Effect of Genotypes and Environments on Oil Content and Oil Quality Parameters and Their Correlation in Peanut (*Arachis hypogaea* L.)[1]

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ABSTRACT

The quality of edible oils is now receiving increasing consideration from consumers and processors. The present study was conducted to investigate the effects of environments on oil content and fatty acid composition in peanut. The correlation between oil content and oil quality parameters was also studied. Thirteen peanut (*Arachis hypogaea* L.) genotypes were grown in 12 environments for the study. Soils at experiment locations differed significantly for pH, EC, and N, P, Zn, Mn, and Fe contents. Significant genotype, environment, and genotype x environment interaction effects were observed for oil content, individual fatty acid contents, and derived oil quality parameters. The original range of 34-54% of oil content based on one season/location evaluation in these lines was not repeatable, and ranged from 45-50% in multilocation evaluation. Oil content was positively correlated with soil pH and Fe content. The correlation of oleic and linoleic acid content with soil pH and Fe content was positive in the former and negative in the latter. The oil content was positively correlated with O/L ratio. Oliec and linoleic acid contents were negatively correlated. Selection for reduced linoleic acid level in genotypes would also reduce levels of total long chain saturated fatty (TLCSF) acids. Of the thirteen genotypes tested, ICG 5856, ICG 5369, and ICGV 87124 could be used in breeding for improved oil quality.

Key Words: Groundnut, genotype x environment interaction, oil quality, soil nutrients.

Peanut (*Arachis hypogaea* L.), with an annual world production of 19 million t from 18 million ha, is a major annual oilseed crop. About two-thirds of the total peanut production is crushed for oil and the remaining one-third is used in confectionery products. With increasing consumer demand for edible oil of good quality, there is a need to investigate and understand various factors that influence peanut oil content and quality. The oil content of 8000 germplasm lines screened at ICRISAT Center, Patancheru, India, ranged from 31 to 55% (ICRISAT, unpublished data). However, these observations were based largely on single season/location evaluations. Earlier studies had revealed that genotypic differences for oil content were highly influenced by locations, seasons, and growing conditions (4, 7, 8, 15, 30, 31).

Nutritional quality of oil is determined by its fatty acid composition. Oleic, a monounsaturated acid, and linoleic, a polyunsaturated fatty acid, account for 75-80% of the total fatty acids in peanut oil. Oleic (O)/linoleic (L) acid ratio and iodine value (IV) are both indicators of oil stability and shelf life of peanut products (3, 4, 12). Peanuts with high O/L ratio and low iodine value have long product stability. Genotypic variation for fatty acid composition in peanut (3, 17, 21, 26, 28) and its interaction with environment (4, 8, 30, 31) are reported in the literature. Two major recessive genes have been identified in peanut which increase the oleic acid content to near 80% and reduce the linoleic acid content to around 2% (18).

Soil application of micro-nutrients such as sulphur and boron resulted in an increase in oil content (2, 6, 23). However, the reports on the effect of macro-nutrients are conflicting. The application of nitrogen either had a negative (2, 24) or no (25) effect on oil content whereas phosphorous had all three effects: no effect (25), positive (2, 11, 24), and negative (20). For potash, the effects were either positive (2, 11, 20) or negative (25).

The present experiment was designed to (i) study the effect of growing environments on oil content and fatty acid composition vis-a-vis soil nutrients, pH, and electrical conductivity (EC), (ii) measure the degree of relationship among fatty acids and between fatty acids and oil content and, (iii) select genotypes with high oil content and better fatty acid composition to breed improved peanut cultivars.

Materials and Methods

Ten peanut germplasm lines (ICG numbers), selected from the preliminary screening of 8000 lines, an improved breeding line ICGV 87124, and two cultivars, ICGV 87123 and JL 24, were selected for the present study. Details of the thirteen genotypes are given in Table 1.

The trial was grown in a randomized complete block design with three replications during two rainy (1988 and 1989) and two postrainy (1988/89 and 1989/90) seasons at two to four locations, resulting in 12 growing environments in India as described in Table 2. Each treatment was represented by four-row plot of 4-m length, with plants spaced at 30 x 10 cm.

1. Soil analysis

After fertilizer application, surface (0-15 cm) soil samples were collected

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Table 1. Description of 13 peanut genotypes included in the study.

Genotype	Origin	Botanical type	Oil content (%)[1]	Remarks
ICG 5369	India	VB	34	Germplasm line
ICG 1171	India	SB	37	Germplasm line
ICG 6706	Brazil	VL	39	Germplasm line
ICG 6288	Brazil	VL	40	Germplasm line
ICG 8047	Zimbabwe	VL	41	Germplasm line
ICG 3509	USA	VL	44	Germplasm line
ICG 5856	India	VB	44	Germplasm line
JL 24	India	SB	45	Cultivar
ICGV 87123	India	SB	48	Cultivar
ICGV 87124	India	SB	49	Breeding line
ICG 7625	Nigeria	VB	52	Germplasm line
ICG 7637	Nigeria	VB	53	Germplasm line
ICG 2411	India	SB	54	Germplasm line

VB = Virginia bunch (*Arachis hypogaea* subsp. *hypogaea* var. *hypogaea*);
SB = Spanish bunch (*Arachis hypogaea* subsp. *fastigiata* var. *vulgaris*);
VL = Valencia (*Arachis hypogaea* subsp. *fastigiata* var. *fastigiata*).

1. Values of oil content are based on single season/location evaluation.

at random from three places in each plot of all the 12 environments before planting. The soil samples were air dried, mixed, and ground to pass through a 2-mm sieve. Subsamples were analyzed for pH, EC, N, P, Zn, Mn, and Fe. EC and pH were measured using 1:2 soil to water ratio (10). Ammonium and nitrate-N contents in the soil samples were analyzed following the procedure described by Keeney and Nelson (14). Later, both values were pooled to obtain total available 'N'. Available P was determined in 0.5 M $NaHCO_3$ extract following the molybdenum blue method (22). Available Zn, Fe, and Mn contents in the soil samples were determined following the method of Lindsay and Norvell (16).

2. Estimation of oil content and fatty acids

After harvest, samples of 100 sound mature seeds from each plot were analyzed for oil content and fatty acid composition. These seeds were handpicked to minimize the influence of maturity on oil content and quality.

Oil content: Oil content was determined using a commercial nuclear magnetic resonance spectrometer following the procedure described by Jambunathan *et al.* (13). All readings were taken on oven-dried (110 C, 16 h) samples and the values were expressed on a uniform 5% seed moisture content.

Fatty acid composition: Fatty acid methyl esters (FAME) of triglycerides were prepared following the method described by Hovis *et al.* (9). FAME were analyzed in a Shimadzu 9A model gas chromatograph (GC) equipped with a flame-ionization detector. They were separated on a glass column (2.1 m, 3 mm I.D.) packed with 10% Altech CS-10 chromosorb W-AW (80-100 mesh). Flow rate of the carrier gas (helium) was 50 mL min^{-1}. The hydrogen flow was 45 mL min^{-1} and the air flow was 500 mL min^{-1}. The injection port temperature/detector temperatures were 260 C. Column temperature was held at 190C for 4 minutes initially, and increased at the rate of 10 C min^{-1} to a final temperature of 250 C where it was held for 2 minutes. About 2 µL of sample was injected for analysis. Peaks were identified by matching their retention times to the reference standard mixture of fatty acids (Nucheck 21A peanut fatty acid composition).

From the fatty acid estimation, the following quality parameters were determined as described by Mozingo *et al.* (19).

i. Iodine value (IV)=(% oleic acid) (0.8601)+(% linoleic acid) (1.7321) +(% eicosenoic acid) (0.7854)

ii. Oleic acid (O)/linoleic acid (L) ratio = % oleic acid / % linoleic acid.

Table 2. Description of 12 environments 1988-1990.

Season	Environment	Location	Lattitude/ Longitude	Soil type	Fertilizer applied P_2O_5 (kg ha^{-1})	Irrigated/ rainfed	Temperature[a]		
							Min.	Max.	Avg.
1988 rainy	E 1	Dharwad	15°N, 75°E	Vertisol	60	Rainfed	19.6	27.9	23.7
	E 2	Hisar	29°N, 75°E	Entisol	60	Irrigated	22.8	33.7	28.3
	E 3	Patancheru	18°N, 78°E	Alfisol	60	Irrigated	21.8	29.7	25.8
1988/89 postrainy	E 4	Bhavanisagar	15°N, 77°E	Alfisol	60	Irrigated	21.7	35.0	28.3
	E 5	Patancheru-1	18°N, 78°E	Alfisol	60	Irrigated	16.4	31.7	24.1
	E 6	Patancheru-2	18°N, 78°E	Vertisol	60	Irrigated	16.9	32.2	24.6
1989 rainy	E 7	Anantpur	15°N, 77°E	Alfisol	46	Rainfed	22.2	32.8	27.5
	E 8	Bhavanisagar	15°N, 77°E	Alfisol	60	Irrigated	23.0	32.4	27.7
	E 9	Patancheru-1	18°N, 78°E	Alfisol	60	Irrigated	21.4	29.9	25.7
	E 10	Patancheru-2	18°N, 78°E	Alfisol	20	Rainfed	20.8	29.7	25.3
1989/90 postrainy	E 11	Bhavanisagar	15°N, 77°E	Alfisol	60	Irrigated	21.2	35.3	28.3
	E 12	Patancheru	18°N, 78°E	Alfisol	60	Irrigated	16.1	31.3	23.7

a = Temperature recorded during the crop season only.

iii. Total saturated fatty acids (%) (TSF) = % palmitic acid +% Stearic acid + % arachidic acid + % behenic acid + % lignoceric acid.
iv. Polyunsaturated (P)/saturated (S) ratio = % linoleic acid / TSF.
v. Total long chain saturated fatty acids (%) (TLCSF)= % arachidic acid % behenic acid + % lignoceric acid.

Analysis of variance was conducted using a mixed model where growing environments were treated as random and genotypes as fixed effects. Pooled analysis of variance over environments was performed after testing the homogeneity of error variance following Bartlett's test. Since error variance was heterogenous for all characterers under study, a weighted analysis was conducted to test the genotype x enviroment interaction component. As this interaction was highly significant in all cases, it was used to test the significance of genotypes and environments.

Phenotypic and genotypic correlations among oil content, individual fatty acids, and other oil quality parameters were determined following the method of Al-Jibouri *et al.* (1). Correlations of soil parameters with oil content and individual fatty acid contents were also determined.

Results and Discussion

Genotype, environment, and genotype x environment interaction effects were highly significant for oil content, individual fatty acid content, TSF, TLCSF, IV, O/L ratio, and P/S ratio (Table 3). Significant interactions due to effects related to location, genotype, season, soil moisture, temperature, and latitude have been previously reported for oil content and fatty acid composition (4, 8, 12, 15, 28, 30, 31).

The environments included in the present study differed significantly for soil pH and EC, and for available N, P, Zn, Mn, and Fe contents. Environment means for pH, EC, N, P, Zn, Mn, and Fe are presented in Table 4. The mean pH ranged between 6.10 and 8.52. Large variations in the mean N (4.38-32.91), P (3.54-31.11), Zn (0.27-4.76), Mn (8.02-42.56), and Fe (4.50-18.23) contents were observed across environments. Means for oil content, individual fatty acid contents, TSF, TLCSF, IV, O/L ratio, and P/S ratio for 12 environments averaged over 13 genotypes are given in Table 5. Correlation coefficients of soil parameters with oil and individual fatty acid contents were low but significant in many cases (Table 6). Oil content was positively correlated with pH and Fe, and negatively with Mn, N, and Zn. The correlation of pH and Fe with oleic acid was positive and with linoleic acid negative.

Means for oil content, individual fatty acids, TSF, TLCSF,

Table 4. Mean pH, EC, N, P, Zn, Mn, and Fe content in the soil samples before planting from 12 environments.

Environment[1]	pH	EC (m.mhos/cm)	N (ppm)	P (ppm)	Zn (ppm)	Mn (ppm)	Fe (ppm)
E 1	6.78g+	0.16c	18.65b	7.83gh	0.58g	42.56a	18.23a
E 2	8.36b	0.28a	32.91a	15.24d	1.94e	16.81e	4.50i
E 3	8.28c	0.21b	17.01b	15.57cd	2.26d	11.91g	5.64h
E 4	8.00d	0.19b	17.46b	12.45e	0.31h	18.12d	5.41h
E 5	8.02d	0.14c	11.65cd	17.52bc	3.01c	21.49c	14.09c
E 6	8.52a	0.22b	6.07ef	3.90i	1.86e	21.11c	11.29d
E 7	6.41i	0.11d	32.63a	31.11a	0.34h	12.14g	7.26f
E 8	6.67h	0.15c	29.45a	6.62h	0.39gh	14.19f	6.20g
E 9	8.42b	0.26a	7.04def	19.48b	4.44b	12.23f	6.19g
E 10	6.10j	0.05e	10.17cde	3.54i	1.59f	26.60b	14.80b
E 11	7.62f	0.14cd	14.25bc	9.04fg	0.27h	8.02h	5.87gh
E 12	7.83e	0.13cd	4.38f	10.86ef	4.76a	17.76de	8.72e

+ Within a column, means followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's multiple range test.

m.mhos/cm = milli mhos, ppm = part per million.

1. Refer Table 1 for description of each environment.

Table 3. Mean square for oil content, fatty acid contents, TSF, TLCSF, IV, O/L ratio, and P/S ratio for 12 environments and 13 peanut genotypes.

Source	df	Oil	Palmitic	Stearic	Oleic	Linoleic	Arachidic	Eicosenoic
Environment	11	198.91**	7.41**	4.23**	191.88**	199.15**	5.56**	2.01**
Blocks within environment	24	5.45	0.06	0.18	1.96	1.81	0.01	0.01
Genotype	12	74.59**	28.60**	11.92**	1057.34**	639.56**	1.46**	0.67**
Genotype x Environment	132	6.83**	0.46**	0.38**	12.57**	9.96**	0.08**	0.04**

Source		Behenic	Lignoceric	TSF	TLCSF	IV	O/L ratio	P/S ratio
Environment	11	1.52**	0.59**	13.83**	7.74**	219.17**	1.16**	0.80**
Blocks within environment	24	0.06	0.01	0.22	0.08	4.37	0.01	0.01
Genotype	12	2.55**	0.54**	86.08**	6.44**	270.87**	5.29**	0.64**
Genotype x Environment	132	0.14**	0.04**	0.75**	0.36**	9.65**	0.11**	0.02**

** = Significant at 0.01 probability level.

TSF=Total saturated fat, TLCSF = Total long chain saturated fat, IV = Iodine value, O/L = Oelic/Linoleic acid ratio, P/S = Polyunsaturated/saturated fatty acid ratio.

Table 5. Means for oil and fatty acid contents, TSF, TLCSF, IV, O/L ratio, and P/S ratio for 12 environments averaged over 13 peanut genotypes.

Environment	Oil	Palmitic	Stearic	Oleic	Linoleic	Arachidic	Eicosenoic
E 1	44.29g*	11.54d	2.74f	40.73gh	35.23cd	1.57d	1.37ab
E 2	50.51ab	10.85e	2.95def	41.19fg	35.89bc	1.68b	1.36b
E 3	50.94a	11.58d	3.68a	42.78d	33.44f	1.77a	1.07e
E 4	49.68bc	12.16b	3.24bc	42.33de	33.34fg	1.74a	1.23c
E 5	47.54e	10.77e	2.97de	41.81ef	36.01b	1.63c	1.42a
E 6	50.28ab	11.55d	2.85ef	40.16h	36.07b	1.64bc	1.34b
E 7	46.39f	11.50d	3.64a	47.52a	29.51h	1.58d	1.12d
E 8	47.67e	11.58d	3.11cd	43.96c	34.47e	1.01g	0.86g
E 9	48.88cd	11.83c	3.39b	42.27de	34.96de	1.37f	1.08e
E 10	44.26g	11.56d	3.60a	44.70b	32.73g	1.43e	1.04e
E 11	48.21de	12.29a	3.22bc	44.83b	33.77f	0.77h	0.69h
E 12	49.43bc	11.59d	2.84ef	40.05h	38.76a	0.68i	0.93f

Environment	Behenic	Linoleic	TSF	TLCSF	IV	O/L ratio	P/S ratio
E 1	3.80a	1.91a	21.57e	7.28a	97.13d	1.21e	1.63de
E 2	3.30d	1.84b	20.63e	6.82b	98.31c	1.19e	1.72bc
E 3	3.30d	1.55g	21.86ab	6.62cd	95.58e	1.33d	1.53f
E 4	3.29d	1.59fg	22.03a	6.62cd	95.12e	1.33d	1.51f
E 5	3.31d	1.62ef	20.31f	6.56de	99.45b	1.21e	1.77b
E 6	3.40bcd	1.50h	20.94d	6.55de	98.08cd	1.14f	1.72c
E 7	3.47bc	1.88cd	21.87ab	6.73bc	92.86f	1.71a	1.34g
E 8	3.38cd	1.59fg	20.68e	5.98h	98.21cd	1.36cd	1.66d
E 9	3.32b	1.56g	21.67bc	6.45ef	97.76cd	1.24e	1.62de
E 10	3.34d	1.55g	21.48c	6.32f	95.97e	1.46b	1.52f
E 11	3.09e	1.66de	21.03d	5.52i	97.60cd	1.39c	1.60e
E 12	3.74a	1.72c	20.57e	6.14g	102.33a	1.05g	1.88a

* Within a column, means followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's Multiple Range Test.

IV, O/L ratio, and P/S ratio for 13 peanut genotypes averaged over 12 environments are given in Table 7. Oil content of sound mature seeds varied between 45 and 50%, the highest being in ICG 7625 and ICG 5856, and the lowest in ICG 1171. The original variation in oil content among these genotypes (34-54%), based on single location/season test, could not be sustained over locations. The mean oil content of the virginia group was higher than either the spanish or valencia group in the present study.

Oleic acid content ranged from 38-53% and linoleic from 26-38%, and together they contributed 76-79% of the total fatty acids. Except for the six breeding lines from Florida which have oleic acid greater than 63% and linoleic acid less than 18% (21), these ranges of oleic and linoleic acids generally agree with data from previous studies (12, 27, 28, 29). The virginia types included in the present study had a higher mean oleic and a lower mean linoleic acid content than either the spanish or valencia types. Although the genotypes included in the present study are small in number, these observations are similar to those reported by previous workers (26, 28, 30) who studied a large number of genotypes. Genotypic differences in fatty acid composition were also observed within virginia and spanish types. ICG 5369 and ICG 5856 (virginia), and ICGV 87124 (spanish) had higher oleic, and lower linoleic acid contents than other lines in their groups.

Differences in mean TSF, TLCSF, IV, O/L ratio, and P/S ratio were observed among the genotypes included in the study. The range for TSF was from 19.01-24.08%, for TLCSF from 5.91-7.23%, for IV from 91.84-100.50, for O/L ratio from 1.01-2.10, and for P/S ratio from 1.38-1.82. ICGV 87123 (spanish) had the highest P/S ratio and ICG 5856 (virginia) had the highest O/L ratio and lowest IV.

Genotypic and phenotypic correlation coefficients among oil content, fatty acids, TSF, TLCSF, IV, O/L ratio, and P/S ratio are presented in Table 8. The oil content, among fatty acids, was positively correlated with oleic, and eicosenoic, and negatively with palmitic, stearic, linoleic, arachidic, and behenic acid contents. However, in previous studies (17, 27), except for stearic acid content which was correlated with total oil content, no correlation was reported between total oil content and other fatty acid contents. The oil content was also positively correlated with O/L ratio and negatively with TSF, TLCSF, IV, and P/S ratio.

The correlation of palmitic acid content with oleic acid content and that with O/L ratio were significant, of similar magnitude, and negative. On the other hand, its correlation with linoleic acid content was positive as was also observed in an earlier study (29). As in previous tudies (4, 17, 26, 27, 29), the oleic acid and linoleic acid contents were negatively correlated with each other (r=-0.99**). This relationship between these two fatty acid contents resulted in a positive correlation of the former and a negative correlation of the latter with O/L ratio. The P/S ratio was negatively correlated with the oleic acid content and O/L ratio, but positively with linoleic acid content and IV. A negative relationship between O/L and P/S ratio was reported in an earlier study (17). The IV in the present study was positively correlated with linoleic acid content but negatively with oleic acid content and O/L ratio. On the other hand, TSF and TLCSF were positively correlated with linoleic acid content. The correlation between arachidic acid and behenic acid contents, the two long chain saturated fatty acids, was positive.

Varieties with oil content ranging between 45 and 50% have been developed in the past without any directed breeding for higher oil content. For making desired progress in breeding for increased oil content, the available genetic variability in the cultivated peanut for oil content should be enlarged. The donors for high oil content in the breeding program should be selected after their mulitlocation evaluation to ensure the stability of this character.

Some of the wild species in section *Erectoidis* (PI 276209, PI 266225, Pi 262859 and PI 331188) and section *Rhizomatosae* (PI 262797, and PI 262286) have been reported to have oil contents of 60-63% (5). However, most of these accessions are cross incompatible with *A. hypogaea* and their exploitation in a breeding program is only a distant possibility.

The positive correlation between oil content and O/L ratio should enable breeders to select lines with high oil content and improved oil stability. Because of the negative correlation between oleic and linoleic acids, and a positive correlation between linoleic acid and total long chain saturated fat, selection of genotypes with high oleic content will not only improve their O/L ratio and lower the iodine value, but would also reduce undesirable long chain saturated fat

content. Genotypes, ICG 5856, ICG 5369, and ICGV 87124, offer promise in breeding for improved oil quality.

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Table 6. Correlations of oil content and individual fatty acids with soil parameters.

	pH	EC	N	P	Zn	Mn	Fe
Oil	0.51**	0.02	-0.34**	0.06	-0.29**	-0.45**	0.19**
Palmitic	0.00	0.40**	0.29**	0.29**	0.27**	0.13	-0.25**
Stearic	-0.03	0.00	0.00	0.11	0.28**	-.0.21**	-0.02
Oleic	0.23**	-0.23**	-0.24**	-0.29**	-0.07	0.02	0.29**
Linoleic	-0.30**	0.21**	0.25**	0.27**	0.04	-0.02	-0.29**
Arachidic	0.10	0.00	-0.02	0.21**	0.17*	-0.33**	-0.13
Eicosenoic	0.12*	-0.15	-0.22**	-0.24**	-0.42**	0.20**	0.24**
Behenic	0.06	0.20**	0.22**	0.37**	-0.04	-0.17*	-0.23**
Lignoceric	-0.06	-0.09	-0.10	0.10	-0.58**	0.08	-0.08
Iodine value	-0.40**	0.18*	0.25**	0.21**	-0.02	0.00	-0.27**
TSF	0.01	0.26**	0.19**	0.31**	0.23**	-0.07	-0.21**
TLCSF	0.07	0.09	0.10	0.36**	-0.11	-0.24**	-0.23**
O/L ratio	0.25**	-0.28**	-0.27**	-0.33**	-0.08	0.05	0.26**
P/S ratio	-0.44**	0.11	0.22**	0.15*	-0.12	0.04	-0.23**

*, ** = Significant at 0.05 and 0.01 probability level

Table 7. Mean oil and fatty acid contents, TSF, TLCSF, IV, O/L ratio, and P/S ratio for 13 peanut genotypes averaged over 12 environments.

Genotype	Growth habit	Oil	Palmitic	Stearic	Oleic	Linoleic	Arachidic	Eicosenoic
ICG 2411	SB+	48.44bcd++	12.39b	4.46a	38.89de	34.92cd	1.86a	0.92f
ICG 1171	SB	44.99f	12.50b	3.39cde	37.98f	37.84ab	1.46c	0.96ef
ICGV 87124	SB	49.27ab	11.23f	2.69gh	48.74b	32.12e	1.21ef	1.26ab
JL 24	SB	46.62e	12.91a	3.59bcd	37.95f	37.86ab	1.49bc	0.94f
ICGV 87123	SB	47.49de	12.41b	2.41h	38.77def	38.19a	1.09f	1.28ab
Mean		47.36	12.29	3.31	40.07	36.18	1.42	1.07
ICG 6706	VL	47.38de	11.66cd	3.13ef	39.01def	37.87ab	1.43c	1.10d
ICG 3509	VL	47.83cde	11.57de	3.29de	38.52ef	38.04a	1.43c	1.11cd
ICG 6288	VL	47.93bcde	11.19f	3.67bc	40.46d	36.37bc	1.61b	1.05de
ICG 8047	VL	48.36bcd	11.23f	3.71b	39.79def	37.02ab	1.53bc	1.06de
Mean		47.88	11.41	3.45	39.44	37.32	1.50	1.08
ICG 5369	VB	48.28bcd	10.08g	2.76g	52.27a	27.24g	1.28de	1.33a
ICG 5856	VB	50.23a	10.01g	2.89fg	53.02a	26.14g	1.39cd	1.21bc
ICG 7625	VB	50.34a	11.96c	2.60gh	42.87c	34.22d	1.28de	1.25ab
ICG 7637	VB	49.09abc	11.31ef	2.77g	47.73b	30.65f	1.20ef	1.21bc
Mean		49.48	10.84	2.75	48.97	29.56	1.29	1.25

Genotype	Growth habit	Behenic	Lignoceric	TSF	TLCSF	IV	O/L ratio	P/S ratio
ICG 2411	SB	3.93a	1.44d	24.08a	7.23a	95.53de	1.15cd	1.45f
ICG 1171	SB	3.66b	1.59bc	22.62b	6.72bc	98.97ab	1.01d	1.68cd
ICGV 87124	SB	3.13ef	1.57bc	19.83f	5.90f	96.84cd	1.50d	1.62d
JL 24	SB	3.44cd	1.52cd	22.95b	6.45cd	98.97ab	1.01d	1.65cd
ICGV 87123	SB	3.28de	1.87a	21.06e	6.25de	100.50a	1.02d	1.82a
Mean		3.48	1.60	22.11	6.51	98.16	1.14	1.65
ICG 6706	VL	3.49bc	1.77a	21.50cd	6.70bc	100.02ab	1.04d	1.76ab
ICG 3509	VL	3.62bc	1.80a	21.72e	6.85b	99.89ab	1.03d	1.76ab
ICG 6288	VL	3.53bc	1.63bc	21.64c	6.78b	98.63b	1.12cd	1.68cd
ICG 8047	VL	3.53bc	1.67b	21.67c	6.73bc	99.19ab	1.08d	1.71bc
		3.54	1.72	21.63	6.76	99.43	1.07	1.73
ICG 5369	VB	3.01f	1.62bc	18.68g	5.91f	93.18f	1.99d	1.46f
ICG 5856	VB	3.14ef	1.57bc	19.01g	6.10ef	91.84f	2.10a	1.38g
ICG 7625	VB	3.49bc	1.78a	21.12de	6.55bc	97.14c	1.27c	1.62d
ICG 7637	VB	3.09f	1.62bc	19.99f	5.91f	95.09e	1.61b	1.53e
Mean		3.18	1.65	19.70	6.12	94.31	1.74	1.50

+ SB = Spanish bunch, VL = Valencia, VB = Virginia bunch.

++ Within a column, means followed by the same letter are not significantly different at the 0.05 probability level according to Duncan's Multiple Range Test.

Table 8. Genotypic (below diagonal) and phenotypic (above diagonal) correlations among oil, fatty acids, TSF, TLCSF, IV, O/L ratio and P/S ratio in 13 peanut genotypes.

	Oil	Palmitic	Stearic	Oleic	Linoleic	Arachidic	
Oil	-	-0.56**	-0.33**	0.64**	-0.64**	-0.21**	0.57**
Palmitic	-0.58	-	0.31**	-0.84**	0.80**	0.20**	-0.58**
Stearic	-0.36	0.33	-	-0.47**	0.36**	0.97**	-0.88**
Oleic	0.67	-0.84	-0.48	-	-0.99**	-0.37**	0.66**
Linoleic	-0.67	0.80	0.38	-0.99	-	0.36**	-0.57**
Arachidic	-0.24	0.23	0.98	-0.39	0.29	-	-0.84**
Eicosenoic	0.64	-0.61	-0.92	0.70	-0.60	-0.90	-
Behenic	-0.40	0.65	0.82	-0.80	0.71	0.81	-0.89
Lignoceric	0.05	0.04	-0.56	-0.26	0.37	-0.56	0.44
TSF	-0.56	0.84	0.78	-0.86	0.78	0.71	-0.92
TLCSF	-0.35	0.53	0.42	-0.77	0.69	0.83	-0.86
IV	-0.63	0.68	0.16	-0.91	0.96	0.06	-0.38
O/L ratio	0.63	-0.83	-0.44	0.99	-0.99	-0.35	0.64
P/S ratio	-0.53	0.52	-0.07	-0.78	0.86	-0.16	-0.14

	Behenic	Lignoceric	TSF	TLCSF	IV	O/L ratio	P/S ratio
Oil	-0.39**	0.00	-0.54**	-0.35**	-0.59**	0.60**	-0.50**
Palmitic	0.62**	0.08	0.83**	0.51**	0.67**	-0.83**	0.52**
Stearic	0.78**	-0.56**	0.77**	0.79**	0.14**	-0.42**	-0.08
Oleic	-0.78**	-0.27**	-0.86**	-0.75**	-0.91**	0.99**	-0.78**
Linoleic	0.69**	0.37**	0.78**	0.67**	0.96**	-0.99**	0.88**
Arachidic	0.78**	-0.54**	0.70**	0.81**	0.03	-0.32**	-0.18**
Eicosenoic	-0.81**	0.45**	-0.88**	-0.78**	-0.36**	0.61**	-0.13*
Behenic	-	-0.08	0.92**	0.98**	0.49**	-0.74**	0.29**
Lignoceric	-0.12	-	-0.18**	-0.01	0.54**	-0.30**	0.69**
TSF	0.94	-0.20	-	0.86**	0.57**	-0.83**	0.35**
TLCSF	0.98	-0.05	0.87	-	0.48**	-0.71**	0.30**
IV	0.51	0.55	0.58	0.51	-	-0.93**	0.97**
O/L ratio	-0.77	-0.30	-0.84	-0.73	-0.94	-	-0.81**
P/S ratio	0.31	0.71	0.36	0.32	0.97	-0.81	-

** Significant at 0.05 and 0.01 probability level.

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