Combining Ability Estimates from Line x Tester Mating Design in Upland Cotton

Mir Yar Mohammad Talpur[1,#,*], Shabana Memon[1,#], Sadaf Memon[1], Shah Nawaz Mari[1], Sawan Laghari[2], Zahoor Ahmed Soomro[1], Samia Arain[1], Washu Dev[1], Aamir Ali Abro[1] and Saifullah Abro[2]

[1]Department of Plant Breeding and Genetics, Sindh Agriculture University, Tando Jam, Hyderabad, 70060, Pakistan

[2]Nuclear Institute of Agriculture (NIA) Tandojam, Pakistan

Abstract: Combining abilities of cotton varieties were evaluated using a line x tester mating design, twelve hybrids which developed from 3 testers (male) and 4 lines (females). The experiment was conducted on Randomized Complete Block Design (RCBD) with three replications during 2014. The data were recorded for plant height, sympodial plant^{-1}, bolls plant^{-1}, boll weight and seed cotton yield plant^{-1}. Chandi-95, NIA-Ufaq and Sadori displayed the highest mean performance and GCA for more or less all the traits, indicating their superiority for inclusion in future breeding programme. The crosses Chandi-95 x BT 802, Sadori x BT A-1, Sohni x BT A-1 and NIA-Ufaq x BT-802 manifested meaning full SCA effects for economic traits, which could be used either for hybrid seed programme or developing superior varieties by applying selection in late segregating generations.

Keywords: Cotton, Combining Ability Estimates, Line x tester analysis.

INTRODUCTION

Cotton provides raw material for various agro based industries like ginning factories, oil mills, textiles and ghee industries which also provide employment to thousands of people [1]. It also provides raw material to domestic cotton industry comprising 503 textile mills, 1135 ginning factories and over 5000 oil expelling units. Cotton accounts for about 11 percent of the cropped area and produces 55 percent of the domestic edible oil. It has 80 percent share in the total vegetable oil production in the country [2]. Hybrid cotton seed offer many advantages over the conventional variety seed such as increase in productivity, tolerance to a biotic stresses (drought, heat, cold) and is highly responsive to inputs [3].

Cotton breeders are trying to develop varieties those well adapted to our environmental conditions and produce higher yields, higher ginning outturn percentage, better fiber quality and respond to higher fertilizer doses along with increased tolerance to complex diseases and insect pest. For breeding program, parents must be genetically superior, physiologically efficient, possess better general and specific combining ability so that they could be utilized for both variety development and commercial exploitation of heterosis for hybrid crop development. Improvement in quantitative characters is usually based on progeny performance. In quantitative genetics, only additive genes determine progeny performance. Dominant genes, on the contrary, are specific to only genotypic value of an individual [4], thus do not contribute to the progeny from one generation to another. Plant breeders make number of crosses among inbred parents to determine type of gene actions and also proportions of genetic variances attributable to additive and dominant genes for various plant characters. In early breeding large numbers of crosses were also attempted and potential parents based on progeny performance were identified. These approaches of locating potential parents and gene functioning for various plant characters require lot of resources in terms of manpower, space and time [5].

Combining ability or productivity of crosses is the combination of potential line concerning the transmission of desirable genes to their offspring. The aptitude of combination between two parents has been classified into general combining ability, defined as the average performance of a line in a series of crosses, and specific combining ability is referred to as performance of inbred parents in specific combination [6]. Kempthorne [8] introduced line x tester analysis method estimating the combining ability effects useful in selecting desirable parents and crosses for interpretation the pedigree.

MATERIALS AND METHODS

The trial was conducted at the experimental farm of Nuclear Institute of Agriculture (NIA) Tandojam to

*Address correspondence to this author at the Department of Plant Breeding and Genetics, Sindh Agriculture University, Tando Jam, Hyderabad, 70060, Pakistan; Tel: 0222765870 ext 364/365; Fax: 022765300;
E-mail: miryareltalpur@yahoo.com, mytalpur14@gmail.com

#These authors contributed equally to this work.

ISSN: 1814-8085 / E-ISSN: 1927-5129/16

estimate the combining ability for quantitative trait in upland cotton (*Gossypium hirsutum* L). The experimental material i.e. seeds of F_1 hybrid along with their parents was sown in the Randomized Complete Block Design during kharif season 2012. The experimental material comprised four lines (Chandi, Sohni, Sadori, NIA Ufaq) and three testers (BT 802, BT 703, BT A1) and their 12 F_1 hybrids. The trait studied were Plant height (cm), Sympodial branches plant$^{-1,}$ Boll plant$^{-1,}$ Boll weight (g), Seed cotton yield plant^{-1}. The collected data was be subjected to the statistical analysis (ANOVA) after [7] Gomez and Gomez (1984) and combining ability by Kempthorne [8].

RESULTS AND DISCUSSIONS

Mean performance for formulating the breeding strategy of any crop it is important to know the genetics of the genotype/varieties to be included in the breeding programme. In this experiment the general and specific combining ability effects of 7 parents and their 12 crosses were determined. Mean squares and the mean performance of parents (lines and testers) including their 12 F_1 hybrids is presented in Tables **1** & **2** respectively. Table **1** reveals that genotypes were highly significant at 0.01 level of probability for plant height, number of sympodial plant^{-1}, number of bolls plant^{-1}, boll weight, seed cotton yield plant^{-1}, which states that there were considerable variation among parents and their F_1 hybrids.

The mean performance of parents and their F_1 hybrids for various traits under study is presented in Table **2**. This indicates that among the parents Sadori (121.49cm) and BT-70(121.78cm) produced tallest plants and Sohni (98.9cm) dwarf plants. Hybrid, Sadori X Bt-A-1 (126.52cm) and Chandi-95 X BT-802 (126.27cm) also produced tallest plant). Sympodial branches (23.57), bolls plant^{-1} (37.18) and seed cotton yield (106.86g) produced by parent Sadori. While Chandi-95 produced maximum boll weight (3.27g).

Combining Ability (Variance and Effects)

The general combining ability (GCA), Specific combining ability (SCA) effects are obtainable in Tables **1**, **3** and **4** correspondingly. Whereas the mean square of GCA present in Table **1** indicated the significant dissimilarity for all the characters. Mean square of SCA and reciprocals were also significant which indicates additive and non additive type of gene action apprehensive in the manifestation of character under study. Several studies have been conducted to guess the gene action for yield and yield contributing characters. However, they reported inconsistent results including non-additive [9, 10].

General Combining Ability (GCA)

The perusal of Table **3** shows that among parents, lines Chandi (0.99), Sadori (0.647) and NIA- Ufaq (1.613) and in case of testers BT 703 (1.77) are the parents that manifested positive GCA effects for plant height and Sohni showed negative effect (-3.25) for plant height hence suggesting that in breeding programme for development of tall plant height and dwarf plant these varieties mentioned above would be useful. Lines Chandi (1.36) and NIA Ufaq (1.44) showed significant GCA effects pertaining to number of sympodial branches plant^{-1}. Among testers BT-703 (0.40) genotypes displayed significant positive effects for number of sympodial branches plant^{-1}. And BT A-1 and BT-802 exhibited significant negative GCA effects for number of sympodia branches plant^{-1}. So far the

Table 1: Mean Squares for Seed Cotton Yield and its Components of *Gossypium hirsutum* L.

Source of variance	D.F	Plant height (cm)	Sympodial Plant^{-1}	Bolls plant^{-1}	Seed cotton yield plant^{-1}(g)	Boll weight (g)
Replication	2	5.63	2.05	28.44	23.08	0.93
Genotype	18	167.55**	8.91**	99.45**	647.52**	0.11**
Parents	6	252.01**	4.23**	27.71**	153.36**	0.11**
P vs.C	1	822.4**	2.10*	112.0**	703.20**	0.20*
Crosses	11	61.95**	12.09**	137.44**	911.99**	0.10**
Lines (female)	3	43.69**	28.95**	365.19**	2659.67**	0.26^{NS}
Tester (male)	2	29.92*	1.61^{NS}	62.62*	366.94**	0.01 ^{NS}
Line xTester	6	81.76**	7.14**	48.50**	219.85**	0.05 ^{NS}
Pooled error	36	0.55	0.34	1.58	0.19	0.02

* = Significant at 5% level of Probability, ** = Significant at 1% level of Probability , NS = Non Significant.

Table 2. Mean Performance of Parents and their Hybrids for Seed Cotton Yield and their Associated Traits in *Gossypium hirsutum* L.

Genotype	Plant height (cm)		Sympodial Plant^{-1}		Bolls plant^{-1}		Seed cotton yield plant^{-1} (g)		Boll weight (g)	
Chandi	113.54	h	22.097	cd	29.97	gh	92.68	k	3.2667	c
Sohni	98.9	j	21.197	def	33.34	de	92.63	k	2.8333	cd
Sadori	121.49	d	23.57	ab	37.18	bc	106.86	c	2.8133	e
NIA Ufaq	115.64	g	21.997	cd	32.777	ef	90.43	l	2.8167	ef
BT-802	118.69	ef	20.863	c	30.127	gh	92.85	jk	3.1767	abc
BT-703	121.78	d	22.763	d	33.693	de	98.31	h	3.0833	ab
BT-A-1	102.2	i	20.053	ef	28.017	h	83.75	n	3.1433	a
Chandi x BT 802	126.87	a	23.667	ab	47.66	a	131.85	a	2.66	f
Chandi x BT 703	123.77	c	23.887	a	46.333	a	131.49	a	2.84	cdef
Chandi x BT A-1	115.48	g	20.56	fg	34.547	de	103.37	e	3.05	abcd
Sohni x BT 802	112.98	h	18.647	i	24.657	i	75.8	p	2.9633	bcde
Sohni x BT 703	120.91	d	18.293	i	28.43	h	85.44	m	2.7233	ef
Sohni x BT.A-1	119.51	e	20.123	gh	28.71	h	80.37	o	2.7533	ef
Sadori x BT.802	117.67	f	19.197	hi	34.237	de	93.45	j	2.82	def
Sadori x BT.703	120.9	d	21.877	cde	36.78	bc	101.44	f	2.8233	def
Sadori x BT.A-1	126.52	a	21.94	cd	35.443	bcd	99.46	g	2.7667	ef
NIA Ufaq x BT.802	124.62	bc	23.563	ab	37.513	b	108.82	b	3.0833	abc
NIA Ufaq x BT.703	125.71	ab	23.19	ab	35.323	cd	105.6	d	3.18	ab
NIA Ufaq x BT-A-1	117.66	f	21.83	cde	31.127	fg	97.43	i	3.2267	a

trait number of bolls plant^{-1} is concerned, Chandi (7.70) and Sadori (0.45) exhibited significant positive GCA effects, which indicates that these parents are good combiner for improvement of this trait. Additive genes controlled the trait in these parents. In terms of seed parent NIA-Ufaq (0.26) and for testers BT A-1 (0.04) exhibited significant positive GCA effects which indicated additive type of gene action for boll weight. Chandi (21.03) and NIA Ufaq (2.74) gave significant positive GCA effects for seed cotton yield plant^{-1}. Two pollen parents i.e. BT 802 (1.27) and BT 703 (4.78) exhibited positive GCA effects. BT A-1 showed significant negative GCA effect for seed cotton yield plant^{1}. These results are in accordance with the findings of [11] Zia-ul-Islam *et al.* (2001b), [12] Banumathy *et al.* (2001), [13] Deshpande *et al.* (2003), [14] Laxman *et al.* (2003), [15] Tuteja *et al.* (2003), [16]Abdel-Hafez *et al.* (2007), [17] Ilyas *et al*. (2007), [18] Abro.S *et al*. (2009).

Specific Combining Ability (SCA)

Table **4** shows that the F_1among hybrids Sadori x BT A-1 manifested significant positive SCA effects, while, remaining hybrids like Sohni x BT-801 and NIA-Ufaq x BT A-1 recorded negative SCA effects for plant height. So far trait number of sympodial branches plant^{-1} is concerned, out of twelve crosses only eight hybrids manifested significant positive SCA effect, while, for remaining four crosses negative SCA effects were recorded. While as trait number of bolls plant-1 concerned hybrids i.e. Chandi x BT 802 (4), Sadori x BT A-1 (3) and Sohni x BT-A1 (4) expressed significant positive SCA effect for number of bolls plant^{-1}. Regarding hybrids i.e. Chandi x BT A-1 (0.1), NIA Ufaq x BT 703 (0.4) and NIA Ufaq x BT A1 (0.4) showed significant positive SCA effects for the character boll weight. Seed cotton yield is very important character and is a resultant of so many variables. The hybrids, which manifested significant positive SCA, effect for the character seed cotton yield plant^{-1} are important from viewpoint of framing future breeding strategy. Keeping in view the importance of such hybrids in present study, Chandi x BT 802 (8) and Sadori x BT A-1 (7) attract the attention of plant breeder because they manifested significant positive SCA effects for the character seed cotton yield plant^{-1}. Present results are in accordance with the findings of [11] Banumathy *et al.* (2001), [18] El-Adl *et al.* (2001), [19] Pedrosa *et al.* (2001), [20]

Table 3: General Combining Ability Effects for Various Traits in *Gossypium hirsutum* L

	Genotype	Plant height (cm)	Sympodial plant^{-1}	Bolls plant^{-1}	Seed cotton yield plant^{-1} (g)	Boll weight (g)
LINES	Chandi	0.99	1.36	7.70	21.03	-0.06
	Sohni	-3.25	-2.40	-7.77	-20.67	-0.09
	Sadori	0.647	-0.41	0.45	-3.09	-0.10
	NIA Ufaq	1.613	1.44	-0.38	2.74	0.26
TESTERS	BT-802	-0.52	-0.09	0.98	1.27	-0.03
	BT-703	1.77	0.40	1.60	4.78	-0.02
	BT-A-1	-1.26	-0.30	-2.58	-6.05	0.04

Table 4: Specific Combining Ability Effects for Various Traits in *Gossypium hirsutum* L

Genotype	Plant height (cm)	Sympodial plant^{-1}	Bolls plant^{-1}	Seed cotton yield plant^{-1} (g)	Boll weight (g)
Chandi x BT 802	5	1	4	8	-0.2
Chandi x BT 703	0	1	2	4	0.0
Chandi x BT A-1	-5	-2	-6	-13	0.2
Sohni x BT 802	-4	0	-4	-6	0.1
Sohni x BT 703	1	-1	0	0	-0.1
Sohni x BT.A-1	3	1	4	6	-0.1
Sadori x BT.802	-4	-2	-2	-6	0.0
Sadori x BT.703	-3	0	0	-1	0.0
Sadori x BT.A-1	6	1	3	7	-0.1
NIA Ufaq x BT.802	2	1	2	4	0.3
NIA Ufaq x BT.703	1	0	-1	-3	0.4
NIA Ufaq x BT-A-1	-4	-1	-1	0	0.4

Mert and Boyaci (2003), [12] Deshpande *et al.* (2003), [13] Laxman *et al.* (2003), [14] Tuteja *et al.* (2003), [21] Baloch *et al.* (2004), [16] Ilyas *et al*. (2007), [17] Abro *et al*. (2009).

CONCLUSIONS

For general combining ability effects, line Chandi showed highest effects for seed cotton yield along with more than two yield contributing characters. In case of testers BT-703 showed highest effects for seed cotton yield and more than one yield contributing characters. BT 703 showed good general combiner for number of bolls plant^{-1}, and seed cotton yield plant^{-1}. Whereas for specific combining ability effects the cross Chandi x BT 802 showed seed cotton yield plant^{-1} and Chandi x BT 703 revealed best specific combiner followed by Sadori x BT A-1 for number of bolls plant^{-1}, and seed cotton yield plant^{-1}.

REFERENCES

[1] Soomro ZA. Genetic architecture of quantitative and qualitative traits G. hirsutum. M. Phil. Thesis, Sindh Agric. Univ. Tandojam, Pakistan 2000.

[2] http://www.pakistaneconomist.com/pagesearch/Search-Engine2008/S.E340.php

[3] Ali GM. Cotton hybrid seed production at PARC. Technical Reporter 2011; 2(4): 14-18.

[4] Falconer DS. Introduction to quantitative genetics, (3rd ed). Longman Scientific and Technical Co. UK 1989; pp. 117.

[5] Baloch MJ. Relative performance of F_1 and F_2 intra-*hirsutum* Hybrids for some quantitative traits in upland cotton. Pak J Sci Ind Res 2002; 45(6): 407-411.

[6] Sprague FF, Tatum LA. General versus specific Combining ability in ingle crosses of corn. J Amer Soc 1942; 34: 923.

[7] Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. John Wiley, New York, New York 1984.

[8] Kempthorne O. An Introduction to Genetical Statistics. The Iowa State University Press, Ames, Iowa. pp. 545. Narladkar, V.W. and Khapre, P.R. (1997). J Maha Agric Univ 1957; 22: 36-39.

[9] Shakeel A, Khan IA, Azhar FM. Study pertaining to the estimation of gene action controlling yield and related traits in upland cotton. J Biol Sci 2001; 1: 67-70. http://dx.doi.org/10.3923/jbs.2001.67.70

[10] Ahuja S, Dhayal S. Combining ability estimates for yield and fibre quality traits in 4 × 13 line × tester crosses of Gossypium hirsutum Euph 2007; 153: 87-98.

[11] Zia-ul-Islam, Sadaqat HA, Khan FA. Evaluation of some cotton strains for their combining ability in important genetic traits. International Journal of Agriculture and Biology 2001b; 3(4): 409-410.

[12] Banumathy S, Patil S. Diallel analysis for seedcotton yield and its components in cotton. Annals of Plant Physiology, 2001; 14(1): 56-61.

[13] Deshpande LA, Baig KS. Combining ability analysis for yield economic and morphological traits in American cotton (*Gossypium hirsutum* L.). Journal of Research ANGRAU 2003; 31(3): 28-34.

[14] Laxman S, Ganesh M. Combining ability for yield components and fiber characters in cotton (*Gossypium hirsutum* L.). Journal of Research ANGRAU 2003; 31(4): 19-23.

[15] Tuteja OP, Luthra P, Kumar S. Combining Ability analysis in upland cotton (Gossypium hirsutum L.) fot yield and its components. Indian Journal of Agriculture Sciences 2003; 73(12): 671-675.

[16] Abdel-Hafez AG, El-Keredy MS, El-Okkia AF, Gooda BMR. Estimates of heterosis and combining ability for yield, yield components and fiber properties in Egyptian cotton (*Gossypium barbadense* L.). Egyptian J Pl Breed 2007; 11(1): 423-435.

[17] Ilyas M, Naveed M, Khan TM, Khan IA. Combining Ability studies in some quantitative and qualitative traits of *Gossypium hirsutum* L. J Agri S Sci 2007; 3(2): 39-42.

[18] Abro S, Kandhro MM, Laghari S, Arain MA, Deho ZA. Combining ability and heterosis for yield Contributing traits In upland cotton (*Gossypium hirsutum* L.) Pak J Bot 2009; 41(4): 1769-1774.

[19] El-Adl AM, El-Diasty ZM, Awad AA, Zeina AM, El-Bary AMA. Inheritance of quantitative traits of Egyptian cotton. (G. *barbadense* L.). Egyptian Journal Agriculture Research 2001; 79(2): 625-646.

[20] Pedrosa MB, Freire EC, da Costa JN, de Andrade FP. Estimation of combining ability in hybrid F_1 of cotton (*Gossypium hirsutum* L.). 2001; 5(3): 439-445.

[21] Mert M, Gencer O, Akiscan Y, Boyaci K. Determination of superiority parents and hybrid combinations in respect to lint yield and yield components in cotton (G. *hirsutum* L.) Turkish J Agric Fore 2003; 27: 337-43.

[22] Baloch M, Sheerin RB, Bashir AA. Estimation of combining ability for useful characters in intra- Hirsutum hybrids of cotton. The Indus Cotton 2004; 1(1): 14-17.

[23] Muhammad MY, Mari TS, Laghari S, Soomro ZA, Abro S. Estimation of Heterosis and Heterobeltiosis in F1 Hybrids of Upland Cotton. Journal of Biology Agriculture and Healthcare 2014; 4(11): 68-72.

Received on 01-02-2016 Accepted on 04-05-2016 Published on 20-09-2016

http://dx.doi.org/10.6000/1927-5129.2016.12.58