__Original Research Article__

Confectionery groundnut genotypes (*Arachis hypogaea* L.): A study on genetic variability parameters with special reference to confectionery traits improvement

Abstract

Diverse groundnut parents were used to generate 36 advanced breeding lines to develop into a confectionery genotype for yield, quality, and main biotic stress. Advanced breeding lines evaluated in randomized complete block design including parents and checks during *kharif* and summer, 2021 respectively. High genetic variability and heritability observed for hundred seed weight, pod yield per plant, pod yield (kg/ha), late leaf spot (LLS), rust disease, oil content, blanchability, oleic acid, linoleic acid and O/L ratio. The correlation between hundred seed weight, sound mature kernels, shelling percentage and pod yield per plant with kernel yield showed positive association. Rust and LLS disease revealed a high positive connection indicating that an increase in late leaf spot disease incidence enhances the incidence of rust disease and vice versa in groundnut. Substantial negative association was found between two crucial quality parameters such as oil content and protein content, as these two characteristics determine the quality of groundnut for confectionary purposes. Path analysis indicates kernel yield had the greatest direct positive effect on pod yield, followed by seed weight, oil content and sound mature kernel and direct selection for these characteristics would be effective. The path analysis of quality attributes revealed that at the genotypic level, oil content, protein content, and O/L ratio have the most direct effect on hundred seed weight.

Key Words: confectionary groundnut, rust, LLS correlation and path analysis

Introduction

Groundnut (*Arachis hyogaea* L.) a wonder legume, is high in oil (43-55%), protein (25-28%), carbs (10-25%), vitamins (K, E, and B complex), minerals (Ca, P, Mg, and Fe) and fibre. Groundnut is grown in over 100 nations on an area of 29.6 million hectares, yielding 48.7 million tonnes with a productivity of 1647 kg/ha (Annonymous, 2020). Groundnut is predominantly utilized in India for the extraction of edible oil and breeding efforts have thus far been concentrated on boosting oil content because it is a crucial element in yield potential. With the increased availability of cheaper vegetable oils over the last three decades, the pattern of groundnut consumption has turned progressively towards use in food and confectionery.

Consumption of groundnut contributes towards fighting malnutrition as it is rich source of protein, energy and micronutrients. Confectionery groundnut with premium edible grade has great demand all over the world (Vaghasia*et al.,* 2016).Unfortunately, the premium grade large seeded groundnut varieties are low yielders with low shelling outturn, lower percentage of sound mature kernels, prolonged maturity and fresh seed dormancy(Kale *et al*., 2000).

On the positive side the global peanut market for confectionary types has recorded significant surge in the growth rate in the last few years. The considerable aspect causing an upsurge in the market's growth is the wide range of applications across the food and beverage sector. In addition, the adoption of a healthy lifestyle and changes in consumption patterns across the globe is also anticipated to catalyze the market's growth over the coming years. India being one of the leading producers, has enormous potential for exporting bold seeded groundnut. However, the lack of suitable varieties has restricted the scope for exports.

Thus far, breeding efforts have been directed towards improving oil output, either by increasing oil content or by increasing productivity. Breeding studies focused solely on the development of confectionary peanut cultivars are relatively new. Breeding objective for confectionary groundnut include the quality factors such as high shelling outturn, high proportion of sound mature kernels, easy blanching, and nutty flavor are followed by high O/L ratio, high protein content, high carbohydrate content, low oil content, and low allergen content (Bentur, 2001).

Similar to genotypes ideal for oil extraction, biotic and abiotic stressors have great impact on the productivity of confectionary groundnut cultivars also. Late leaf spot (LLS) caused by *Phaeoisariopsispersonata* and rust induced by *Puccinia arachidis* are both widespread and economically significant biotic stressors. These two foliar diseases frequently occur together, causing yield losses of up to 70*per cent* and negatively impacting seed quality and seed grade (Wankhade *et al*., 2021). As a result, disease resistance breeding is an environmentally benign and cost-effective method of decreasing crop yield losses (Divyadarshini *et al*., 2017).

Materials and methods

The study comprises of 36 advanced breeding lines derived from hybridization of LLS and rust susceptible confectionery genotypes TG-76 and TGLPS-3 with LLS and rust resistant donors v*iz.,* GPBD-5, ICGV-86699 were used for the study. The female parents TG-76 and TGLPS-3 are virginia bunch and bold seeded confectionery type, late maturing and susceptible to rust and late leaf spot respectively. The male parent GPBD-5 is spanish bunch type, high yielding, medium bold seeded, resistant to LLS, tolerant to rust and early to mature whereas ICGV 86699 is virginia bunch type, high yielding, interspecific derivative, resistant to rust and LLSdisease and early to mature.

The experiment was carried out in a randomized complete block design with two replications at AICRP on Sesame and Niger, Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad (UASD). Thirty-six confectionery genotypes including four parents *viz*., TG-76, TGLPS-3 GPBD-5, ICGV86699 and one confectionery check ICGV-06189 (Table1) were evaluated for productivity and quality traits during summer-2021 and for disease incidence during *kharif*-2021. Advanced breeding lines were sown 6 rows each in 3 beds with a spacing of 45cm x 15cm.

Phenotypic evaluation for yield attributes, yield and quality traits was carried out on five randomly chosen plants in each entry and replications. Field observations recorded on days to 50 per cent flowering, pod length, sound mature kernels, number of pods per plant, mature pods per plant, days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, shelling percentage, pod yield per plant, kernel yield, haulm yield and pod yield(kg/ha). The same set of genotypes were screened at 80 and 90 days after sowing for rust and late leaf spot diseases following modified nine-point disease scale given by Subbarao *etal.*(1990) during *kharif*-2021. The following quality parameters were measured; oil content, protein content, blanchability, oleic acid, linoleic acid, palmitic acid, stearic acid, oleic acid/linoleic acid ratio, and hundred seed weight.

Quality traits *viz.*, oil content, protein content, oleic acid, linoleic acid, palmitic acid, stearic acid, oleic acid/linoleic acid ratio were estimated by Near Infrared Spectroscopy (NIRS) at AICRP on Oilseed, MARS, UAS, Dharwad. Blanching was carried out as per the method given by Singh *et al.,* 1996. Due to non-availability of blancher, pre-heated roasted kernels were subjected to blanching by hands with normal pressure. The number of blanched seeds were counted and expected as percentage. Observation was recorded to determine the percentage of blanched whole seeds or blanching percentage. The analysis of variance (ANOVA), genotypic coefficient of variation, phenotypic coefficient of variation (Burton and De Vane, 1953), heritability (Robinson *et al.* 1996), genetic advance as percent mean (Johnson *et al*. 1955) character association and path analysis were analysed.

Table 1:Pedigree of the studied confectionery groundnut genotypes

Sl. No	Names	Pedigree
1	CG-1	TG – 76 × ICGV 86699
2	CG-2	TG – 76 × ICGV 86699
3	CG-3	TG – 76 × ICGV 86699
4	CG-4	TG – 76 × ICGV 86699
5	CG-5	TG – 76 × ICGV 86699
6	CG-6	TG – 76 × ICGV 86699
7	CG-7	TG – 76 × ICGV 86699
8	CG-8	TG – 76 × ICGV 86699
9	CG-9	TG – 76 × ICGV 86699
10	CG-10	TG – 76 × ICGV 86699
11	CG-11	TG – 76 × ICGV 86699
12	CG-12	TG – 76 × ICGV 86699
13	CG-13	TG – 76 × ICGV 86699
14	CG-14	TGLPS 3 x GPBD-5
15	CG-15	TGLPS 3 x GPBD-5
16	CG-16	TGLPS 3 x GPBD-5
17	CG-17	TGLPS 3 x GPBD-5
18	CG-18	TGLPS 3 x ICGV 86699
19	CG-19	TGLPS 3 x ICGV 86699
20	CG-20	TGLPS 3 x ICGV 86699
21	CG-21	TG – 76 × GPBD-5
22	CG-22	TG – 76 × ICGV 86699
23	CG-23	TG – 76 × ICGV 86699
24	CG-24	TG – 76 × ICGV 86699
25	CG-28	ICGV 06189X DH 245-10
26	CG-29	ICGV 06189X AGL 2766-8
27	CG-30	ICGV 06189X ICGV 08025-1
28	CG-31	JSP-39 X GM6-1SSD-5
29	CG-32	JSP-39 X GM6-1- SSD-25
30	CG-33	ICGV 06189 X GM 6000-24-5
31	CG-34	ICGV 06189 X 6000-65-3
32	ICGV 86699	Parental lines
33	TG 76	Parental lines
34	GPBD-5	Parental lines

35	TGLPS 3	Parental lines
36	ICGV 06189	Check

*CG- confectionary groundnut

Results and discussion

Analysis of variance (ANOVA)

Analysis of variance for yield and yield attributing traits as well as for foliar diseases such as rust and late leaf spot at 80and 90 days after sowing revealed a substantial difference among the confectionery groundnut genotypes showing the presence of high degree of genetic variation (Table 2). Similarly, the quality traits; blanchability, oil content, protein content, oleic acid, linoleic acid, palmitic acid, stearic acid and O/L ratio showed the highly significant variation (Table 3).The variability exists for all the yield and its contributing traits, rust and late leaf spot diseaseand the majority of the quality traits indicate that the material under research was genetically diverse since the genotypes were developed by crossing diverse parents.

Components of variation

Genetic variability is a basic requirement of any breeding program to evolve superior genotypes through selection. Higher amount of genetic variation for a character represents a greater scope for its improvement through selection (Johnson *et al*. 1955). The estimates of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV)for yield and yield attributing traits in the present study revealed the presence of high level of variability for secondary branches per plant, number of pods per plant, mature pods per plant, hundred seed weight, pod yield per plant, pod yield (kg/ha), kernel yield and haulm yield (Table 4). Moderate level of variability was exhibited by plant height, primary branches per plant, shelling percentage and pod length. High values of GCV were observed for pod yield, kernel yield, haulm yield, late leaf spot at 80 and 90 days after sowing and rust at 90 days after sowing indicates a predominant role of additive gene action and amenability for phenotypic selection. Low GCV and PCV were recorded for sound mature kernels, oil content, days to 50 per cent flowering and days to maturity. For foliar diseases *viz.,* rust and late leaf spot at 80 and 90 DAS, high PCV and GCV were observed. Heritable portion of variability existing in the character indicates the probability and degree to which improvement is possible through selection (Robison *et al.,* 1996).

All of the variables studied, including disease reaction, had moderate to high heritability, indicating that these attributes will respond to selection. At 80 and 90 DAS, the genetic advance over the mean for yield-related variables was high for secondary branches per plant, number of pods per plant, mature pods per plant, shelling percentage, hundred seed weight, pod yield per plant, pod yield, haulm yield, LLS, and rust. For days to maturity, sound mature kernels, and oil content, low GAM was observed.

Among quality traits, O/L ratio had ahigh PCV and GCV indicating that additive gene action predominated. The traits *viz.,*blanchability, linoleic acid and stearic acid revealed moderate PCV but oil content, protein content, oleic acid, and palmitic acid showed low PCV and GCV, indicating the presence of less diversity across the genotypes studied. Oil content, blanchability, oleic acid, linoleic acid and O/L ratio expressed high heritability, whereas oil content had low GAM. Protein content had a moderate heritability and genetic advance over mean indicating modest response to

Table 2: Analysis of variance for yield and yield attributing traits of confectionery groundnut genotypes

Source of variation	d.f	DFF	PH (cm)	DTM	PBPP	SCBP	NPP	MPPP	SP	HSW(g)	SMK (%)
Replication	1	6.13	1.43	0.01	2.68	3.97	30.68	84.50	23.75	10.13	9.1
Genotypes	35	20.04**	51.73**	3.55**	1.60**	2.77**	200.61*	249.11*	169.48**	342.27**	52.35**
Error	35	2.98	6.04	1.19	0.7	0.26	18.68	31.73	13.06	25.09	7.19

Source of variation	d.f	PL	OC	PYPP(g)	PY(kg/ha)	KY(kg/ha)	HY(kg/ha)	L-80	L-90	R- 80	R-90
Replication	1	0.01	0.42	305.045	272062.6	82606.86	38596.09	0.22	0.89	0.13	0.05
Genotypes	35	0.18**	2.99**	3341.74**	731462.6**	298867.6**	6880415.8**	2.65**	7.39*	1.41*	6.99**
Error	35	0.05	0.34	219.741	64844.37	20933.79	38596.09	0.34	0.86	0.24	0.48

*- Significant at 5% probability level **-Significant at 1% probability level

DFF-Days to 50% flowering; **PH**: Plant height (cm); **DTM**: Days to maturity; **PBPP :** Primary branches per plant; **SBPP:** Secondary branches per plant; **NPP:** Number of pods per plant; **MPP:** Mature pods per plant; **SP:** Shelling percentage; **HSW:** Hundred seed weight; **SMK**: Sound mature kernels; **PL:** Pod length; **OC:** Oil content: **PYPP:** Pod yield per plant; **KY:** Kernel yield (kg/ha); **HY:** Haulm yield (kg/ha); **PY:** Pod yield (kg/ha); **L-80** :late leaf spot 80 days after sowing ; **R-80**: rust 80 days after sowing; **L-90**: late leaf spot 80 days after sowing; **R-90**: rust 80 days after sowing.

Table 3: Analysis of variance for quality traits of confectionery groundnut genotypes

Source of variation	d.f	Blanchability	Oil content (%)	Protein content (%)	Oleic acid (%)	Linoleic acid (%)	Palmitic acid (%)	Stearic acid (%)	O/L ratio
Replication	1	15.13	0.42	3.28	26.67	29.52	2.27	0.01	0.39
Genotypes	35	479.83**	2.99**	4.46**	53.09**	43.04**	1.01**	0.12**	0.72**
Error	35	7.29	0.34	1.7	8.31	6.59	0.44	0.05	0.11

*- Significant at 5% probability level **-Significant at 1% probability level

selection (Parameshwarappa*et al.,* 2003). Blanchability exhibited moderate PCV and GCV, as well as strong heritability and genetic progress as a percentage of mean, indicating that selection is effective for this trait. (Singh *et al.,* 1996, Bentur, 2001, Cruickshank *et al.,* 2003, Janila *et al.,* 2012 and Wright *et al.,* 2018).

Character association and path analysis

Yield is a complex character that cannot beachieved successfullythrough direct selection. Correlation assesses the relationship among several traits, assisting in the identification of successful strategies for indirect selection employing associated qualities and simultaneous selection of numerous traits. The current study found a substantial and positive link between hundred seed weight and pod yield (Table 6). The correlation between hundred seed weight, sound mature kernels, shelling percentage, and pod yield per plant with kernel yield was positive and significant, showing that selecting for greater kernel size, high shelling percentage, and individual plant yield helps enhance kernel yield. As a result, breeding for high pod yield can be accomplished without compromising the large seed size, which is a desirable characteristic for confectionary peanuts. There was a substantial and positive correlation between pod length and hundred seed weight.

Correlations between both diseases, rust and LLS, at 80 and 90 days after sowing, revealed a high positive connection. This positive relationship between both diseases indicates that an increase in late leaf spot disease incidence enhances the incidence of rust disease and vice versa in groundnut. As a result, in most peanut growing locations, these two diseases are the most damaging to groundnuts. Both of these diseases have a negative correlation with pod yield, oil content, and haulm yield, indicating that biotic stressors influence oil content, yield, and even fodder quality. As a result, the study clearly indicates that resistance to biotic stressors is critical to minimizing chemical spray and pesticide residue accumulation. Substantial negative association was found between two crucial quality indicators, oil content and protein content, as these two characteristics also determine the quality of groundnut for confectionary purposes. Before developing any acceptable breeding strategy for cultivar growth, it is vital to understand the link between different components of oil quality (Alam, 2014). Oil content had a positive association with linoleic acid, protein content had negative association with linoleic acid and oleic acid had inverse relationship with linoleic acid. O/L ratio, an important oil quality determinant is expected to be high in the cultivar and depends on the amount of oleic acid and linoleic acid present in the oil. Oil content has positive association with linoleic acid content, but oleic acid had inverse relationship with linoleic acids. Here desirable traits like protein content, oil content, oleic acid had inverse relationship among themselves (Table 7).

To determine the direct and indirect effects of pod yield and yield-related features, the correlation coefficient was further partitioned into direct and indirect effects by using pod yield as a dependent character. Path coefficient analysis, on the other hand, aids in understanding the nature and magnitude of each character's direct and indirect contribution to the dependent character, such as pod yield. (Table 8). The path analysis employing genotypic and phenotypic path coefficients between pod yield and other characters revealed that the kernel yield had the greatest direct effect on pod yield, implying that these traits should be emphasized for selection to improve pod yield. The genotypic path coefficient between pod yield, hundred seed weight, and sound mature kernel has the most direct effect on pod yield. At the genotypic level, sound mature kernel and oil content had the most favourable direct effect on pod production, while haulm yield had a minimal direct effect.The strongest direct effect on pod yield was from pod yield per plant and kernel yield. The attributes pod yield per plant and haulm yield had a strong direct positive effect on pod yield (kg/ha). These characteristics can be used as selection criteria for greater yield because they were found to be mutually and directly related to pod yield. Kernel yield had the greatest direct positive effect on pod

Table 4: Genetic variability analysis for yield and yield attributing traits in confectionery groundnut genotypes

Traits	Range		Mean	PCV (%)	GCV (%)	h^2b.s. (%)	GAM
	Min	Max					
Days to 50% Flowering	44.00	55.00	46.79	7.25	6.24	74.10	11.07
Plant height	18.18	40.25	29.80	18.03	16.04	79.10	29.38
Days to maturity	110.00	115.00	111.54	1.38	0.97	49.97	1.42
Primary branches per plant	4.70	8.70	6.72	15.99	9.99	39.03	12.86
Secondary branches per plant	2.50	6.90	4.55	27.05	24.64	64.96	46.41
Number of pods per plant	32.00	68.00	48.74	21.49	19.57	82.96	36.72
Mature pods per plant	25.00	63.50	42.03	28.20	24.81	77.41	44.96
Shelling percentage	43.60	73.00	57.70	16.56	15.33	85.69	29.23
Hundred seed weight (g)	41.00	91.00	59.73	22.69	21.08	86.34	40.35
Sound mature kernels (%)	77.00	97.00	91.27	5.98	5.21	75.86	9.34
Pod length	2.49	4.12	3.17	10.69	7.98	55.60	12.25
Oil content (%)	43.22	47.64	45.12	2.86	2.55	79.60	4.69
Pod yield per plant(g)	94.00	241.00	155.70	27.10	25.37	87.66	48.94
Pod yield(Kg/ha)	884.86	3473.46	1825.38	34.57	31.63	83.71	59.61
Kernel yield (Kg/ha)	613.79	1917.71	1047.95	38.16	35.57	86.91	68.31
Haulm yield (Kg/ha)	322.77	8726.46	4565.92	42.65	38.49	81.42	71.54
LLS-80 DAS	0.00	5.00	3.36	36.33	31.97	77.43	57.95
LLS-90 DAS	0.00	9.00	5.53	36.76	32.71	79.16	59.95
Rust-80DAS	0.00	4.00	2.74	33.23	28.01	71.05	48.63
Rust -90DAS	0.00	8.00	4.53	42.72	39.86	87.06	76.61

PCV-Phenotypic coefficient of variationh^2bs - Heritability in broad sense

GCV-Genotypic coefficient of variationGAM- Genetic advance as percent of mean

Table 5: Genetic variability analysis for quality traits in confectionery groundnut genotypes

Traits	Range		Mean	PCV (%)	GCV (%)	h^2b.s. (%)	GAM
	Min	Max					
Blanchability	46.00	96.50	81.93	19.05	18.76	97.00	38.06
Oil content (%)	43.22	47.64	45.12	2.86	2.55	79.60	4.69
Protein content (%)	27.86	33.96	30.77	5.71	3.82	44.80	5.27
Oleic acid (%)	45.00	66.27	55.57	9.97	8.52	72.90	14.98
Linoleic acid (%)	16.81	33.88	26.15	19.05	16.32	73.40	28.82
Palmitic acid (%)	7.44	10.13	8.84	9.63	6.03	39.30	7.79
Stearic acid (%)	1.79	2.86	2.47	11.82	8.01	45.90	11.19
O/L ratio	1.35	3.83	2.24	28.72	24.64	73.60	43.53

PCV- Phenotypic coefficient of variation

GCV- Genotypic coefficient of variation

h^2bs - Heritability in broad sense

GAM- Genetic advance as percent of mean

Table 6: Phenotypic and genotypic correlation for yield and yield attributingtraits with disease resistance of confectionery groundnut genotypes

Traits		HSW	PL	SMK	NPP	MPP	DTM	PH	PBPP	SCBP	SP	OC	R-80	R-90	L-80	L-90	PYPP	KY	HY	PY
DFF	P	-0.437**	-0.13	-0.304**	0.048	-0.184	0.562**	-0.245*	0.215	0.314**	-0.063	0.116	-0.152	0.131	-0.089	0.068	-0.355**	-0.352**	-0.082	-0.326**
	G	-0.502**	0.043	-0.385**	0.126	-0.202	0.853**	-0.327**	0.582**	0.429**	-0.152	0.169	-0.23	0.107	-0.075	-0.021	-0.448**	-0.480**	-0.114	-0.443**
HSW	P		0.349**	0.465**	0.197	0.419**	-0.148	0.257*	-0.339**	-0.191	0.197	-0.302**	0.297*	-0.246*	0.157	-0.229	0.395**	0.279*	-0.149	0.180
	G		0.518**	0.618**	0.192	0.530**	-0.160	0.324**	-0.573**	-0.201	0.232	-0.374**	0.375**	-0.301*	0.195	-0.272*	0.452**	0.336**	-0.220	0.232*
PL	P			0.361**	0.192	0.200	0.120	-0.024	-0.238*	-0.087	-0.026	-0.312**	0.147	0.079	0.145	0.084	-0.09	-0.195	-0.114	-0.185
	G			0.450**	0.155	0.349**	0.095	0.003	-0.843**	-0.188	0.007	-0.471**	0.171	0.144	-0.026	0.149	-0.156	-0.246*	-0.169	-0.242*
SMK	P				0.126	0.130	-0.114	0.119	-0.289*	-0.039	0.260*	-0.228	-0.024	-0.100	0.018	-0.028	0.255*	0.230	-0.083	0.127
	G				0.095	0.090	-0.152	0.045	-0.520**	-0.051	0.328**	-0.362**	-0.005	-0.111	0.011	-0.026	0.316**	0.294*	-0.166	0.186
NPP	P					0.519**	0.104	0.145	0.035	0.064	0.206	0.043	0.159	-0.217	0.311**	-0.279*	0.001	-0.392**	-0.533**	-0.558**
	G					0.541**	0.142	0.125	0.035	0.098	0.183	0.069	0.188	-0.222	0.325**	-0.282*	0.064	-0.354**	-0.523**	-0.526**

MPP	**P**						-0.134	0.423**	-0.186	-0.310**	0.285*	0.066	0.337**	-0.209	0.227	-0.266*	-0.009	-0.181	-0.494**	-0.333**
	G						-0.219	0.480**	-0.319**	-0.368**	0.378**	0.138	0.524**	-0.272*	0.319**	-0.385**	-0.014	-0.164	-0.544**	-0.357**
DTM	**P**							-0.243*	0.203	0.265*	0.144	-0.154	-0.099	-0.151	0.045	0.057	-0.088	-0.081	-0.041	-0.13
	G							-0.267*	0.143	0.364**	0.070	-0.155	0.004	-0.250*	-0.026	0.075	-0.077	-0.084	-0.090	-0.122
PH	**P**								-0.294*	-0.315**	0.204	-0.051	0.208	-0.349**	0.173	-0.348**	0.281*	0.179	-0.338**	0.123
	G								-0.501**	-0.308**	0.199	-0.094	0.324**	-0.405**	0.201	-0.440**	0.347**	0.227	-0.372**	0.191
PBPP	**P**									0.415**	-0.313**	0.187	-0.195	0.175	-0.016	0.103	-0.069	-0.193	0.004	-0.065
	G									0.666**	-0.703**	0.300*	-0.311**	0.454**	-0.307**	0.256*	-0.015	-0.305**	0.039	-0.036
SCBP	**P**										-0.272*	0.021	-0.279*	0.047	-0.157	-0.034	-0.200	-0.281*	0.020	-0.185
	G										-0.299*	0.027	-0.389**	0.076	-0.206	-0.019	-0.275*	-0.376**	-0.014	-0.271*
SP	**P**											-0.191	0.199	-0.110	0.185	-0.098	0.070	0.354**	-0.123	-0.076
	G											-0.29	0.377**	-0.06	0.231	-0.05	0.159	0.447**	-0.12	0.005

												8*		5		1			4	
OC	**P**												-0.274*	-0.136	-0.224	-0.223	-0.175	-0.229	-0.103	-0.193
	G												-0.117	-0.296*	-0.227	-0.149	-0.249*	-0.144	-0.192	-0.344**
R-80	**P**													0.292*	0.729**	0.284*	-0.009	0.017	0.061	-0.053
	G													0.373**	0.937**	0.385**	0.027	0.064	0.101	-0.06
R-90	**P**														0.285*	0.926**	-0.17	-0.020	0.369**	0.046
	G														0.371**	0.955**	-0.221	-0.042	0.505**	0.009
L-80	**P**															0.327**	0.006	-0.040	0.084	-0.115
	G															0.402**	0.039	0.003	0.188	-0.091
L-90	**P**																-0.151	0.033	-0.468**	0.104
	G																-0.212	0.016	-0.607**	0.065
PYPP	**P**																	0.800**	-0.004	0.800**
	G																	0.806**	-0.03	0.797**

																			2	
KY	**P**																		0.282*	0.873**
	G																		0.267*	0.872**
HY	**P**																			0.372**
	G																			0.362**

DFF-Days to 50% flowering; **HSW:** Hundred seed weight; **PL:** pod length; **SMK**: Sound mature kernels; **NPP:** number of pods per plant; **MPP:** mature pods per plant; **DTM**: Days to maturity; **PH**: plant height (cm); **PBPP:** primary branches per plant; **SBPP:** secondary branches per plant; **SP:** shelling percentage; **KY:** kernel yield (kg/ha); **HY:** Haulm yield (kg/ha); **PY:** Pod yield (kg/ha); **PYPP:** pod yield per plant; **LLS-80** :late leaf spot 80 days after sowing ; **R-80**: rust 80 days after sowing; **L-90**: late leaf spot 80 days after sowing ; **R-90**: rust 80 days after sowing; **LLS-80** :late leaf spot 80 days after sowing ; **R-80**: rust 80 days after sowing; **L-90**: late leaf spot 80 days after sowing ; **R-90**: rust 80 days after sowing.

Table 7: Correlation for quality traits of confectionery groundnut genotypes

Traits		**OC**	**PC**	**OLAC**	**LN AC**	**PLAC**	**STAC**	**O/L**
BLA	**P**	-0.012	0.216	-0.187	0.009	-0.039	0.376**	-0.026
	G	-0.022	0.352**	-0.21	0.01	-0.094	0.591**	-0.027
OC	**P**		-0.357**	-0.248*	0.439**	0.305**	-0.148	-0.401**
	G		-0.702**	-0.326**	0.556**	0.567**	-0.327**	-0.499**
PC	**P**			0.317**	-0.374**	-0.456**	0.510**	0.352**
	G			0.337**	-0.495**	-0.677**	0.872**	0.483**
OLAC	**P**				-0.681**	-0.778**	0.033	0.811**
	G				-0.646**	-0.908**	0.051	0.810**
LN AC	**P**					0.786**	-0.114	-0.950**
	G					0.929**	-0.202	-0.956**
PLAC	**P**						-0.199	-0.815**
	G						-0.366**	-1.013**
STAC	**P**							0.072
	G							0.132

BLA: Blanchability; **OC:** Oil content; **PC:** Protein content; **OLAC:** Oleic acid; **LNAC**: Linoleic acid; **PLAC:** Palmitic acid; **STAC:** Stearic acid; **O/L:** oleic acid/linoleic acid.

Table 8: Path analysis of confectionery groundnut genotypes for yield attributing traits with disease resistance

Traits		DFF	HSW	PL	SMK	NPP	MPP	DTM	PH	PBPP	SCBP	SP	OC	R-80	R-90	L-80	L-90	PYPP	KY	HY	PY
DFF	**G**	**0.504**	-0.253	0.022	-0.194	0.063	-0.102	0.430	-0.165	0.293	0.217	-0.077	0.085	-0.116	0.054	-0.038	-0.011	-0.226	-0.242	-0.116	-0.443**
	P	**-0.023**	0.010	0.003	0.007	-0.001	0.004	-0.013	0.006	-0.005	-0.007	0.001	-0.003	0.003	-0.003	0.002	-0.002	0.008	0.008	0.001	-0.326**
HSW	**G**	-0.678	**1.350**	0.699	0.835	0.260	0.716	-0.216	0.437	-0.774	-0.271	0.313	-0.505	0.506	-0.407	0.263	-0.367	0.610	0.454	0.506	0.232*
	P	0.028	**-0.063**	-0.022	-0.029	-0.012	-0.026	0.009	-0.016	0.021	0.001	-0.012	0.019	-0.019	0.016	-0.010	0.014	-0.025	-0.018	0.012	0.180
PL	**G**	-0.042	-0.501	-0.968	-0.436	-0.150	-0.338	-0.092	-0.003	0.816	0.182	-0.007	0.456	-0.166	-0.139	0.025	-0.144	0.151	0.238	0.163	-0.166
	P	-0.002	0.006	**0.017**	0.006	0.003	0.003	0.002	0.000	-0.004	-0.002	0.000	-0.005	0.003	0.001	0.002	0.001	-0.002	-0.003	-0.003	0.003
SMK	**G**	-0.246	0.396	0.288	**0.640**	0.061	0.058	-0.097	0.029	-0.333	-0.033	0.210	0.456	-0.003	-0.071	0.007	-0.017	0.202	0.188	-0.003	0.186
	P	-0.003	0.005	0.004	**0.004**	0.011	0.001	0.001	-0.001	0.001	0.000	0.003	-0.005	0.003	0.001	0.002	0.001	-0.002	-0.003	-0.003	-0.185

NPP	**G**	-0.240	-0.367	-0.295	-0.181	**-1.908**	-1.032	-0.270	-0.239	-0.067	-0.187	-0.350	-0.232	-0.358	0.423	-0.620	0.538	-0.122	0.676	-0.358	-0.526**
	P	-0.016	-0.064	-0.063	-0.063	**-0.041**	-0.326	-0.169	-0.034	-0.047	-0.021	-0.067	-0.002	0.000	-0.001	0.000	0.000	0.003	0.003	-0.002	0.127
MPP	**G**	0.304	-0.795	-0.523	-0.136	-0.811	**-1.500**	0.329	-0.719	0.478	0.552	-0.566	-0.132	-0.786	0.408	-0.478	0.577	0.022	0.246	-0.786	-0.357**
	P	-0.001	0.003	0.001	0.001	0.001	**0.004**	0.007	-0.001	0.003	-0.002	0.002	-0.014	-0.052	0.071	-0.101	0.091	0.000	0.128	0.170	-0.558**
DTM	**G**	-0.266	0.050	-0.030	0.047	-0.044	0.068	**-0.312**	0.083	-0.045	-0.113	-0.022	-0.207	-0.001	-0.078	0.008	-0.023	0.024	0.026	-0.001	-0.122
	P	0.010	0.003	0.002	0.002	-0.002	0.002	**-0.002**	0.018	-0.004	0.005	0.003	0.000	0.002	-0.001	0.002	-0.002	0.000	-0.001	-0.003	-0.333**
PH	**G**	0.113	-0.112	-0.001	-0.016	-0.043	-0.166	0.092	**-0.346**	0.173	0.107	-0.069	0.048	-0.112	0.140	-0.070	0.152	-0.120	-0.079	-0.112	0.191
	P	-0.008	0.008	-0.008	-0.008	0.004	0.005	0.014	**-0.008**	0.033	-0.010	0.007	-0.003	-0.002	0.003	0.001	0.001	-0.002	-0.001	0.000	-0.130
PBPP	**G**	0.024	-0.024	-0.035	-0.021	0.001	-0.013	0.006	-0.021	**0.041**	0.027	-0.029	0.033	-0.013	0.019	-0.013	0.011	-0.001	-0.013	-0.013	-0.036
	P	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**	-0.001	0.000	-0.002	0.007	-0.011	0.006	-0.011	0.009	0.006	-0.010	0.123
SCBP	**G**	-0.119	0.056	0.052	0.014	-0.027	0.102	-0.101	0.086	-0.185	**-0.278**	0.083	0.012	0.108	-0.021	0.057	0.005	0.076	0.105	0.108	-0.271*
	P	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.065
SP	**G**	-0.224	0.341	0.000	0.010	0.484	0.270	0.557	0.104	0.293	-1.037	**-0.410**	-0.008	0.556	-0.096	0.341	-0.075	0.234	0.659	-0.183	0.005
	P	0.009	-0.0	0.004	-0.0	-0.0	-0.0	-0.0	-0.0	0.045	0.039	**-0.0**	0.000	0.016	-0.0	0.014	-0.0	-0.05	0.017	-0.0	-0.18

			28		37	30	41	21	29			**29**			27		10	1		29	5
OC	**G**	0.210	-0.465	-0.585	-0.585	-0.450	0.086	0.171	-0.193	-0.117	0.373	0.034	**1.243**	-0.009	0.289	-0.060	0.161	-0.152	-0.257	-0.009	0.289
	P	-0.006	0.017	0.017	0.017	0.013	-0.002	-0.004	0.009	0.003	-0.001	0.011	-0.055	0.015	0.008	0.012	0.012	0.010	0.013	0.007	0.015
R-80	**G**	-0.215	0.349	0.159	-0.005	0.175	0.489	0.004	0.302	-0.289	-0.362	0.352	-0.321	**0.436**	-0.770	0.277	-0.807	0.417	0.439	0.436	-0.060
	P	-0.006	0.011	0.005	-0.001	0.006	0.012	-0.004	0.008	-0.007	-0.010	0.007	-0.010	**0.036**	0.011	0.026	0.010	0.000	0.001	0.004	-0.076
R-90	**G**	-0.080	0.226	-0.108	0.083	0.166	0.204	-0.188	0.303	-0.341	-0.057	0.049	0.088	0.932	**0.348**	0.873	0.359	0.025	0.059	0.932	0.009
	P	-0.004	0.008	-0.002	0.003	0.007	0.006	-0.005	0.011	-0.005	-0.001	0.003	0.004	-0.009	**-0.031**	-0.009	-0.028	0.005	0.001	-0.013	0.046
L-80	**G**	-0.004	0.010	-0.001	0.001	0.017	0.016	-0.001	0.010	-0.016	-0.011	0.012	-0.015	-0.280	-0.750	**-0.278**	-0.716	0.166	0.032	-0.280	-0.091
	P	0.003	-0.005	-0.005	-0.001	-0.010	-0.007	-0.001	-0.005	0.001	0.005	-0.006	0.007	-0.023	-0.009	**-0.032**	-0.010	0.000	0.001	-0.005	-0.115
L-90	**G**	-0.008	-0.098	0.054	-0.009	-0.102	-0.139	0.027	-0.159	0.093	-0.007	-0.018	-0.082	0.048	0.019	0.051	**0.021**	0.002	0.000	0.048	0.065
	P	0.002	-0.008	0.003	-0.001	-0.009	-0.009	0.002	-0.012	0.003	-0.001	-0.003	-0.008	0.010	0.031	0.011	**0.034**	-0.005	0.001	0.018	0.104
PYPP	**G**	-1.319	1.331	-0.458	0.932	0.189	-0.043	-0.227	1.023	-0.044	-0.810	0.467	-0.439	0.140	0.346	0.146	0.362	**-0.077**	0.006	0.140	0.797**
	P	-0.192	0.214	-0.048	0.138	0.000	-0.005	-0.048	0.152	-0.037	-0.108	0.038	-0.095	-0.005	-0.092	0.003	-0.082	**0.541**	0.433	-0.011	0.800**
KY	**G**	1.747	-1.223	0.894	-1.070	1.288	0.596	0.307	-0.825	1.110	1.369	-1.626	0.905	0.079	-0.650	0.114	-0.625	2.946	**2.376**	0.079	0.872**
	P	-	0.1	-	0.0	-	-	-	0.0	-	-	0.1	-	0.0	-	-	0.0	0.29	**0.3**	0.0	0.87

		0.128	01	0.071	83	0.142	0.066	0.029	65	0.070	0.102	28	0.083	06	0.007	0.014	12	0	**62**	98	3^{**}
HY	**G**	0.025	0.049	0.038	0.037	0.117	0.121	0.020	0.083	-0.009	0.003	0.028	0.032	-0.231	0.153	-0.011	-0.059	-2.933	-3.637	**-0.231**	0.362^{**}
	P	-0.003	-0.011	-0.010	-0.008	-0.031	-0.028	-0.001	-0.018	0.002	0.001	-0.007	-0.007	0.006	0.025	0.010	0.031	-0.001	0.016	0.059	0.372^{**}

DFF-Days to 50% flowering; **HSW:** Hundred seed weight; **PL:** Pod length; **SMK**: Sound mature kernels; **NPP:** Number of pods per plant; **MPP:** Mature pods per plant; **DTM**: Days to maturity; **PH**: Plant height (cm); **PBPP:** Primary branches per plant; **SBPP:** Secondary branches per plant; **SP:** Shelling percentage; OC: Oil content; **PYPP:** Pod yield per plant; **KY:** Kernel yield (kg/ha); **HY:** Haulm yield (kg/ha); **PY:** Pod yield (kg/ha); ; **LLS-80** :late leaf spot 80 days after sowing ; **R-80**: rust 80 days after sowing; **L-90**: late leaf spot 80 days after sowing ; **R-90**: rust 80 days after sowing; **LLS-80** :late leaf spot 80 days after sowing ; **R-80**: rust 80 days after sowing; **L-90**: late leaf spot 80 days after sowing ; **R-90**: rust 80 days after sowing.

Table 9: Path analysis of confectionery groundnut genotypes for quality traits with yield contributing trait

Traits		**BLA**	**OC**	**PC**	**OLAC**	**LN AC**	**PLAC**	**STAC**	**O/L**	**HSW**
BLA	**G**	**-0.989**	0.022	-0.349	0.207	-0.828	-0.834	0.363	0.792	0.102
	P	**-0.006**	0.000	-0.001	0.001	0.000	0.000	-0.002	0.000	0.105
OC	**G**	-0.028	**1.243**	-0.873	-0.406	-0.010	0.093	-0.585	0.026	-0.374^{**}
	P	0.005	**-0.008**	0.022	0.007	-0.008	-0.010	0.011	0.008	-0.302**
PC	**G**	0.158	-0.315	**0.448**	0.151	0.691	0.704	-0.406	-0.620	0.296^{*}
	P	-0.012	-0.016	**0.020**	0.063	-0.043	-0.049	0.002	0.051	0.186
OLAC	**G**	0.420	0.653	-0.675	**-2.002**	-0.222	-0.304	0.391	0.217	0.533^{**}
	P	-0.001	-0.024	0.021	**0.038**	-0.055	-0.044	0.006	0.053	0.435**
LN AC	**G**	0.013	0.706	-0.628	-0.820	**1.293**	1.817	-0.102	-1.620	-0.335^{**}
	P	-0.001	0.005	-0.007	-0.012	**0.012**	0.016	-0.003	-0.013	-0.264*
PLAC	**G**	0.087	-0.523	0.624	0.837	1.269	**1.178**	-0.256	-1.213	-0.530^{**}
	P	-0.023	0.009	-0.031	-0.002	0.007	**0.012**	-0.062	-0.004	-0.361**
STAC	**G**	0.639	-0.353	0.942	0.055	-0.856	-0.922	**0.338**	0.934	0.054
	P	0.004	0.069	-0.060	-0.139	0.162	0.139	**-0.012**	-0.171	-0.011
O/L	**G**	-0.048	-0.905	0.878	1.470	-0.218	-0.395	1.080	**0.142**	0.454^{**}
	P	0.005	-0.008	0.022	0.007	-0.008	-0.010	0.011	**0.008**	0.357**

BLA: Blanchability; **OC:** Oil content; **PC:** Protein content; **OLAC:** Oleic acid; **LNAC**: Linoleic acid; **PLAC:** Palmitic acid; **STAC:** Stearic acid; **O/L:** oleic acid/linoleic acid; **HSW:** Hundred seed weight.

yield, followed by seed weight, oil content, and sound mature kernel. As a result, direct selection for these characteristics would be effective. The path analysis of quality traits showed that oil content, protein content and O/L ratio have highest direct effect on hundred seed weight at genotypic level.Hence these characters can be considered as criteria for selection as direct selection for these traits would be effective (Table 9).

Conclusion

Confectionery groundnut of the highest edible grade is in high demand all around the world. The goal of breeding programmes around the world is to develop new varieties that meet the needs of growers, processors, and consumers; however, exclusive breeding efforts to develop confectionary groundnut genotypes are very limited due to their negative association with low shelling outturn, lower percentage of sound mature kernels, prolonged maturity, and fresh seed dormancy. As a result, it is critical to access the genetic diversity of groundnuts for confectionery kinds with adequate physical and chemical attributes in order to establish a cultivar that meets not only domestic needs but also the export market. In the present investigation helped in identifying the promising lines with better sound mature kernels with minimum oil content and high protein and O/L ratio.

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