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The Genetic Effects of Combining Abilities on Oil and Protein Contents in *Gossypium hirsutum* L. Seed

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An eight parent diallel cross data was analysed by following Griffing's method of genetic analysis, to examine genetic effects of general and specific combining abilities of the parents on cotton seed oil and protein contents. The higher gca:sca mean squares showed, that genes showing additive properties had predominant influence on the inheritance of the characters. The parents having better general combining ability (gca) for the characters, appeared to result in better specific combinations. The nature of the gene's action suggests that further improvement in oil and protein contents may be achieved by making single plant selections from the F_2 population.

Key words: Additive genes, Cotton, General combining ability, Oil and Protein, Specific combining ability.

Introduction

Fat and protein are two essential components of our food, which supply energy and nourishment to adults and young growing They are obtained from animal and vegetable sources. Seed of *G. hirsutum* L. contains oil content ranging from 20 to 24%. In Pakistan, approximately 72% of the total local edible oil production is obtained from cottonseed (Khan *et al* 1995). Despite the availability of the potential source of edible oil, cotton breeders did not previously investigate this aspect as vigorously as they did to improve seed cotton yield and other characters of the plant. It is only in recent years that the breeders turned their attention to examine this unexploited source of oil and to meet the current and future demand of edible oil supply for the increasing population of Pakistan.

Previous examination showed that oil content differed among varieties of *G. hirsutum* species (Dani and Kohel 1989; Dani 1991), the variation being the product of genes showed additive and non-additive properties (Wang and Li 1991; Azhar and Ajmal 1999). In addition, significant varietal differences were found in protein content, controlled by additive and non-additive genes (Wang and Li 1991; Ming *et al* 1994; Khan *et al* 1995).

A research programme was carried out to examine the breeding potential of eight diverse varieties of *G. hirsutum* L., by following Griffing's method of genetic analysis and for improving oil and protein contents in cottonseed.

Materials and Methods

The plant material used in the present study was developed by crossing eight parents of *Gossypium hirsutum* L., in all possible combinations. The parents used in the crossing programme were BJA, Reba-B50, A89/FM and Changmiah (all exotics) and CIM250, S12, NIAB78 and AUH50 (all local types). The parents were grown in glasshouse and crossed when flowering began. Buds were emasculated and pollinated by hand and a large number of pollinations were made to produce sufficient quantity of F_1 seed. The F_1 population was field grown, with randomised complete block design in three replications. The 56 F_1 families and their parents were spaced in single rows at the distance of 30 cm apart within the row and 75 cm between the rows, with 12 plants row^{-1}. One plant at either end of each row was left as non-experimental. At maturity, whole seedcotton of 10 plants was picked separately and ginned to get samples of seed of each family. A representative sample of seeds from each plant was taken and oil and protein contents were determined by Wideline "Nuclear Magnetic Resonance (NMR) 4000".

The family means for oil and protein contents in each replication were examined which were based upon the analysis of variance. Combining ability analyses of oil and protein contents were carried out by following the Griffing Method 1 Model 2 (Griffing 1956).

Results and Discussion

Means of oil content in the eight parents ranged between 19.25%, Reba-B50 to 23.69%, S12 and protein 19.14%, AUH 50, to 22.22%, S12 (Table 1). In cross combinations (including reciprocals) oil content varied from 19.26 in A-89/FM x Reba - B50 to 23.84 in A-89/FM x NIAB78 (reciprocal). Minimum protein contents (19.08) were in CIM250 x Chiangmiah and maximum (23.18) in AUH 50 x S12. These differences in both

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Table 1
Means of oil and protein contents in eight parents and their gca, sca and reciprocal effect

Parents	Oil content	Protein content
NIAB78	23.62, 0.99[a]	20.07, 0.26[a]
S12	23.69, 1.31	22.22, 0.84
AUH50	20.29, -0.38	19.14, -0.39
CIM250	20.06, -0.62	20.18, -0.34
Changmiah	19.57, - 1.05	19.29, -0.60
BJA	21.61, 0.15	20.30, -0.04
A89/FM	21.87, 0.34	20.74, -0.20
Reba-B50	19.25, 0.73	21.44, 0.47
cd_1 $(g_i - g_j)$	(0.07)	(0.04)
Cross Combination		
NIAB78 x S12	23.77 (23.80)[b]	21.80 (22.15)[b]
	-0.35 (-0.02)[c]	-0.40 (-0.17)[c]
- x AUH50	21.52 (21.68)	19.55 (20.13)
	-0.85 (-0.08)	-1.30 (-0.29)
- x CIM250	21.47 (21.80)	22.61 (22.72)
	-0.57 (-0.17)	1.47 (-0.06)
- x Changmiah	21.42 (22.43)	22.19 (22.38)
	0.15 (-0.50)	1.34 (-0.10)
- x BJA	22.88 (23.14)	21.90 (21.87)
	0.03 (-0.13)	0.39 (0.03)
- x A89/FM	23.83 (23.84)	22.17 (22.36)
	0.66 (-0.01)	0.93 (-0.09)
- x Reba-B50	22.66 (23.80)	22.38 (20.21)
	1.13 (0 -57)	-0.71 (1.08)
SI2 x AUH50	22.67 (23.79)	23.14 (23.18)
	0.46 (-0.56)	1.45 (0.02)
- x CIM250	22.69 (22.56)	21.64 (21.60)
	0.10 (0.07)	-0.14 (0.02)
- x Changmiah	21.92 (22.08)	21.34 (21.37)
	0.10 (-0.08)	-0.16 (-0.02)
- x BJA	23.00 (23.15)	22.22 (22.44)
	-0.22 (-0.08)	0.26 (-0.11)
- x A89/FM	23.50 (23.63)	21.41 (21.75)
	0.08 (-0.07)	-0.33 (-0.17)
- x Reba-B50	23.42 (23.62)	22.42 (22.83)
	1.10 (-0.10)	0.05 (-0.21)
AUH50 x CIM250	20.23 (20.24)	19.49 (19.39)
	0.61 (-0.01)	- 1.09 (0.05)
- x Changmiah	20.13 (20.21)	20.22 (20.16)
	-0.25 (-0.04)	-0.09 (0.03)
- x BJA	21.76 (21.79)	21.36 (21.65)
	0.16 (-0.02)	0.67 (-0.14)
- x A89/FM	22.73 (22.69)	21.35 (21.48)
	0.90 (0.02)	0.74 (-0.07)
- x Reba-B50	21.49 (21.96)	22.37 (22.26)
	0.99 (-0.23)	0.97 (0.06)

(cont'd .....)

(Table 1 cont'd ....)

Parents	Oil content	Protein content
CIM250 x Changmiah	20.16 (21.13)	19.08 (19.24)
	0.48 (-0.49)	- 1.17 (-0.08)
- x BJA	21.70 (22.11)	21.35 (21.89)
	0.54 (-0.20)	0.73 (-0.27)
- x A89/FM	21.79 (21.65)	20.18 (20.17)
	0.16 (0.07)	-0.55 (0.00)
- x Reba-B50	20.73 (21.15)	22.38 (22.72)
	0.45 (-0.21)	1.15 (-0.17)
Changmiah x BJA	20.63 (20.68)	21.28 (19.37)
	0.21 (-0.02)	-0.31 (0.96)
- x A89/FM	21.36 (21.48)	21.07 (21.28)
	0.29 (-0.06)	0.70 (-0.11)
- x Reba-B50	20.44 (19.43)	21.43 (21.80)
	-0.13 (0.50)	0.47 (-0.18)
BJA x A89/FM	22.79 (23.14)	20.73 (20.29)
	0.63 (-0.17)	-0.52 (0.22)
- x Reba-B-50	20.54 (21.30)	21.29 (21.44)
	-0.34 (-0.38)	-0.34 (-0 .07)
A89/FM x Reba-B50	19.26 (19.51)	20.59 (20.85)
	-2.07 (-0.13)	-0.82 (-0.13)
cd_1 $(S_{ij} - S_{ik})$	0.20	0.09
cd_1 $(r_{ij} - r_{kl})$	0.21	0.10

[a] mean values, and gca effects (Italics); [b] mean values of direct crosses, and indirect crosses (parenthesis); [c] sca effects and reciprocal effects (parenthesis).

characters in the 64 families were highly significant, P≤ 0.01 (analysis of variance not given). The analysis of variance for combining ability examines the genetic effects of general (gca), specific combining ability (sca) and of reciprocals on the variation in oil and protein contents. Highly significant differences were present in the three components for both the characters Table 2. The ratio of gca mean squares to sca mean squares for oil (1:1) and protein content (2.4:1) suggests that additive gene effects control the inheritance of the characters.

General combining ability effects of the individual line for oil and protein contents were compared Table 1. The parents S12 and NIAB78 with maximum coefficient, 1.31 and 0.99 respectively, had better gca than Reba - B50, A - 89/FM, and BJA which have positive gca effects for oil content. The parents in cross combination, NIAB - 78 x A - 89/FM (0.66), NIAB - 78 x Reba - B50 (1.13), S12 x Reba - B50 (1.10), AUH 50 x A - 89/FM (0.90), AUH 50 x Reba - B50 (0.99), CIM250 x BJA (0.54), BJA x A - 89/FM (0.63) with the highest values, had the best sca for oil content. In reciprocals, the cross Reba - B50 x Chingmiah with the highest numerical value, 0.50 appeared to be superior to the others.

In regard to the gca of the parents for protein content, S12 with the highest coefficient, 0.84 had better gca than Reba -

Table 2
Combining ability analysis of oil and protein contents in *G. hirsutum* L. seed

Source of variation	DF	Mean squares	
		Oil content	Protein content
gca	7	11.397**	3.807**
sca	28	11.032**	1.569**
reciprocals	28	0.129**	0.183**
Error	126	0.012	0.003

** Significant at 0.01 probability level.

B50 and NIAB78, having coefficients 0.47 and 0.26 respectively. The direct crosses, NIAB78 x CIM250, NIAB78 x Changmiah, S12 x AUH 50 and CIM250 x Reba -B50 with highest coefficients, 1.47, 1.34, 1.45 and 1.15 showed best sca for protein content. In reciprocal combinations Reba-B50 x NIAB78 and BJA x Changmiah with sca coefficients of 1.08 and 0.96 respectively, appeared to possess better sca than the others, and these crosses involved one parent having best gca. In contrast, BJA x Changmiah, both parents had negative gca, yet produced good hybridisation for protein content.

Previous reports on the inheritance of oil content indicated both additive and non-additive gene effects. Oil content in cottonseed was additively controlled (Kohel 1980; Azhar and Ajmal 1999), whereas the character was found to be controlled also by non-additive gene effects (Dani and Kohel 1989 and Wang and Li 1991). Similar pattern of inheritance for protein content in cottonseed had been reported in literature (Wang and Li 1991; Ming *et al* 1994; Khan *et al* 1995; Azhar and Ajmal 2000). Oil contents in the crops, rapeseed (Hu 1988; Gupta and Labana 1988) and pearl millets (Bharaj *et al* 1989), were mainly additively influenced and therefore, estimates of narrow sense heritability were moderate to high. However, in studies reported recently oil and protein contents in *G. hirsutum* L. seeds were found to have high heritability (Azhar and Ajmal 1999; 2000). Although from the present data, heritability was not estimated, the predominant influence of additive gene effects in the expression of the characters may result modest to high estimates of heritability, as suggested by Falconer and Mackey (1996). The present study may be used advantageously for exploiting the variation in the characters and single plant selection may be practised to select superior plants from F_2 populations and their progenies for evaluating for higher oil and protein in cottonseed.

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