Research Journal of Agriculture and Biological Sciences, 4(6): 798-802, 2008

Genetic Studies of Combining Ability Estimates for Seed Oil, Seed Protein and Fibre Quality Traits in Upland Cotton (*G. Hirsutum* L.)

[1]K. Ashokkumar and [2]R. Ravikesavan

[1]PhD. Research Scholar, Department of Plant Molecular Biology and Biotechnology Tamil Nadu Agricultural University, Coimbatore-3, Tamil Nadu, India.
[2]Associate Professor, Cotton Breeding station, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore-3, Tamil Nadu, India.

Abstract: An investigation was taken up to explore the possibility of transferring the genes responsible for seed oil content in cotton through intra-*hirsutum* crosses. The inheritance of seed oil, seed protein, seed cotton yield and fibre quality characters were studied in twenty eight hybrids involving four adapted varieties as females (lines) and the seven *G. hirsutum* accessions as males (testers) in Line X Tester analysis. It was found that all the characters studied, (i.e., seed oil, seed protein, seed cotton yield, 2.5% span length, bundle strength, micronaire, uniformity ratio and fibre elongation percentage) are controlled by predominantly non-additive gene action. The best general combiners among the parents were F 776 and Surabhi for seed oil and MCU 5 for seed protein and bundle strength, MCU 12 and F 1861 for seed cotton yield and micronaire and SVPR 2 for uniformity ratio and elongation percentage. The best specific combiners in the hybrids were Surabhi x TCH 1646 and Surabhi x F 1861 for seed oil and MCU 12 x TCH 1644 for seed protein and 2.5% span length and MCU 12 x SOCC 11 and Surabhi x TCH 1641 for seed cotton yield and Surabhi x TCH 1644 for uniformity ratio and elongation percentage. The present study indicated the possibility of developing high yielding hybrids with high seed oil content and better fibre quality traits through heterosis breeding.

Key words: Combining ability, fibre quality characters, seed cotton yield, seed oil and seed protein content.

INTRODUCTION

Cotton (*Gossypium* spp.) is an important cash crop cultivated over an area of 9 million hectares in India. Cotton production in India is 310 lakh bales during 2007-08. Cotton, also known as “King of fibres” plays a remarkable role in national economy. Cotton crop is mainly cultivated for fibre. The cotton seed, which is byproduct, is an important source of edible oil. Cotton seed is the second largest source of vegetable oil in the world. In India primary source of edible oil production is 59.52 lakh tons and secondary source of edible oil production is 19.90 lakh tons during 2003-04. Among these the current availability of cotton seed oil is ranged from 5.5 to 6 lakh tons per annum. In India, a total quantity of about 67.7 lakh bales (@ 333 kg cotton seed/ bale) cotton seeds were produced of which only 13.89 per cent (6.3 lakh bales) seeds are being only used for extraction of oil and rest is used for sowing and cattle feed. Cotton seed oil is generally considered as healthy vegetable oil. It is cholesterol free and hence termed as “Heart oil”. The processed cotton seed oil is the fifth leading vegetable oil in the world. Refined cotton seed oil is free from phenolic compound, gossypol and it can be directly used as cooking medium. Chemical analysis showed that by and large cotton seed oil and groundnut oil have similar physiochemical properties except free fatty acids. This is less in cotton seed oil indicating its better keeping quality. In India nearly entire cotton seed oil being utilized for edible purpose and mostly for Vanaspati, only small quantity (5-10 %) is used for manufacturing soaps. It has high level of antioxidants (Vitamin E) that contribute to its long life in the cooking or on the shelf.

The concept of combining ability plays a significant role in crop improvement, since it helps the breeder to determine the nature and magnitude of gene action involved in the inheritance traits. Combining ability will be useful in selection of desirable parents for exploitation of hybridity and transgressive expressions and also assessing the ability of parents to generate potential hybrids with a reasonable level of

Corresponding Author: K. Ashokkumar, PhD. Research Scholar, Department of Plant Molecular Biology and Biotechnology Tamil Nadu Agricultural University, Coimbatore-3, Tamil Nadu, India.
E- email : agriashokkumar@yahoo.co.in, and biotech.ashok@gmail.com,

stability. The present study was undertaken to estimate the combining ability of parents and their cross combinations, to evaluate the seed oil content, to obtain information on General (*gca*), Specific (*sca*) Combining ability and heterotic potential so as to develop hybrid with improved yield with high seed oil content.

MATERIALS AND METHODS

The material for the study consisted of 11 parental genotypes and their 28 hybrids of cotton. Twenty-eight crosses were synthesized during kharif 2004-2005 by utilizing four high yielding, adapted varieties as female lines (MCU 5, MCU 12, Surabhi, and SVPR 2) and seven high oil content genetic accessions (F 776, F 1861, SOCC 11, SOCC 17, TCH 1641, TCH 1644 and TCH 1646) as male testers. The parents and their hybrids were evaluated in randomized block design with three replications during kharif 2005-2006 crop season at Cotton Breeding Station Coimbatore. Each genotype was grown in 3 row plot of 4.5m length adopting a spacing of 75 cm between rows and 30 cm between the plants in the row, so as to have 15 plants per row. Data were recorded on five randomly selected plants per replication for eight characters viz. seed oil(%), seed protein(%), seed cotton yield per plant (g), 2.5% span length(mm), bundle strength(g/tex), micronaire, uniformity ratio and fibre elongation percentage. Fibre quality traits were analyzed by High Volume Instrument (HVI). The parent materials and their F_1 hybrids seed oil content was estimated by Nuclear Magnetic Resonance Analyses (Oxford 4000 NMR auto Analyser) 10g delinted seed samples are dried at 38°C for 24 hour. Seed protein content was estimated through total nitrogen content using Microkjeldhal method[4]. and seed protein content was calculated by multiplying the nitrogen content with a factor 6.25 and the result was expressed as percentage. The Line x Tester analysis of combining ability was performed as suggested by[5].

RESULTS AND DISCUSSION

The analysis of variance presented in (Table. 1) revealed significant divergences among all the parents for all characters. Significant differences among hybrids indicated the existence of variability among the cross combinations for seed oil, seed protein, seed cotton yield, 2.5 per cent span length, bundle strength, micronaire, uniformity ratio and fibre elongation percentage for both parents and hybrids. The variance due to lines was significant for the characters *viz.*, 2.5 per cent span length, bundle strength and elongation percentage, while the testers showed significant differences for seed cotton yield and 2.5 per cent span length. However[8]. indicated presence of both additive and non-additive gene action for these characters. The line x tester components exhibited significant variability for all the characters studied. The lines contributed a major share to genetic variance with respect 2.5 per cent span length, bundle strength and elongation percentage and seed protein, while the line x tester had the maximum share of genetic variance for all characters (Table 2).

The variance components and also the ratio between *gca* and *sca* variances revealed that there is predominance of specific combining ability variance and thus revealed the non-additive gene action for all the characters (including seed oil). The non-additive gene action of seed oil suggests that seed oil content can be improved through heterosis breeding. Seed protein also predominantly under the control of non-additive genetic systems as seen from the proportion of the SCA variance to GCA.[10,3]. reported similar results. While for seed oil[1,9,2,6]. have indicated non-additive gene action. The combining ability analysis gives useful information regarding selection of parents based on the performance of their hybrids and further it helps for the exploitation of heterosis. Among the lines Surabhi had significant *gca* effects for seed oil followed by MCU5, While SVPR 2 and MCU 12 had negative gca effects. Among the tester F776 recorded significantly higher *gca* followed by SOCC 11. The line MCU 5 also had significant seed protein. However the tester F776 showed high *gca* for seed protein. For fibre quality characters MCU 5 and MUC 12 showed high significant *gca* for 2.5 % span length and bundle strength. Similarly among the testers F776 recorded high gca for both fibre length and strength. In addition it also showed high *gca* for 2.5 per cent span length (F 776) as indicated in Table 3.

Fibre quality parameter are of paramount importance in varietal improvement research in cotton, as varieties not conforming to industrial needs will not stand the test of time. So in the present investigation importance was given to seed oil, seed protein, seed cotton yield and fibre quality traits. Eleven hybrids recorded significant and positive *sca* effects for seed oil and seed protein content. Among these the hybrid MCU 12 x TCH 1644 recorded high *sca* effect for seed protein. Hybrid Surabhi x TCH 1646 recorded high *sca* effect with high *per se* performance for seed oil. Earlier results reported by[6,7]. also confirmed this. Four hybrids recorded significant and positive *sca* effects for fibre elongation percentage, the hybrids being SVPR 2 x TCH 1641, Surabhi x TCH 1644, MCU 12 x SOCC 17 and MCU 5 x F 1861. Among these, SVPR 2 x TCH 1641 and MCU 12 x SOCC 17 had superior *per se* performance, significant standard heterosis with high *sca* effects for fibre elongation. For ginning outturn MCU 5 x TCH 1641 had superior *per se* performance, significant standard heterosis with high *sca* effects. These hybrids can be exploited as basic material for breeding purposes. Five hybrids recorded significant and positive *sca* effects for uniformity ratio. Among them Surabhi x TCH 1644 exhibited high *sca* for uniformity ratio. Six hybrids recorded significant and positive *sca* effects for bundle strength, with MCU 5 x SOCC 17 recording the highest value followed by Surabhi x F 776, MCU 5 x F 1861, MCU 12 x TCH 1644, MCU 12 x TCH 1641 and Surabhi x TCH 1646. Among these, the hybrid MCU 5 x SOCC 17 exhibited (good x poor general combiner) *sca* for bundle strength and MCU 12 x TCH 1644 (moderate x good general combiner) for micronaire were the other crosses with high *per se* performance and high *sca* effects for the characters mentioned (Table.4). The four hybrids recorded significant and positive *sca* effects for fibre elongation percentage being SVPR 2 x TCH 1641, Surabhi x TCH 1644, MCU 12 x SOCC 17 and MCU 5 x F 1861. The results indicated the predominance of non-additive genetic variation in the inheritance of these characters.

The results indicated the predominance of non- additive genetic variation in the inheritance of these characters. The study indicated the possibility of developing hybrids with high seed oil, seed protein, and quality traits through heterosis breeding.

Conclusion: The genetic study of combining ability analysis disclosed that all the traits are predominantly controlled by non-additive gene action. Among the parents MCU 12 as a good combiner for seed cotton yield, bundle strength, micronaire and seed protein. Surabhi and F 776 were good general combiners for seed oil and 2.5 per cent span length. the hybrid MCU 12 x SOCC 17 exhibited high heterotic effect and *per se* performance is found to best for seed cotton yield along with seed oil content and MCU 5 x SOCC 17 had high *per se* performance and positive significant heterotic effect is found to best for seed protein with seed cotton yield. The present study indicated the possibility of hybrids with high seed oil and improved fibre quality traits by heterosis breeding.

Table 1. Analysis of Variance for seed oil, seed protein and fibre quality traits

Sources of Variation	df	Mean Squares							
		Seed oil (%)	Seed protein (%)	Seed cotton yield	2.5 % Span length (mm)	Uniformity Ratio	Micronaire	Bundle Strength(g/tex)	Elongation Percentage
Replication	2	1.64	8.42	2.41	117.64	23.05	41.97	13.20	18.49
Parents	10	15.61**	25.47**	12.22**	108.48**	29.30**	5.42**	22.74**	25.06**
Hybrids	27	24.54**	102.49**	23.53**	77.15**	9.59**	4.19**	23.27**	11.73**
Parents X Hybrids	1	1.70	48.48**	523.99**	322.09**	6.36*	16.70**	105.71**	4.35*
Error	76	0.28	0.86	8.9	0.18	0.55	0.08	0.19	0.14
Replication	2	1.98	13.84	3.35	78.11	19.00	43.17	8.41	10.28
Lines	3	1.12	14.19**	12.47**	6.59**	1.45	0.71	8.74**	6.76**
Testers	6	0.26	1.19	3.23**	2.80*	0.58	0.81	1.14	1.02
Lines x Testers	18	30.37**	75.20**	10.15**	32.45**	8.74*	5.02**	12.90**	6.38**
Error	54	0.27	0.46	9.4	0.21	0.63	0.07	0.18	0.15

** Significant at 1% level,
* Significant at 5% level

Table 2: Genetic components of Variance and genetic contribution of lines, testers and line x testers to seed oil, seed protein and fibre quality traits

Genetic Parameter	Seed oil (%)	Seed protein (%)	Seed cotton yield	2.5 % Span length (mm)	Uniformity Ratio	Micronaire	Bundle Strength(g/tex)	Elongation Percentage
σ^2 GCA	-	1.18	8.86	0.16	-	-	0.04	0.01
σ SCA	2.69	11.58	54.2	2.28	1.64	0.09	0.72	0.28
GCA/SCA	-	0.1	0.17	0.07	-	-	0.05	0.03
Lines	14.71	62.87	55.37	36.21	16.89	8.52	51.32	45.66
Testers	6.87	10.55	23.17	30.85	13.57	19.55	13.48	13.87
Lines x Testers	78.42	26.58	21.47	32.94	69.54	71.92	35.20	40.47

Table 3. General combining ability effects of parents for seed oil, seed protein and fibre quality traits

Characters ------------ Hybrids	Seed oil (%)	Seed protein (%)	Seed cotton yield	2.5 % Span length (mm)	Uniformity Ratio	Micronaire	Bundle Strength(g/tex)	Elongation Percentage
Lines								
MCU 5	0.30 *	5.23 **	-1.51	1.13 **	-0.26	-0.14*	0.86 **	-0.29 **
MCU 12	-0.25 *	1.14 **	17.15 **	0.53 **	-0.40 *	0.16 *	0.50 **	-0.11
Surabhi	0.75 **	0.17	-8.12 **	0.54 **	-0.36*	-0.03	0.04	-0.43 **
SVPR 2	-0.79 **	-6.54 **	-7.53 **	-2.20 **	0.93 **	-0.02	-1.40 **	0.83 **
SE	0.1145	0.1493	1.1336	0.102	0.1744	0.0593	0.0933	0.0870
Testers								
F 776	0.75 **	1.13 **	-3.28 *	2.07 **	-0.48 *	-0.26 **	0.51 **	0.24*
F 1861	-0.35 *	0.97 **	11.60 **	-0.52 **	0.52 *	0.19 *	0.24	0.06
SOCC 11	0.44 **	-0.89 **	0.68	-0.72 **	-0.31	-0.14*	0.59 **	-0.24*
SOCC 17	-0.03	2.39 **	7.89 **	-1.51 **	0.77 **	0.06	-0.44 **	0.26 *
TCH 1641	-0.31 *	1.08 **	-7.06 **	-0.23	-0.56 *	-0.01	-0.36 **	0.23*
TCH 1644	-0.36*	-2.13 **	-4.29 **	-0.58 **	0.27	-0.04	-0.60 **	0.06
TCH 1646	-0.34*	-2.56**	-5.53*	1.49**	-0.23	0.17*	0.06	-0.57**
SE	0.1514	0.1975	1.4996	0.1349	0.2307	0.0785	0.1235	0.1151

** Significant at 1% level, * Significant at 5% level

Table 4. Specific combining ability of hybrids for seed oil, seed protein and fibre quality traits

Characters ----------- Hybrids	Seed oil (%)	Seed protein (%)	Seed cotton yield	2.5 % Span length (mm)	Uniformity Ratio	Micronaire	Bundle Strength(g/tex)	Elongation Percentage
MCU 5 X F 776	-1.72 **	0	-2.46	-1.02 **	-1.24 **	0.19	-0.56 *	-0.17
MCU 5 X F 1861	1.03 **	-1.24 **	-0.92	-1.23 **	0.76	0.31*	0.91 **	0.57*
MCU 5 X SOCC 11	0.68 *	0.41	-1.49	-0.14	1.60 **	0.14	-0.05	0.14
MCU 5 X SOCC 17	-0.85 **	1.75 **	-3.09	1.05 **	-0.49	-0.14	1.79 **	-0.53 *
MCU 5 X TCH 1641	0.85 **	0.43	-0.66	-0.22	0.85	-0.16	-0.99 **	0.13
MCU 5 X TCH 1644	1.01 **	-3.77 **	4.74	0.73 **	-1.99 **	0.06	-0.69 **	-0.03
MCU 5 X TCH 1646	-1.00 **	2.43 **	3.88	0.85 **	0.51	-0.31 *	-0.41	0.09
MCU 12 X F 776	1.33 **	2.96 **	-8.06 **	0.67 *	0.94*	-0.32*	0	0.24
MCU 12 X F 1861	-1.03 **	1.58 **	9.69 **	0.06	-0.1	-0.63 **	-0.22	0.08
MCU 12 X SOCC 11	-0.01	-3.70 **	12.25 **	0.65 *	-1.26 **	0.07	0.32	-0.54 *
MCU 12 X SOCC 17	1.97 **	-7.43 **	9.47 **	-1.86 **	-0.35	0.39 *	-1.35 **	0.98 **
MCU 12 X TCH 1641	-2.27 **	0.53	-15.32 **	0.27	-0.01	-0.33 *	0.68 **	-0.36
MCU 12 X TCH 1644	1.19 **	4.44 **	-4.95	2.02 **	-0.85	0.09	0.81 **	-0.52 *
MCU 12 X TCH 1646	-1.17 **	1.61 **	-3.08	-1.79 **	1.65 **	0.69 **	-0.25	0.11
SURABHI X F 776	0.53	-0.37	7.04 *	0.06	-0.24	0	1.46 **	0.03
SURABHI X F 1861	2.07 **	2.10 **	-6.74*	1.15 **	0.76	0.55 **	-0.96 **	-0.49 *

Table 4: Continue

SURABHI X SOCC 11	-2.04 **	3.36 **	-6.41*	0.61 *	-0.4	-0.15	-0.42	0.18
SURABHI X SOCC 17	-1.54 **	2.57 **	0.64	0.34	0.51	-0.32 *	-0.69 **	0.01
SURABHI X TCH 1641	0.03	-0.67	10.52 **	1.96 **	-2.15 **	0.35 *	0.34	-0.87 **
SURABHI X TCH 1644	-1.41 **	-1.20 **	-1.75	-3.09 **	2.01 **	-0.12	-0.13	1.01 **
SURABHI X TCH 1646	2.36 **	-5.78 **	-6.60*	-1.03 **	-0.49	-0.33 *	0.51*	0.13
SVPR 2 X F 776	-0.15	-2.59 **	3.48	0.3	0.57	0.09	-0.90 **	-0.1
SVPR 2 X F 1861	-2.06 **	-2.44 **	-3.03	0.02	-1.43 **	-0.16	0.27	0.04
SVPR 2 X SOCC 11	1.37 **	-0.07	-6.64*	-1.12 **	0.07	-0.06	0.15	0.22
SVPR 2 X SOCC 17	0.42	3.11 **	-7.46 *	0.47	0.32	0.07	0.25	-0.46 *
SVPR 2 X TCH 1641	1.39 **	-0.29	5.46	-2.00 **	1.32 **	0.14	-0.03	1.10 **
SVPR 2 X TCH 1644	-0.79 *	0.54	1.96	0.35	0.82	-0.03	0.01	-0.46 *
SVPR 2 X TCH 1646	-0.18	1.74 **	4.8	1.97 **	-1.68 **	-0.04	0.25	-0.33
SE	0.3028	0.3951	2.9993	0.2698	0.4614	0.1569	0.2469	0.2302

** Significant at 1% level, * Significant at 5% level

REFERENCES

1. Boghra, D.G., N.P. Mehta, K.V. Pethani, 1985. Genetic studies on oil content in upland cotton (*G. hirsutum* L.) GUA. Res. J., 10(2): 1-4.
2. Dani, R.G., 1992. Maternal effects of cotton seed oil. Ann. Agric. Res., 13(4) : 406 - 409.
3. Hiremath, C.G., 1993. Studies on inheritance of yield, yield components and some characters conferring tolerance to boll worms in cotton (*G. hirsutum* L.). Karnataka J. Agric. Sci., 7(1): 104.
4. Humphries, E.C., 1956. Mineral components and ash analysis. In: Modern methods of plant analysis. Springes- verlag, Berlin, 468-502.
5. Kempthrone, O., 1957. An introduction to genetic statistics. John Wiley and Sons Inc., New York: Chapman and Hall, London.
6. Kowsalya, R., T.S. Raveendran and T. Pushpalatha, 1999. Heterosis and inbreeding depression for seed oil and protein contents in upland cotton (*G. hirsutum* L.). Madras Agric. J., 86: 362-365.
7. Manimaran, R., 2003. Genetic and molecular investigations on fuzzless and fuzzy linted upland cotton (*G. hirsutum* L.) varieties and their hybrids. Ph.D. Thesis, Tamil Nadu Agric. Univ. Coimbatore, (Unpublished).
8. Shimna Baskaran and R. Ravikesavan, 2008. Combing ability analysis of yield related traits and fibre quality traits in cotton. J. Cotton Res. Dev., 22 (1): 23-27.
9. Singh, P. and S.S. Narayanan, 1988. Heterotic potential for seed oil in *G. arboreum* L. Current Sci., 57(19): 1077.
10. Wang, G.Y., and M.E. Li, 1991. Genetic study of cotton seed quality traits. Acta Agricultural Boreali Sinica, 6(2): 20-24.