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Variation for fatty acids and oil quality parameters in backcross population of groundnut (*Arachis hypogaea* L.)

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ABSTRACT

Groundnut is an important oilseed legume and oil quality mainly depends on its fatty acid composition. In present study, backcross populations of the cross between GPBD 4 × GM 4-3 (using GPBD 4 as recurrent parent) were evaluated for two generations in augmented randomized block design at experimental plots of University of Agricultural Sciences, Dharwad. Frequency distribution and mean values of both generations showed considerable variability for oleic acid, linoleic acid, O/L ratio and iodine value. Both Oleic acid and linoleic acid are associated strongly with linoleic acid and iodine value in both backcross generations. Moderate heritability of oleic acid and high heritability of O/L ratio and also negative correlation between O/L ratio and linoleic acid suggests the scope for selection of oleic acid and O/L ratio to improve oil quality in groundnut.

Key words: Backcross, Heritability, Linoleic acid, Oil quality, Oleic acid.

INTRODUCTION

Oil quality has become an important healthy issue with increasing alarms of many health disorders in the Indian population. Oil quality mainly depends on fatty composition of oil and groundnut kernels contained 33 to 55% oil (Asibuo *et al*., 2008). Both oleic and linoleic acids accounted for 80% of total fatty acid in groundnut oil (Hammond *et al.*, 1997).Groundnut genotypes with high O/L ratio and low iodine value had greater flavor stability and longer shelf-life than normal-oleic groundnuts (Braddock *et al.*, 1995; O'Keefe *et al.*, 1993). High oleic acid character in a natural high oleate mutant was governed by two recessive genes (ol_1 and ol_2) (Moore and Knauft, 1989). Oleic acid had negative correlation with linoleic acid and positive association with O/L ratio (Anderson *et al*., 1998; Dwivedi *et al*., 1993).

Variability is an essential base for selection and variability can be created by hybridization and/or mutation. In the present study, high oleate mutant GM 4-3, isolated through artificial mutagenesis by gamma rays irradiation was backcrossed to well adapted genotype (GPBD 4) to recover the superior oil quality traits. The objectives of the present studies were 1) to estimate variability parameters and narrow sense heritability for fatty acids and oil quality parameters in backcross population 2) to assess the magnitude of relationship between fatty acids and oil quality parameters in intergeneration as well intra-generation of backcross of the cross (GPBD 4 × GM 4-3)-38 × GPBD 4.

MATERIALS AND METHODS

The material for present study consists of backcross population derived from the cross between GPBD 4 × GM 4-3. GPBD 4 was recurrent parent, possessing higher yield with moderate O/L ratio. Initially crossing was effected between GPBD 4 and higher oleate mutant GM 4-3 and true first filial generation hybrids were selfed to generate F_2 generation. High oleate segregants found in F_2 generation were backcrossed to recurrent parent GPBD 4. Both BC_1F_2 and BC_1F_3 generations consists of 269 and 327 respectively were evaluated by following the augmented design with three checks and standard agronomic practices were followed to raise the healthy crop. Well matured dried kernels were used for fatty acid estimation using Near Infrared Reflectance Spectroscopy (model 6500). NIR diffuse reflectance spectra were collected by a monochromator NIR spectrometer model 6500 (Foss NIRS systems, France) with the range from 400 to 2500 nm, which consisted of a light source of tungsten halogen lamps of 50 W 12 volts. The spectrometer was equipped with silicon detector. For NIRS analysis, single seed was placed in a special adapter about 3 mm thick, with a diameter of 37 mm and a central hole of 6 mm. Before spectra acquisition, a reference spectrum was collected from a standard check cell (IH-0324A, Infrasoft International, LLC, France). Different oil quality parameters estimated as per the formula by Velasco *et al*., (1997); Mozingo *et al*., (1988) and Dwivedi *et al*., (1998).

Frequency distribution of BC_1F_2 and BC_1F_3 generations was plotted using SPSS 16.0. Simple phenotypic correlation coefficients were calculated to determine the relationship between the fatty acid composition in BC_1F_2 and BC_1F_3 generations. Heritability estimates in narrow sense (h^2_{rg}) were calculated by parent offspring method using the

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data of BC_1F_3 on BC_1F_2 families as suggested in Smith and Kinman (1965). Linear regression coefficients (b) were calculated by regressing of BC_1F_3 progeny means (Y_i) on BC_1F_3 plants (X_i). Standard errors (SE) for the slope of each regression were calculated as for Ibrahim and Quick (2001).

RESULTS AND DISCUSSION

Variability is a pre-requisite for successful selection of superior progenies from segregating generations. The present investigation aims to determine the magnitude and extent of variability and pattern of segregation in BC_1F_2 and BC_1F_3 generations of GPBD 4 x GM 4-3 cross.

Frequency distribution of backcross population indicated substantial variation (Table 1 and 2) for fatty acids and other oil quality parameters (Figure 1). Oleic acid and linoleic acid were displayed large variation in fatty acids and in oil quality parameters iodine value showed broad range of variation compared to other traits. Oleic acid content in the BC_1F_2 ranged from 40.48 to 70.02 per cent with mean of 50.52 per cent and 48.58 to 74.62 per cent with mean of 57.67 per cent in the BC_1F_3 generation. Linoleic acid content varied from 14.79 to 40.82 31.72 per cent in BC_1F_2 generation and 7.04 to 31.16 per cent with mean of 21.11 per cent in the BC_1F_3 generation. O/L ratio ranged from 0.99 to 4.73 with mean of 1.64 in BC_1F_2 and in BC_1F_3 it ranged from 1.55 to 10.59 with mean of 2.9. Iodine value ranged from 86.7 to 106.8 with mean of 99.26 in BC_1F_2 and 76.7 to 97.42 with mean of 86.9 in BC_1F_3 generation. Total saturated fatty acids ranged from 16.67 to 20.87 per cent with mean

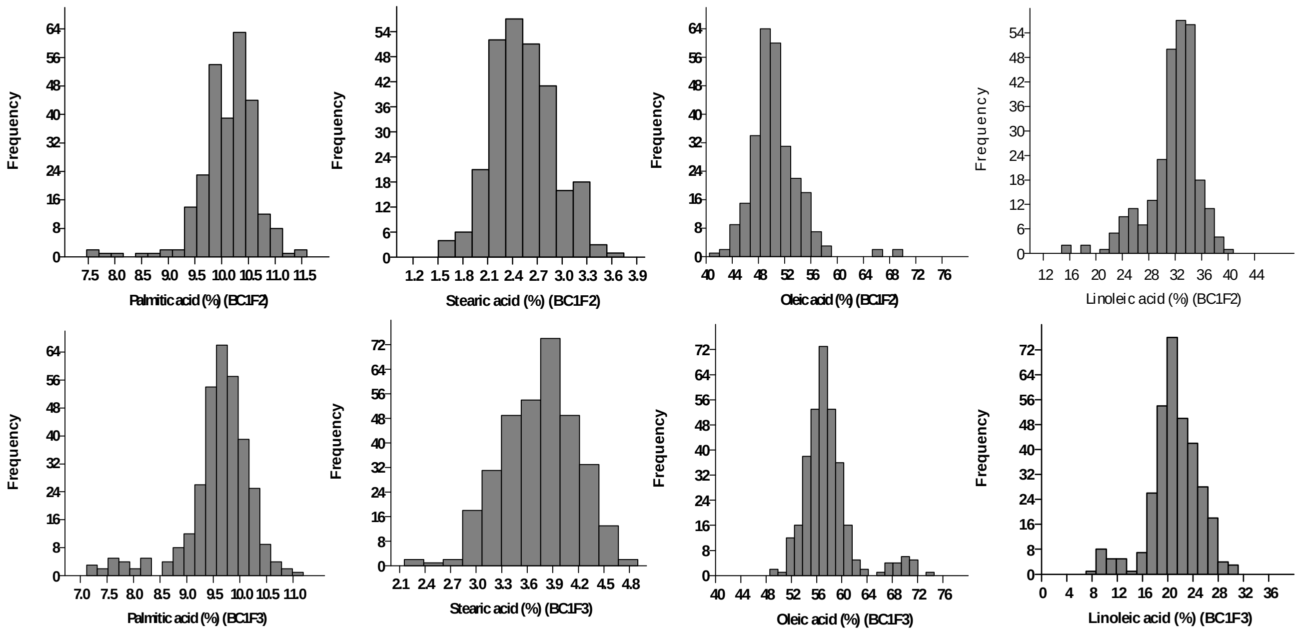

FIG 1: Frequency distribution of fatty acids in BC_1F_{-3} and BC_1F_3 generations of groundnut

TABLE 1: Descriptive statistics and narrow sense heritability for fatty acids in backcross generations of groundnut

Fatty acid	Generation	Min	Max	Mean	S	K	r (Intergeneration)	h^2 (rg)
Palmitic acid (C16:0)	BC_1F_2	7.473	11.597	10.131±0.528	-1.466	5.825	0.896	0.306
	BC_1F_3	7.116	11.189	9.599±0.634	-1.468	3.352		
Stearic acid (C18:0)	BC_1F_2	1.504	3.745	2.528±0.376	0.151	-0.019	0.977	1.745
	BC_1F_3	2.158	4.897	3.741±0.442	-0.379	0.16		
Oleic acid (C18:1)	BC_1F_2	40.489	70.028	50.523±3.702	1.482	6.098	1.00	0.478
	BC_1F_3	48.589	74.62	57.679±3.910	1.629	3.844		
Linoleic acid (C18:2)	BC_1F_2	14.796	40.823	31.720±3.873	-1.314	2.833	0.973	0.683
	BC_1F_3	7.044	31.163	21.11±3.839	-0.768	1.642		
Arachidic acid (C20:0)	BC_1F_2	0.815	2.004	1.225±0.243	1.499	2.058	0.998	0.737
	BC_1F_3	1.172	2.315	1.837±0.250	-1.083	0.185		
Eicosenoic acid (C22:0)	BC_1F_2	0.94	1.308	1.111±0.045	0.16	2.004	-0.734	-0.893
	BC_1F_3	0.86	1.229	1.006±0.047	0.565	3.568		
Behenic acid (C22:1)	BC_1F_2	3.316	4.311	3.697±0.171	0.549	0.571	-0.752	-1.447
	BC_1F_3	3.257	4.268	3.764±0.187	-0.125	-0.006		
Lignoceric acid (C24:0)	BC_1F_2	1.106	1.703	1.344±0.079	1.099	2.334	0.282	0.648
	BC_1F_3	1.131	1.557	1.364±0.084	-0.33	-0.344		

of 18.9 per cent in BC_1F_2 generation and 15.96 to 21.86 per cent with mean of 20.3 per cent in BC_1F_3 generation. There is increase mean oleic acid content and decrease in the linoleic acid content from BC_1F_2 to BC_1F_3 generation.

In both BC_1F_2 and BC_1F_3 generations, traits *viz.*, oleic acid, eicosenoic acid, O/L ratio, palmitic to stearic acid ratio and oleic acid desaturation ratio exhibited positive skewness. Other traits *viz.*, palmitic acid, linoleic acid, total saturated fatty acids and polyunsaturated to saturated fatty acid ratio showed negative skewness. There was shift skewness for positive to negative for traits *viz.*, Stearic acid, arachidic acid, behenic acid, lignoceric acid, total long chain saturated fatty acids from BC_1F_2 to BC_1F_3 generation. Other traits unsaturated to saturated fatty acid ratio and iodine value were moved from negative to positive skewed direction from BC_1F_2 to BC_1F_3 generation. This movement of skewness for traits under study from BC_1F_2 and BC_1F_3 generations suggest the effect of selection and their inter-relation between them. Fatty acids *viz.*, palmitic acid, oleic acid and O/L ratio showed leptokurtic nature whereas other traits showed platykurtic nature in both BC_1F_2 and BC_1F_3 generations. Narrow sense heritability estimates are showed in Table 1 and 2. Palmitic acid and oleic acid exhibited moderate heritability whereas O/L ratio showed high heritability. Moderate heritability of oleic acid and high heritability of O/L ratio and also negative correlation between oleic acid suggests the scope for selection of these traits for improving oil quality in groundnut.

Association between the fatty acids and oil quality parameters were shown in the Table 3 and Figure 2 and 3. The correlation coefficients between oleic acid and linoleic

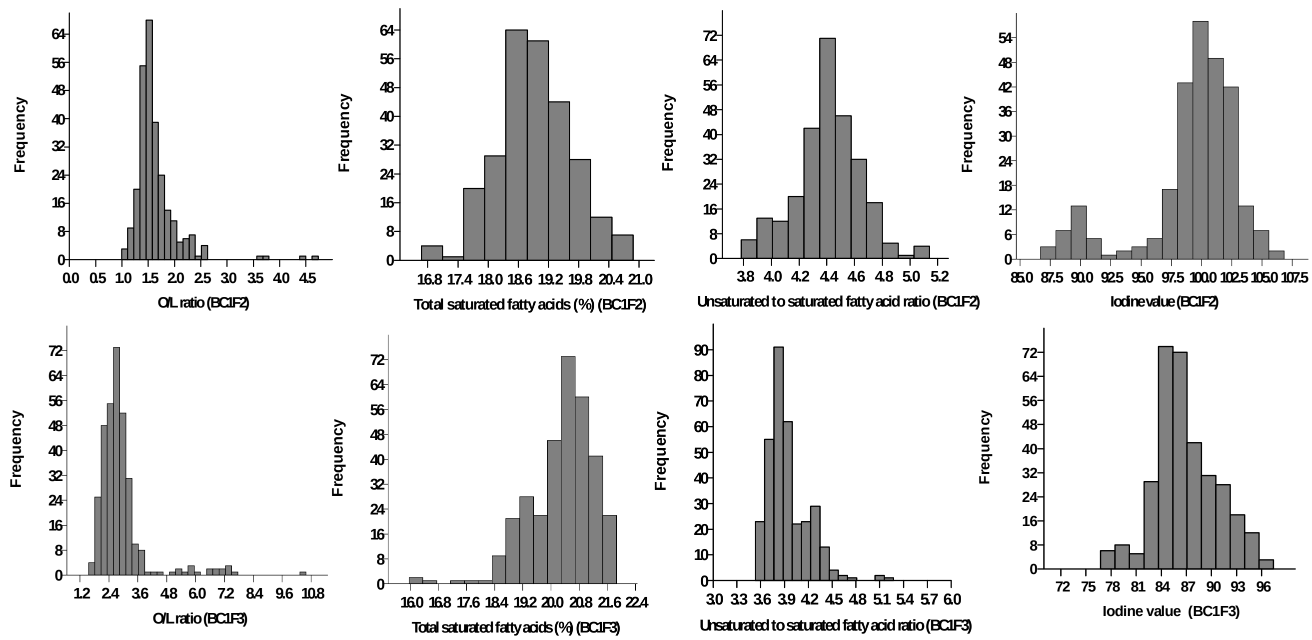

FIG 2: Frequency distribution of oil quality parameters in BC_1F_{-3} and BC_1F_3 generations of groundnut

TABLE 2: Descriptive statistics and narrow sense heritability for oil quality parameters in backcross generations of groundnut

Parameter	Generation	Min	Max	Mean	S	K	r (Intergeneration)	$h^2_{(NS)}$
O/L ratio	BC_1F_2	0.992	4.733	1.641±0.422	3.609	19.915	0.988	1.279
	BC_1F_3	1.559	10.593	2.908±1.074	3.294	13.761		
TSFA	BC_1F_2	16.672	20.879	18.926±0.749	-0.012	0.152	0.843	3.888
	BC_1F_3	15.968	21.867	20.305±0.913	-1.168	2.634		
TLCSFA	BC_1F_2	5.506	7.604	6.266±0.389	1.118	1.43	1.00	1.475
	BC_1F_3	5.662	7.851	6.965±0.441	-0.941	0.082		
P/S ratio	BC_1F_2	0.886	2.092	1.677±0.204	-1.446	2.142	0.976	0.743
	BC_1F_3	0.378	1.568	1.041±0.197	-0.184	0.936		
U/S ratio	BC_1F_2	3.782	5.141	4.413±0.237	-0.107	0.53	0.70	2.773
	BC_1F_3	3.534	5.272	3.941±0.259	1.532	3.868		
CIV	BC_1F_2	86.702	106.828	99.269±3.967	-1.455	1.791	0.953	0.949
	BC_1F_3	76.77	97.424	86.965±3.772	0.206	0.117		
(C16:0) / (C18:0) Ratio	BC_1F_2	2.32	7.194	4.107±0.718	0.711	1.84	0.988	0.941
	BC_1F_3	1.531	3.847	2.609±0.397	0.367	0.132		

TABLE 3: Phenotypic correlation coefficients among oil quality traits in groundnut (*Arachis hypogaea* L) genotypes in BC_1F_2 and BC_1F_3 generations of (GPBD 4 × GM 4-3)-38 × GPBD 4

	C16:0 (%)	C18:0 (%)	C18:1 (%)	C18:2 (%)	C20:0 (%)	C20:1 (%)	C22:0 (%)	C24:0 (%)	O/L ratio	TSFA (%)	TLCSFA (%)	P/S ratio	U/S ratio	CIV	Pm/St ratio	ODR
C16:0 (%)	1	-.272**	-.868**	.818**	-.394**	-0.048	.401**	-.397**	-.756**	.425**	-.151**	.701**	-.324**	.693**	.488**	-.846**
C18:0 (%)	-.197**	1	.203**	-.465**	.667**	-.557**	.330**	.470**	.442**	.675**	.688**	-.674**	-.716**	-.636**	-.925**	.367**
C18:1 (%)	-.857**	0.098	1	-.931**	.385**	.163**	-.657**	.310**	.839**	-.451**	0.004	-.797**	.349**	-.777**	-.392**	.972**
C18:2 (%)	.787**	-.269**	-.955**	1	-.643**	-0.009	.459**	-.495**	-.889**	.135*	-.304**	.956**	-0.004	.953**	.591**	-.990**
C20:0 (%)	-.284**	.455**	.360**	-.548**	1	-.235**	0.098	.793**	.583**	.528**	.864**	-.785**	-.627**	-.790**	-.688**	.561**
C20:1 (%)	-.185**	-.580**	.288**	-.162**	-.197**	1	-.433**	-0.053	-.130*	-.494**	-.365**	.148*	.443**	.127*	.388**	0.078
C22:0 (%)	.352**	.405**	-.535**	.385**	.194**	-.386**	1	.114*	-.409**	.713**	.564**	.235**	-.634**	.245**	-.174**	-.551**
C24:0 (%)	-.159**	0.036	.108*	-.222**	.605**	.159**	.176**	1	.539**	.392**	.791**	-.603**	-.462**	-.597**	-.464**	.439**
O/L ratio	-.810**	.196**	.866**	-.873**	.489**	.126*	-.340**	.360**	1	-0.108	.301**	-.859**	0.002	-.839**	-.506**	.889**
TSFA (%)	.624**	.517**	-.594**	.367**	.395**	-.512**	.755**	.241**	-.402**	1	.764**	-.158**	-.978**	-.143*	-.468**	-.258**
TLCSFA(%)	-0.021	.480**	-0.042	-.172**	.828**	-.273**	.673**	.693**	.196**	.679**	1	-.525**	-.805**	-.522**	-.626**	.195**
P/S ratio	.693**	-.417**	-.863**	.969**	-.689**	-0.032	.196**	-.323**	-.850**	.137*	-.376**	1	.279**	.988**	.741**	-.910**
U/S ratio	-.579**	-.545**	.526**	-.273**	-.450**	.517**	-.698**	-.259**	.346**	-.983**	-.685**	-0.045	1	.283**	.529**	.132*
CIV	.640**	-.424**	-.815**	.951**	-.692**	-0.008	.192**	-.317**	-.798**	0.094	-.379**	.986**	0.019	1	.697**	-.902**
Ps/St ratio	.613**	-.884**	-.475**	.583**	-.518**	.374**	-.154**	-.128*	-.526**	-.135*	-.410**	.660**	.182**	.642**	1	-.519**
ODR	-.812**	.217**	.978**	-.995**	.493**	.207**	-.446**	.184**	.873**	-.442**	0.099	-.944**	.353**	-.917**	-.552**	1

Above diagonal - **BC_1F_2 generation** Below diagonal - **BC_1F_3 generation**
C16:0- Palmitic acid C18:0 - Stearic acid C18:1 - Oleic acid C18:2 - Linoleic acid
C20:0 –arachidic acid C22:0- Eicosenoic acid C 22:1- Behenic acid C24 –Lignoceric acid

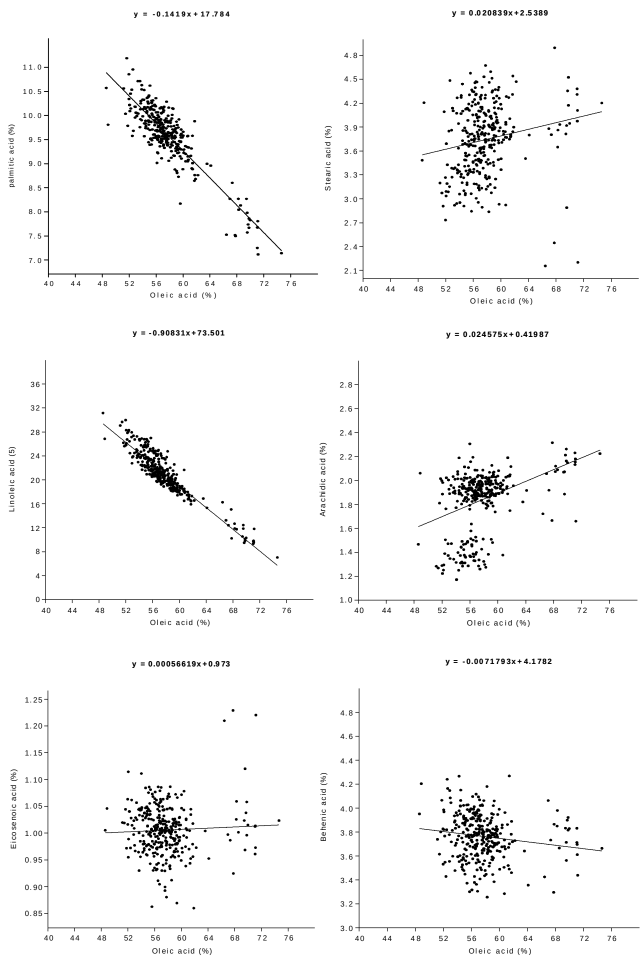

FIG 3: Relationship between oleic acid and other fatty acids in groundnut

acid were significantly negative in both generations. Oleic acid and O/L ratio had positive significant in both generations. Most phenotypic correlations were highly significant between fatty acids and oil quality parameters in both BC_1F_2 and BC_1F_3 generations.

Palmitic acid associated positively with linoleic acid, total saturated fatty acids, polyunsaturated fatty acid to saturated fatty acid ratio, iodine value and palmitic acid to stearic acid ratio. Palmitic acid associated negatively with stearic acid, oleic acid, arachidic acid, lignoceric acid, O/L ratio, total long chain saturate fatty acids, unsatuarated to saturated fatty acid and oleic acid desaturation ratio. These results are conformity with studies of Channayya (2009) and Sarvamangala (2009). Stearic acid correlated positively with oleic acid, arachidic acid, behenic acid, lignoceric acid, O/L ratio, total long chain saturate fatty acids and oleic acid desaturation ratio. Stearic acid associated with negatively with palmitic acid, linoleic acid, eicosenoic acid, polyunsaturated fatty acid to saturated fatty acid ratio, iodine value and palmitic acid to stearic acid ratio. Similar kind of relationships was noticed by Kavera (2008) and Channayya (2009).

Oleic acid associated positively with stearic acid, arachidic acid, behenic acid, lignoceric acid, O/L ratio, unsatuarated to saturated fatty acid and oleic acid desaturation ratio. Oleic acid associated with negatively with palmitic acid, linoleic acid, behenic acid, total saturated fatty acids, polyunsaturated fatty acid to saturated fatty acid ratio, idonce value and palmitic acid to stearic acid ratio (Figure 2 and 3). Linoleic acid associated with positively with palmitic acid, behenic acid, total saturated fatty acids, polyunsaturated fatty acid to saturated fatty acid ratio, iodine value and palmitic acid to stearic acid ratio. Linoleic acid associated negatively with stearic acid, oleic acid, arachidic acid, lignoceric acid, O/L ratio, total long chain saturated fatty acids and oleic acid desaturation ratio. The higher ratio of oleic acid to linoleic acid content ratio imparts oil stability and many health advantages (Holley and Hammons, 1968). O/L ratio associated positively with stearic acid, oleic acid, arachidic acid, lignoceric acid, total long chain saturate fatty acids and oleic acid desaturation ratio. O/L ratio associated negatively with palmitic acid, linoleic acid, eicosenoic acid, behenic acid, iodin value and palmitic acid to stearic acid ratio. Simlilar kind association between oleic acid and O/L ratio with linoleic acid was observed by Anderson and Gorbet (2002), Kavera (2008), Anderson (1998) and Sarvamangala (2009).

Saturated fatty acids are associated with health risks and higher levels of saturated fatty acids are undesirable for oil stability and nutrition. The reduction of the saturated fatty acid of groundnut is also important for the production of biodiesel as reduced saturated fatty acids content would improve winter operability of biodiesel (Korbitz, 2003). Total saturated fatty acids associated positively with palmitic acid, stearic acid, Linoleic acid, arachidic acid, behenic acid, lignoceric acid and total long chain saturated fatty acids. Total saturated fatty acids associated negatively with oleic acid, eicosenoic acid, polyunsaturated fatty acid to saturated fatty acid ratio, unsaturated to saturated fatty acid ratio, iodine value, palmitic acid to stearic acid ratio and oleic acid desaturation ratio. The higher the proportion of polyunsatuarated fatty acids (PUFA), the greater is the oxidation leading to unpleasant odour and tastes, thus limiting the storage quality of the oil (Tatum and Chow, 1992). Polyunsaturated fatty acid to saturated fatty acid ratio associated positively with palmitic acid, linoleic acid, eicosenoic acid, behenic acid, unsaturated fatty acid to saturated fatty acid ratio, iodine value and palmitic acid to stearic acid ratio. It also associated negatively with stearic acid, oleic acid, arachidic acid, lignoceric acid, O/L ratio, total saturated fatty acids, total long chain saturated fatty acids and oleic acid desaturation ratio.

An overall ratio of 2:1 unsaturated to saturation fatty acid ratio was considered to be best for human diet (Weiss, 2000).Unsaturated fatty acid to saturated fatty acid ratio associated positively with oleic acid, eicosenoic acid, polyunsaturated fatty acid to saturated fatty acid ratio, iodine value, palmitic acid to stearic acid ratio and oleic acid desaturation ratio. Unsaturated fatty acid to saturated fatty acid ratio associated negatively with palmitic acid, stearic acid, arachidic acid, behenic acid, lignoceric acid, total saturated fatty acids and total long chain saturated fatty acids. The iodine value is a common measure of the unsaturation of fats and oils and is widely used in the groundnut industry as an indicator of the relative storage life of groundnut products (Holley and Hammons, 1968). Iodine value associated positively with palmitic acid, linoleic acid, eicosenoic acid, behenic acid, polyunsaturated fatty acid to saturated fatty acid ratio, unsaturated fatty acid to saturated fatty acid ratio and palmitic acid to stearic acid ratio. Iodine value associated negatively with stearic acid, oleic acid, arachidic acid, lignoceric acid, O/L ratio, total saturated fatty acids, total long chain saturated fatty acids and oleic acid desaturation ratio (Fig 4).

Palmitic to stearic acid ratio of storage lipids had been proposed as an indicator for the efficiency of oil biosynthesis in the seeds (Harwood, 1996). A low ratio of this would be an indicator for efficient oil synthesis in the seeds and *vice versa*. (Mollers and Schierholt, 2002). Palmitic acid to stearic acid ratio associated positively with palmitic acid, linoleic acid,eicosenoic acid, polyunsaturated fatty acid to saturated fatty acid ratio and unsaturated fatty acid to saturated fatty acid ratio. It is negatively with stearic acid, oleic acid, arachidic acid, behenic acid, lignoceric acid, O/L ratio, total saturated fatty acids, total long chain saturated fatty acids and oleic acid desaturation ratio. Understanding enzymatic and genetic control of denaturation has helped breeders to select for specific fatty acid profiles in groundnut. Oleic acid desaturation ratio was used to measure the activity of desaturase enzyme (Velasco *et al.*, 1997). Oleic acid desaturation ratio associated positively with stearic acid, oleic acid, arachidic acid, lignoceric acid, O/L ratio, total long chain saturated fatty acids and unsaturated fatty acid to saturated fatty acid ratio. Oleic acid desaturation ratio associated negatively with palmitic acid, linoleic acid, behenic acid, total saturated fatty acids, polyunsaturated fatty acid to saturated fatty acid ratio, iodine value and palmitic acid to stearic acid ratio.

CONCLUSION

Backcross generations were exhibited substantial variation for fatty acids and oil quality parameters, which helped for early generation selection of high heritable oil quality traits as evident form from improved mean values of BC_1F_3 generation. There was considerable increase in

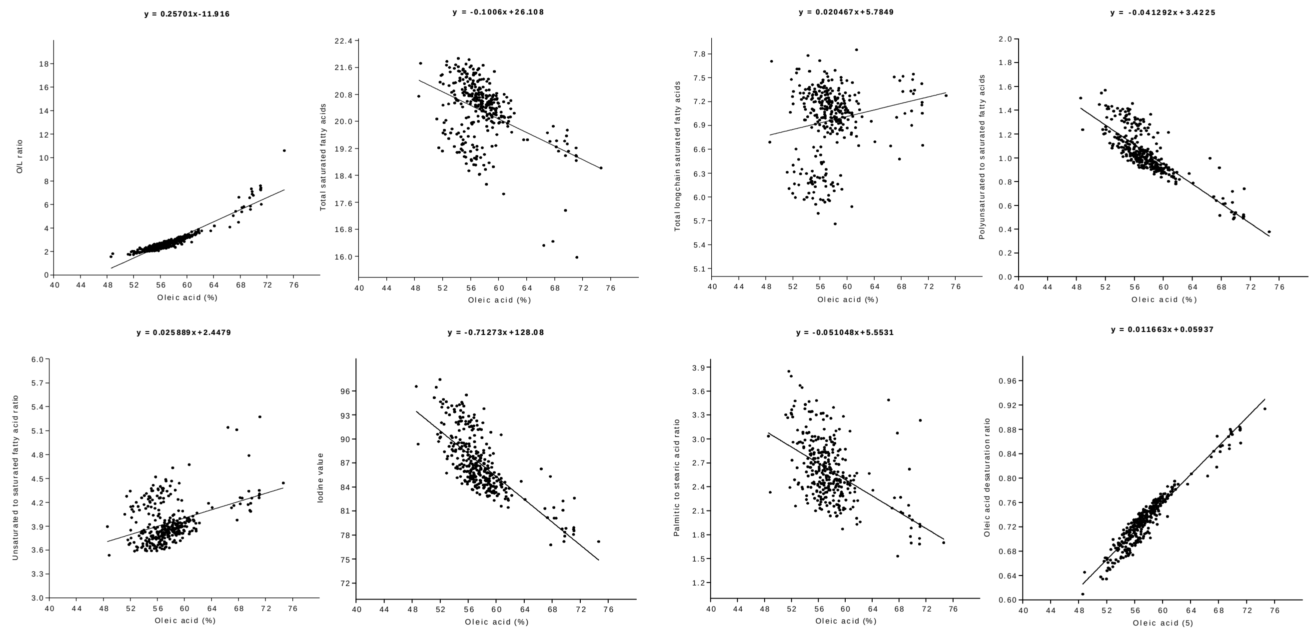

FIG 4: Relationship between oleic acid and oil quality parameters in groundnut

desirable oil quality traits (Oleic acid and O/L ratio) from BC_1F_2 to BC_1F_3 generation at the cost of other fatty acids (linoleic acid). Modified the fatty acids at fatty acid chain level can be observed by correlation and regression coefficients. The strong negative correlation between oleic acid and linoleic acid indicate increased oleic acid at expense of linoleic acid in the pathway. Hence selection of O/L ratio and its positively associated traits can be considered for further improvement of high oil quality traits.

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