male parent (Tester). Five lines and three testers were crossed in L x T fashion, to incorporate QPM character. In another set the parent numbered 1 to 5 were used as male parent (tester) and 6 to 8 as female parent (lines) i.e. three lines and five testers were crossed in L x T fashion are reciprocal combination to incorporate QPM character.

TABLE 1. Details of parent

S.No	Inbreds	Grain type	Source
1	UQPM-5	Yellow, Flint	TNAU, Coimbatore
2	UQPM-11 (8655-6)	Yellow, Dent	TNAU, Coimbatore
3	UQPM-12 (DMR 1024)	Yellow, Flint	DMR, New Delhi
4	UQPM-13 (DMR 1026)	Yellow, Flint	DMR, New Delhi
5	UQPM-15 (DMR 1021)	Yellow, Flint	DMR, New Delhi
6	UQPM-9 (8664-8)	Yellow, Flint	TNAU, Coimbatore
7	UQPM-10 (8654-10)	Yellow ,Dent	TNAU, Coimbatore
8	UQPM-14 (DMR 1161)	Yellow, Dent	DMR, New Delhi

UQPM –University Quality Protein Maize, TNAU- Tamil Nadu Agricultural University
DMR- Directorates of Maize Research

The parental seeds were raised at Millet Breeding Station, Department of Millets, CPBG, TNAU, and Coimbatore during summer in three staggered sowing to get synchronization of flowering and for continuous availability of pollen. Tassel bag method was used for hybridization. Thirty hybrids obtained from Line X Tester crossing fashion using five lines and three testers as direct crosses as well as reciprocal crosses. All the hybrids were evaluated along with eight parents and with the normal commercial hybrid COH (M) 5 during Kharif. Their seeds were raised in randomized block design with three replications and 60 x 45 cm spacing was adopted. Each entry was sown in two rows of 4m length. Five random plants from each entry per replication were tagged and the observation recorded for fifteen characters viz., days to silking, plant height, ear height, cob length, cob girth, number of kernels per row, number of grains per cob, 100 grain weight, grain length, grain breadth, grain width, grain yield per plant, crude protein, grain tryptophan, and grain lysine.

Grain protein percentage was estimated by Microkjeldhal method (Humphries, 1956). Tryptophan and Lysine in grain sample was estimated by calorimetric method (Mertz *et al*., 1975, Theymoli Balsubramanian and Sadasivam., 1987). Tryptophan in the grain sample was calculated using the formula, Grain tryptophan or lysine % = Value from graph in µg X 0.096(g/16 g N).The data on the hybrids and parents recorded were subjected to L × T analysis described by Kempthorne (1957). The assumption of null hypothesis was tested for differences among the genotypes as detailed by Panse and Sukhatme (1964). The mean squares due to different sources of variation as well as their genetic expectations were estimated. ANOVA used to estimate GCA and SCA effects.

RESULTS & DISCUSSION

The eight parents of the study were deliberately chosen based on their variability for grain characters. All the parents possessed yellow grain. Three parents' viz., UQPM 11, UQPM 10, and UQPM 14 had dent grain texture and other five viz., UQPM 5, UQPM 12, UQPM 13, UQPM 15, and UQPM 9 had flint grain texture. Fifteen hybrids were generated from five lines viz., UQPM-5, UQPM -11, UQPM-12, UQPM-13, UQPM-15 and three testers UQPM-9, UQPM-10, and UQPM-14. In another set fifteen more hybrids generated in a reciprocal manner that is using lines as testers and tester as lines, here the lines are UQPM-9, UQPM-10, and UQPM-14 and testers are UQPM – 5, UQPM -11, UQPM-12, UQPM-13, and UQPM-15. Therefore, totally thirty hybrids derived from both direct and reciprocal crosses were evaluated for fifteen characters viz., days to silking, plant height, ear height, cob length, cob girth, number of kernels per row, number of grains per cob, 100 grain weight, grain length, grain breadth, grain width, grain yield per plant, crude protein, grain tryptophan, and grain lysine.

Evaluation of Parents

In the present study, desirable mean value and gca effect were revealed by the parent UQPM11 for two characters in direct crosses viz., grain breadth, grain width and grain protein whereas in reciprocal crosses it was for three characters viz., number of grains per cob, grain tryptophan and grain lysine; UQPM 15 for plant height, grain protein, grain tryptophan and grain lysine in direct and for plant height ,ear height and grain protein in reciprocal crosses; UQPM 9 for two characters viz., plant height and grain protein in both direct as well reciprocal; UQPM 10 for 100 grain weight in reciprocal crosses; UQPM 14 for five character in direct crosses *viz*., cob girth, grain length, grain breadth, grain width and grain yield whereas in reciprocal crosses it was grain length, grain breadth, grain width and grain yield. Hence, these parents can definitely be used for improvement of the respective traits in hybridisation programme. Analysis of variances for combining ability of the both crosses is given in Table 2a and 2b. Also the Magnitude of GCA and SCA variances and proportional contribution of Lines, Testers, and Line X Testers to total variances for various characters for both direct crosses and reciprocal crosses are given in Table 3a and 3b.

TABLE 2a. Analysis of variances for combining ability - Mean squares (Direct crosses)

S.No	Characters	Genotypes (df=22)	Parents (df=7)	Hybrids (df =14)	Parent vs. Hybrid (df = 1)	Lines df=4	Tester (df=2)	Line x tester (df= 8)	Error (df=44)
1	Days to silking	19.44**	12.319**	11.57**	179.39 **	18.97*	13.22	7.46**	1.25
2	Plant height	3301.68**	1649.17**	998.45 **	47114.43**	1273.10	2047.62*	598.83**	6.39
3	Ear height	2224.64 **	660.07**	843.96**	32505.99 **	1503.78**	1631.12**	317.27**	4.00
4	Cob length	29.24**	9.34**	12.57**	401.91**	4.87**	3.85*	18.60**	1.16
5	Kernels/row	11.51**	9.56**	9.69**	50.58**	2.22	16.81	11.65 **	0.69
6	Grains/cob	32175.51**	6776.54**	16882.92**	424064.57**	29205.02**	20878.92	9722.87**	77.52
7	100 grain wt	211.78 **	68.78**	62.71**	3299.82 **	58.77	28.026	73.35 **	1.16
8	grain yld/plant	10535.19**	1435.64**	4941.87**	152538.45**	4389.18	7014.00	4700.18**	26.18
9	cob girth	0.91 **	0.41**	0.14**	15.0954**	0.12	0.09	0.17**	0.0005
10	grain length	0.05**	0.07**	0.02**	0.28**	0.01	0.04	0.02**	0.0018
11	grain breadth	0.04**	0.04**	0.02**	0.22**	0.02	0.01	0.01**	0.0117
12	grain width	0.01**	0.01**	0.0044**	0.04**	0.0024	0.0095	0.0041**	0.0003
13	crude protein	6.56**	3.784**	8.36**	6.875**	11.03**	23.55**	3.23**	0.0005
14	grain tryptophan	0.0003**	0.0004**	0.0002**	0.0006**	0.0001	0.0003	0.0002**	0.00
15	grain lysine	0.0049**	0.0062**	0.0038**	0.01**	0.0020	0.0048	0.0045**	0.00

*- Significant at 0.05 and **- Significant at 0.01 level.

Evaluation of hybrids

Specific combining ability (sca) *i.e*., the deviation from the performance predicted based on general combining ability of parents(Allard,1960) was the third important criterion for evaluation of hybrids. Among the hybrids identified with significant and desirable sca effect for different characters, it was observed that hybrids with significant and desirable sca effects were from the parents of differential combinations *i.e*., hybrids with significant and desirable sca effects were from high x high, high x low, low x high and low x low gca combinations. Similar results of desirable sca have been reported by many workers for yield and its component traits (Debnath and Sarkar, 1987; Mathur *et al*., 1998; Kumar, *et al*., 1998; Kara, 2001; Kalla *et al*., 2001; Dodiya and Joshi, 2003). Yield is the cumulative function of all the components and is the final goal of a maize breeder, for which UQPM13XUQPM14, UQPM5XUQPM9, UQPM15XU QPM10 and UQPM12XUQPM10 were the best under all three evaluation criteria and topped among the hybrids. The hybrid UQPM13XUQPM14 for number of kernels per row, number of grains per cob and 100 grain weight; UQPM5XUQPM9 had qualified for number of grains per cob and 100 grain weight; UQPM15XUQPM10 and UQPM12XUQPM10 for grains per cob and 100 grain weight respectively. For grain yield, in all four hybrids one of the parents had low gca effects (UQPM10) and other hand high gca effects (UQPM14 and UQPM12) and other parents had moderate gca effect (UQPM13, UQPM5, UQPM9 and UQPM15). For effective selection, a hybrid should be with high per se, standard heterosis and sca effect. In addition, the hybrid should have both the parents as good combiners and atleast one parent as a good combiner. Richharia and Singh (1983) also opined that a hybrid should have at least one parent as a good combiner. Hence, going by the above statement, it is suggested that the four hybrids UQPM13XUQPM14, UQPM5XUQPM9, UQPM15XUQPM10 and UQPM12XUQPM10 could be exploited as promising hybrids for grain yield after confirmative testing.

TABLE 2b. Analysis of variances for combining ability - Mean squares (Reciprocal crosses)

S. No	Characters	Genotypes (df=22)	Parents (df=7)	Hybrids (df =14)	Parent Vs. Hybrid (df = 1)	Lines (df=2)	Tester (df=4)	Line x tester (df= 8)	Error (df=44)
1	Days to silking	30.14 **	12.319**	19.82**	299.47**	57.07*	7.05	16.88**	0.89
2	Plant height	4267.75 **	1649.17**	1013.09**	68163.07**	2109.93*	1621.69**	434.58**	9.44
3	Ear height	2668.65 **	660.07**	797.95**	42918.53 **	966.56**	1990.77**	159.39 **	3.67
4	Cob length	35.22 **	9.34**	15.10**	498.09**	1.164	41.59**	5.34**	2.17
5	Kernels/row	11.25**	9.56 **	8.91**	61.56**	15.20	6.08	8.75**	0.78
6	Grains/cob	63832.14**	6776.54**	9667.44**	1221527.08**	34126.61**	14025.66**	1373.55**	94.34
7	100 grain wt	233.56 **	68.78**	83.54**	3487.36 **	215.96**	121.71**	31.35**	2.19
8	grain yld/plant	19619.63 **	1435.64**	7643.65**	314571.23**	33249.26**	3785.48	3171.33**	26.90
9	cob girth	1.74**	0.42**	0.51**	28.14**	0.17	0.68	0.51**	0.00
10	grain length	0.19**	0.07**	0.07**	2.61**	0.035	0.13	0.06**	0.0019
11	grain breadth	0.11690**	0.049**	0.02**	1.92**	0.005	0.063**	0.004**	0.001
12	grain width	0.0247**	0.0145**	0.0037**	0.39**	0.0012	0.0064	0.0029**	0.0003
13	crude protein	8.85**	3.78**	11.85**	2.23**	21.91	15.83	7.35**	0.0006
14	grain tryptophan	0.0002**	0.0004**	0.0001**	0.0008**	0.00008	0.0001	0.0002**	0.00
15	grain lysine	0.004**	0.0062**	0.0026**	0.0132**	0.0013	0.0027	0.0029**	0.00

*- Significant at 0.05 and **- Significant at 0.01 level.

TABLE 3a. Magnitude of GCA and SCA variances and proportional contribution of Lines, Testers, and Line X Testers to total variances for various characters (Direct crosses)

S.No	Characters	GCA variance	SCA variance	GCA : SCA	Proportion contribution (%)		
					Lines	Testers	Lines X Testers
1	Days to silking	1.2419	2.0887	0.59458	46.8283	16.3204	36.8513
2	Plant height	137.7424	197.1249	0.698757	36.4308	29.2971	34.2721
3	Ear height	130.3412	104.637	1.245651	50.9086	27.6098	21.4815
4	Cob length	0.2465	5.7332	0.042995	11.0704	4.3815	84.5482
5	Cob girth	90.7463	570.957	0.158937	23.4899	9.5848	66.9254
6	Kernels/row	0.737	3.6618	0.201267	6.5475	24.7633	68.6893
7	Grains/cob	2079.372	3211.123	0.647553	49.4244	17.667	32.9086
8	100 grain wt	3.4879	23.9346	0.145726	26.7792	6.3842	66.8365
9	Grain length	23.2261	89.8249	0.258571	12.2472	25.8497	61.9031
10	Grain breadth	13.8443	52.8958	0.261728	31.7435	13.0052	55.2514
11	Grain width	4.7379	12.7738	0.370908	15.6315	30.8968	53.4717
12	Grain yield	472.2994	1555.393	0.303653	25.3761	20.2757	54.3482
13	Crude protein	14413.56	10785.95	1.336327	37.6915	40.2095	22.099
14	Grain tryptophan	0.1843	0.9671	0.19057	15.0041	18.056	66.9399
15	Grain lysine	2.852	14.9157	0.191208	15.1722	18.0325	66.7953

Maximum hybrids were found to possess higher grain tryptophan and grain lysine when UQPM 5, UQPM11 and UQPM 15 was used as female parent and also found to have desirable gca effects for the above traits. When UQPM 15 and UQPM 11 (desirable donor parents for improvement of grain protein, grain lysine and grain tryptophan) were used as female parents in the study, hybrids were found to possess higher grain tryptophan and grain lysine where as in reciprocal crosses i.e. when UQPM 15 and UQPM 11 used as male, quality characters do not show improvement to the level to which they are used as female parent, indicating that quality protein content depended on maternal parent. such an observation was also made by Popova (1980). Further, a critical analysis of parental combinations and hybrid performance showed that most of the good hybrids for different traits were from low x low parental combinations. This may be due to the fact that the performance of parents which had diminished due to inbreeding depression resulted from continuous selfing, results also indicate that the high performance of hybrids is not limited to high order of parents, but it could be also produced with all possible combinations of high x low and low x low parental status. Subba Rao and Aruna (1997) and Badhe and Patil (1997) observed similar results in their studies.

TABLE 3b. Magnitude of GCA and SCA variances and proportional contribution of Lines, Testers, and Line X Testers to total variances for various characters (Reciprocal crosses)

S.No	Characters	GCA variance	SCA variance	GCA : SCA	Proportion contribution (%)		
					Lines	Testers	Lines X Testers
1	Days to silking	2.6183	5.414	0.483617	41.1377	10.1726	48.6896
2	Plant height	154.4559	140.7479	1.097394	29.7522	45.7352	24.5125
3	Ear height	122.9231	51.9329	2.36696	17.3043	71.2813	11.4144
4	Cob length	1.5726	0.9461	1.662192	1.1012	78.6753	20.2235
5	Cob girth	356.8914	1707.399	0.209026	4.8064	38.1143	57.0793
6	Kernels/row	0.8172	2.6392	0.309639	24.359	19.5157	56.1254
7	Grains/cob	1996.469	418.3458	4.772292	50.4293	41.4518	8.1189
8	100 grain wt	13.8045	9.3886	1.470347	36.9305	41.6255	21.444
9	Grain length	67.3871	197.8095	0.340667	6.5634	48.2016	45.235
10	Grain breadth	28.3337	14.6439	1.934847	3.7292	83.7298	12.541
11	Grain width	2.9157	8.7016	0.335076	4.8264	49.5659	45.6078
12	Grain yield	1540.212	1045.504	1.473177	62.1417	14.1499	23.7085
13	Crude protein	15725.67	24514.95	0.641473	26.397	38.1554	35.4476
14	Grain tryptophan	0.1101	0.6274	0.175486	7.1114	30.0205	62.8682
15	Grain lysine	1.6868	9.6321	0.175123	7.1012	30.0108	62.888

CONCLUSION

One of the objectives of the present study is to look for high yielding hybrids with desirable quality traits in terms of protein, grain tryptophan and grain lysine content. From the study, it was observed that the hybrid UQPM15XUQPM10 need worth mentioning as it possessed high per se, standard heterosis and sca effect for grain yield and grain protein. It also possessed high standard heterosis and sca effect for grain tryptophan and grain lysine. Besides, the six hybrids UQPM14XUQPM11 registered high per se, standard heterosis and sca effect for grain protein, grain tryptophan, grain lysine and grain yield. UQPM9XUQPM12 and UQPM10XUQPM15 registered high per se, standard heterosis and sca effect for grain protein, grain tryptophan and grain lysine; UQPM11XUQPM10, and UQPM5XUQPM14, registered high per se, standard heterosis and sca effect for grain tryptophan and grain lysine. Development of breeding materials is one another option for a breeder to effectively utilize the developed genetic materials. In this context, the nine promising hybrids identified *viz*., UQPM13XUQPM14, UQPM5XUQPM9, UQPM15XU QPM10, UQPM12XUQPM10, UQPM14XUQPM11, UQPM9XUQPM12, UQPM10XUQPM15, UQPM11XU QPM10, and UQPM5XUQPM14may be utilized in the multiple crosses and development of panmictic populations in order to isolate desirable segregants combining yield and quality.

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