Genetic Analysis of Trichome Characters Associated with Resistance To Jassid (*Empoasca kerri* Pruthi) in Peanut[1]

S. L. Dwivedi*, P. W. Amin, Rasheedunisa, S. N. Nigam,
G. V. S. Nagabhushanam, V. R. Rao, and R. W. Gibbons[2]

ABSTRACT

F_1 progenies resulting from a 10 x 10 diallel cross including reciprocals, in peanut (*Arachis hypogaea* L.) cultivars of different susceptibility to the jassid, *Empoasca kerri* Pruthi, were studied to determine the inheritance of trichomes on the adaxial surface of the leaf, leaf midrib, and petiole, and their association with resistance to *E. kerri*. Genotypes or crosses with long trichomes on the leaves and petioles showed a high level of resistance to jassids (leafhoppers) as evidenced by a very low percentage of yellowed foliage (hopper burn). Nonadditive genetic variance was predominantly observed for all trichome characters. However, additive genetic variance was also important for the presence of long trichomes on the midrib and petioles and for jassid damage. NC Ac 2230, a jassid resistant line, is the best parent to use in a breeding program because of its stable resistance and high general combining ability for the presence of trichomes.

Key Words: Groundnut, *Arachis hypogaea*, pubescence, genetic variance , combining ability, leafhopper.

Jassids (leafhoppers) belonging to the genus *Empoasca* are important pest of peanut (*Arachis hypogaea* L.) in several countries. In India, the peanut jassid, *E. kerri* Pruthi, has caused 9% pod yield losses and 17% haulm yield losses in Andhra Pradesh (7). Pod yield losses up to 22% were observed at Junagadh in India (H. N. Vyas, personal communication). Insecticides are routinely recommended for jassid control on peanut. However, jassid resistant cultivars would be an alternative to pesticide use. Cultivars with jassid resistance have not been developed. The cultivar NC 6, which was primarily bred for resistance to southern corn rootworm (*Diabrotica undecimpunctata howardi* Barber) in North America has moderate resistance to the jassid, *E. fabae* (Harris) (5). At ICRISAT, screening of peanut genotypes resulted in identification of twelve germplasm accessions with stable resistance to *E. kerri* (2).

Trichomes on leaves have been associated with resistance to jassids in lima beans (9), soybean (3, 8, 10, 12), and cotton (1, 11). Jassid resistance in peanut has also been associated with a thick epidermis, and a high density of long straight trichomes (4). Thick leathery leaves and/or the presence of trichomes were indicated as the factors contributing to jassid resistance (2).

Since trichomes have been associated with jassid resistance, an understanding of the nature and the magnitude of gene action for inheritance of trichome characters can be useful in developing cultivars resistant to *Empoasca* spp. The inheritance of trichome characters confering resistance to jassids in peanut has not been reported.

Materials and Methods

Ten peanut accessions which included two highly resistant (NC Ac 2230 and NC Ac 2240), three resistant (NC Ac 2232, NC Ac 2242, and NC Ac 2243), three moderately resistant (NC Ac 1705, NC Ac 343, and NC Ac 785), one resistant to leaf yellowing (hopper burn) but susceptible to jassid infestation (NC Ac 16940), and one susceptible to both jassid infestation and leaf yellowing (Robut 33-1), (Table 1) were crossed in a reciprocal diallel mating design. The ten parents and 90 F_1 progeny were grown in the rainy season (July-October) 1983 at the ICRISAT research farm in randomized block design with three replications. The plots consisted of single 4 m rows on ridges 75 cm apart and with interplant spacing of 15 cm. One row of cowpea (*Vigna unguiculata* L. Walp.) cv. C-152 was sown after every three rows of the test material to encourage the build up of a jassid population. In addition, about 5000 laboratory bred jassid adults were released on the cowpea plants. After two weeks the cowpea plants were uprooted and they were uniformly distributed in the field to facilitate the movement of jassids to the peanut plants.

Table 1. Origin, growth habit and resistance to jassid infestation and leaf injury among the ten parental genotypes.

ICG #	Identity	Pedigree	Growth habit	No.of jassid nymphs/5 plants	% yellowed foliage	Remarks
ICG 5041	NC Ac 2230*	Robusto	Virginia Runner	2	0.1	HR
" 5043	NC Ac 2240* (DP)	"	"	4	2.0	"
" 5042	NC Ac 2232*	"	"	17	0.1	R
" 5044	NC Ac 2242*	"	"	17	0.2	"
" 5045	NC Ac 2243*	"	"	20	0.0	"
" 8060	NC Ac 785+	4003	Virginia Bunch	18	3.7	MR
" 6764	NC Ac 1705+	Lupinous coriaceous	"	32	3.7	"
" 2271	NC Ac 343+	F7#10 (45073)	Virginia Runner	26	6.8	"
" 8099	NC Ac 16940	PI 270934/ BMP 25/1	Virginia Bunch	53	0.4	R
" 799	Robut 33-1	Selection from an Israil line Robut 33	"	34	33	S
	SE			± 7.5	± 3.1	
	CV (%)			45.7	38.5	

* - Mutant lines from X-rayed material from NC 4
\+ - Breeding line from North Carolina State University
DP - Deep purple seed coat
HR - Highly resistant, R - Resistant, MR - Moderately resistant
S - Susceptible to both infestation and injury

Five random plants from each replication of the parents and F_1 progenies were tagged and the following observations of trichome characters were recorded from the adaxial surface of the third fully developed leaf on the main axis:

Trichomes of leaf lamina,	TL
Trichomes on midrib of leaflet,	TM
Long trichomes on midrib of leaflet,	LTM
Medium trichomes on midrib of leaflet,	MTM
Short trichomes on midrib of leaflet,	STM
Trichomes on leaflet margin,	TLM
Long trichomes on leaflet margin,	LTLM

[1]Groundnut Program and Genetic Resources Unit, International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), ICRISAT Center, Patancheru P. O. 502 324, India. ICRISAT Journal Article No. JA-518

[2]Groundnut Breeder, Entomologist, Post Doctoral Fellow, ICRISAT; Principal Groundnut Breeder, Regional Groundnut Program for Southern Africa, Chitedze Research Station, Private Bag 63, Lilongwe, Malawi; Research Associate, Germplasm Botanist and Principal Groundnut Breeder, ICRISAT, respectively.

Medium trichomes on leaflet margin,	MTLM
Short trichomes on leaflet margin,	STLM
Trichomes on petiole,	TP
Long trichomes on petiole,	LTP
Medium trichomes on petiole,	MTP
Short trichomes on petiole,	STP
Percentage leaf yellowing,	PLY

The leaflets were immersed in hot water (70 C) for 60-120s and cleared in 90% ethyl alcohol for one day. They were stained in a 0.5% alcohol solution of sudan IV dye for 600 s. The excess stain was removed by washing leaves in 85% lactic acid at 70 C for 180 s. The leaflets were then cleared in 85% lactic acid for 1800 s at 25 C and mounted on slides in glycerol. Trichome density per mm^2 and length (mm) were measured under a microscope using appropriate micrometers. Trichomes were classified into long (>0.5 mm), medium (0.25-0.5 mm) and short (<0.25 mm). The percentage of yellowed foliage was recorded when the jassid population was highest in the month of September. All the plants from one row plot were scored visually as percentage of yellowed foliage which ranged from 0-100% for jassid susceptibility.

Statistical analysis was performed on plot means by method-I, model-I of Griffing (6). The genotypic variance and covariances were used to estimate the genotypic and phenotypic correlations.

Results and Discussion

Significant genotypic differences in the trichome characteristics and the percentage of yellowed foliage were observed among parents and F_1 progenies (Table 2). Significant negative phenotypic correlations were observed between the percentage leaf yellowing and trichome density on the lamina and leaf margin, and the presence of long trichomes on the leaf midrib, margin, and petiole (Table 3). This indicates that resistance to leaf yellowing caused by jassid was due to the presence of a high trichome density on the lamina and a higher number of long trichomes on leaves and petioles. The number of long trichomes on the leaf margin, midrib, and petiole were highly significant and positively associated among themselves. This suggests that selection for a higher density of long trichomes on the petiole should show a corresponding increase in the density of long trichomes on both the leaf midrib and leaf margin. Studies in cotton (1, 11), lima beans (9) and soybeans (3, 8) revealed the importance of trichome length, density, and orientation, in imparting resistance to jassids.

The mean squares of combining ability and variance estimates due to general (GCA) and specific combining ability (SCA) and reciprocal differences for fourteen characters were determined (Table 4). The GCA and SCA mean squares were highly significant for all characters. Predominant SCA variance was observed for all characters except LTM, LTP, and PLY, for which both the GCA and the SCA variances were equally important. Wynne and Campbell (13) reported that resistance to jassid damage in the F_2 and F_3 generations (bulk progenies of six parent diallel crosses) was due to additive genetic variance. Resistance to jassid injury (i. e. leaf yellowing) in the present study, however, was controlled by both additive and non additive genetic variance.

NC Ac 2230, a virginia runner line, had the best general combining ability for long trichomes on the leaf midrib, margin, and petiole, followed by NC Ac 2232 and NC Ac 2242 (Table 5). NC Ac 2240 had the best general combining ability for trichomes on the midrib and petiole. NC Ac 2242 had the best general combining ability for trichomes on the leaf lamina, and NC Ac 2230 for trichomes on the leaf margin. NC Ac 343, which has a high yield potential and moderate resistance to jassids (7) had low combining ability for most of these traits. Performance of the parents for resistance to jassids and their GCA effects were highly significantly correlated for long trichomes on the leaf midrib (r = 0.92), margin (r

Table 2. Analysis of variance (mean square) for 14 characters in 10 x 10 complete diallel cross in peanut.

Sources	d.f.	TL	TM	LTM	MTM	STM	TLM	LTLM
Treatments	99	198**	452**	20**	284**	3975**	3975**	1631**
Parents	9	1077**	2623**	183**	32**	1518**	22580**	7168**
Crosses	89	35**	32**	53**	17**	66**	392**	667**
Parents vs. Crosses	1	6768**	18316**	894**	146**	8590**	1554**	37587**
Error	198	7	12	5	4	17	64	116

Sources	d.f.	MTLM	STLM	TP	LTP	TP	STP	PLY
Treatments	99	736**	204**	745**	43**	7**	444**	192**
Parents	9	2107**	833**	3616**	175**	20**	1880**	1040**
Crosses	89	435**	75**	94**	17**	3**	111**	18**
Parents vs. Crosses	1	15161**	5973**	32812**	1169**	211**	17226**	8026**
Error	198	116	110	30	25	4	1	34

** - Significant at 0.01 probability level.

TL - Trichomes on leaf lamina, TM - Trichomes on midrib of leaflet, LTM - Long Trichomes on midrib of leaflet, MTM - Medium Trichomes on midrib of leaflet, STM - Short Trichomes on midrib of leaflet, TLM - Trichomes on leaflet margin, LTLM - Long Trichomes on leaflet margin, MTLM - Medium trichomes on leaflet margin, STLM - Short Trichomes on leaflet margin, TP - Trichomes on petiole, LTP - Long Trichomes on petiole, MTP - Medium Trichomes on petiole, STP - Short Trichomes on petiole, PLY - Percentage leaf yellowing.

Table 3. Phenotypic and genotypic correlations among fourteen characters in peanut a/.

	TL	TM	LTM	MTM	STM	TLM	LTLM
TL		0.2	0.3**	-0.1	-0.1	0.4**	0.2*
TM	0.2		0.2*	0.2	0.4**	0.2*	0.2*
LTM	0.4	0.3		-0.1	-0.7**	0.5**	0.6**
MTM	-0.2	0.1	-0.1		-0.3**	0.1	-0.1
STM	-0.2	0.3	-0.7	-0.3		-0.3**	-0.3**
TLM	0.4	0.3	0.6	0.2	-0.4		-0.6**
LTLM	0.3	0.3	0.6	-0.1	-0.3	0.6	
MTLM	0.1	-0.1	-0.1	0.2	-0.1	0.2	-0.6
STLM	0.1	-0.2	-0.3	0.2	0.0	0.1	-0.3
TP	0.2	0.2	-0.2	0.0	-0.1	0.1	0.1
LTP	0.3	0.3	0.8	0.1	-0.6	0.4	0.5
MTP	0.1	0.4	0.4	0.4	-0.4	0.4	0.3
STP	0.0	-0.1	-0.2	-0.1	0.2	-0.1	-0.2
PLY	-0.5	-0.1	-0.7	0.1	0.5	-0.5	-0.4

	MTLM	STLM	TP	LTP	MTP	STP	PLY
TL	0.1	0.1	0.2	0.2*	0.1	0.0	-0.4**
TM	-0.1	-0.1	0.1	0.2*	0.3**	-0.0	-0.1
LTM	-0.2	-0.2*	0.1	0.7**	0.4**	-0.2	-0.5**
MTM	0.2	0.2	0.0	0.1	0.4**	-0.1	0.0
STM	0.0	0.1	-0.1	-0.5**	-0.3**	0.2	0.4**
TLM	0.3*	0.1	0.1	0.3**	0.4**	-0.1	-0.4**
LTLM	-0.6**	-0.3**	0.1	0.4**	0.2*	-0.2	-0.3**
MTLM		0.0	-0.0	-0.1	0.1	0.1	0.0
STLM	0.1		0.2	-0.1	0.1	0.2	-0.1
TP	-0.1	0.2		0.1	0.2*	0.9**	-0.1
LTP	-0.2	-0.2	0.2		0.4**	-0.4**	-0.5**
MTP	0.1	0.1	0.3	0.4		-0.1	-0.2*
STP	0.1	0.2	0.9	-0.3	-0.0		0.1
PLY	0.0	-0.1	0.1	-0.6	-0.3	0.2	

Phenotypic correlations - above diagonal
Genotypic correlations - below diagonal
*,** - Significant at 0.05 and 0.01 probability level, respectively.

a/ See Table 2 explanation of abbreviations

Table 4. Analysis of variance (mean square) and components of general and specific combining ability variance for 14 characters in 10 x 10 complete diallel cross in peanut[a/].

Sources	d.f.	TL	TM	LTM	MTM	STM	TLM	LTLM
GCA	9	55.0**	22.3**	127.7**	6.7**	93.6**	713.7**	988.0**
SCA	45	10.0**	9.5**	9.5**	5.3**	18.5**	98.1**	180.0**
REC	45	6.2**	8.9**	6.2**	5.7**	16.0**	78.4**	127.0**
Error	198	2.4	3.9	1.7	1.2	5.6	21.5	38.6
Var (GCA)	-	2.6	0.9	6.3	0.3	4.4	34.6	47.5
Var (SCA)	-	7.7	5.6	7.8	4.1	13.0	76.7	141.4
Var (REC)	-	1.9	2.5	2.2	2.2	5.0	28.5	44.0

Sources	d.f.	MTLM	STLM	TP	LTP	MTP	STP	PLY
GCA	9	201.2**	38.3**	30.2**	24.00**	2.0**	32.4**	36.1**
SCA	45	137.7**	27.0**	31.4**	3.7**	0.9**	30.9**	4.6**
REC	45	140.2**	20.3**	36.4**	4.3**	0.8**	41.7**	2.5
Error	198	36.7	9.8	8.4	1.2	0.3	11.3	1.8
Var (GCA)	-	8.2	1.4	1.0	1.0	0.1	1.0	1.7
Var (SCA)	-	101.0	17.2	22.9	2.5	0.6	19.6	2.8
Var (REC)	-	51.7	5.2	14.0	1.5	0.3	15.2	0.4

** - Significant at 0.01 probability level.
GCA - General combining ability; SCA - Specific combining ability
REC - Reciprocals crosses.

a/ See Table 2 explanation of abbreviations

= 0.72) and petiole (r = 0.88), indicating that performance of the parents of its ability to transfer resistance to jassids in its progenies could be judged based on the presence of higher density of long trichomes on midrib of leaflet, margin, and petiole in resistant genotype.

Table 5. General combining ability (GCA) effects for 14 characters in 10 x 10 complete diallel cross in peanut[a/].

Cultivars	TL	TM	LTM	MTM	STM	TLM	LTLM
Robut 33-1	-2.5*	0.1	-3.5*	0.6*	2.8*	-8.8*	-4.1*
NC Ac 343	-0.2	0.5	-1.3*	1.0*	0.8	0.7	-1.2
NC Ac 785	-0.4	-1.3*	-1.5*	-0.7*	0.9	-7.4*	-7.1*
NC Ac 1705	-0.8*	0.7	-1.0*	0.2	1.6*	0.1	-3.4*
NC Ac 2230	1.1*	-0.4	4.5*	-0.2	-4.6*	10.7*	15.5*
NC Ac 2232	2.2*	1.0*	3.0*	-0.6*	-1.4*	0.5	6.6*
NC Ac 2240	1.3*	1.1*	-0.5	0.1	1.5*	3.0*	0.6
NC Ac 2242	2.3*	-0.2	2.0*	0.6*	-1.5*	4.0*	3.6*
NC Ac 2243	1.0*	0.6	0.7*	0.5*	-0.9	3.3*	-3.2*
NC Ac 16940	-2.0*	-2.2*	-2.5*	-0.3	0.7	-6.1*	-7.3*
SE gi	0.3	0.4	0.3	0.2	0.5	0.9	1.3
SE gi-gi	0.5	0.6	0.4	0.3	0.7	1.4	1.9

Cultivars	MTLM	STLM	TP	LTP	MTP	STP	PLY
Robut 33-1	-3.3*	-1.2	-0.6	-1.0*	-0.3*	0.5	2.7*
NC Ac 343	-1.4	1.0	0.3	-0.2	-0.1	0.5	-0.3
NC Ac 785	-1.6*	1.5*	-0.2	-1.0*	-0.3*	1.1	-0.5
NC Ac 1705	-2.7*	1.2	0.7	-1.1*	0.1	1.8*	1.2*
NC Ac 2230	-3.5*	-1.4*	0.1	1.7*	0.2	-1.6*	-1.3*
NC Ac 2232	-3.8*	-2.2*	-0.7	1.3*	-0.1	-1.9*	-1.0*
NC Ac 2240	-0.1	1.7*	1.9*	0.3	0.4*	1.3	1.0*
NC Ac 2242	1.7	-1.2	1.4*	1.3*	-0.1	-0.2	-1.2*
NC Ac 2243	6.1*	0.5	-0.4	-0.1	0.5*	-0.4	-0.1
NC Ac 16940	0.4	0.1	-2.5*	-1.0*	-0.5*	-1.2	1.4*
SE gi	1.3	0.6	0.6	0.2	0.1	0.7	0.3
SE gi-gi	1.9	0.9	0.9	0.3	0.5	1.0	0.4

* - Significant at 0.05 probability level.

a/ See Table 2 explanation of abbreviations

Because of the predominant nature of nonadditive genetic variance for most of the trichome characters, SCA effects were also estimated in selected crosses (Table 6). Four crosses for STLM and LTP; five crosses for TL, TLM, and TP; six crosses for TM, STM, LTLM, MTLM, and PLY; and seven for MTP, STP, MTM, and LTM showed significant specific combining ability effects. These crosses also showed higher means for the above characters. The F_1 progenies from NC Ac 1705 and NC Ac 2230, a cross between low and high general combining ability parents for various traits, were found desirable because of their high SCA effects and mean for six traits including resistance to leaf yellowing. Because of its higher mean and SCA effects for high density of long trichomes on leaves and petiole, this cross appears very promising in selecting progenies with high resistance due to transgressive segregation that could occur in the early generations. A selection for long trichomes on the midrib and petiole, and resistance to leaf yellowing in early generations could be possible, because of the presence of an appreciable amount of additive genetic variance for these traits.

Table 6. Specific combining ability (SCA) effects and mean of the five crosses for various characters in 10 x 10 complete diallel cross in peanut[a/].

Crosses	Characters	Sca effects	Mean (X)
NC Ac 1705 x NC Ac 2242	TL	5.8	23.3
NC Ac 1705 x NC Ac 2243	MTLM	15.1	47.5
NC Ac 343 x NC Ac 2232	TP	7.4	41.8
	STP	9.0	32.6
Robut 33-1 x NC Ac 343	MTM	4.9	8.8
	TLM	16.2	84.5
	STLM	6.8	21.5
NC Ac 1705 x NC Ac 2230	TM	3.9	30.5
	LTM	6.0	15.2
	LTLM	19.4	69.5
	LTP	3.7	10.8
	MTP	1.2	4.2
	PLY	-4.6	12.5

a/ See Table 2 explanation of abbreviations

Our investigations and those of Campbell *et al.* (4) reveal that the presence of long trichomes on the midrib, margin, and petiole of leaves contribute to jassid resistance. These characters could be used as marker traits to select for a higher level of resistance in genotypes or in the segregating progenies. This is particularly useful when the jassid population is not adequate for screening purposes. Such a situation occurred in some trials and breeding populations when six hundred segregating progenies with a varying level of resistance to jassid were grown together. The selections were made on the basis of trichomes and were found resistant in subsequent screening. NC Ac 2230, appeared to be the best parent for use in a breeding program for jassid resistance, because of the high general combining ability effects for traits associated with resistance to jassids. However, this genotype has a very low yield potential so large populations in early generations would have to be evaluated in order to obtain recombinants with high yield and jassid resistance.

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