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EVALUATION OF GROUNDNUT GENOTYPES FOR CONFECTIONERY QUALITY CHARACTERS INCLUDING AFLATOXIN RESISTANCE

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ABSTRACT

Fifty-four groundnut genotypes were evaluated for ten morphological and biochemical characters related to quality. For morphological characters like high kernel yield, high shelling percentage, high 100 seed weight, desirable testa colour and elongated shape, the genotype, TPT 4 along with ICGV 86584, TG 40, M 13 and ICG 7633 were adjudged as the best genotypes. Whereas, TPT 4 along with TCGS 584, ICG 1326 and ICG 3643 were identified as superior genotypes for biochemical characters like low aflatoxin content, low oil percentage, high protein and high non-reducing sugar content. Though combination of kernel yield with quality was difficult to find, in view of the relative desirability of quality characters vis-à-vis kernel yield the genotypes; TPT 4, M 13 and ICGV 86564 were identified as the best genotypes suitable for cultivation and trading as HPS varieties.

KEYWORDS: Groundnut, quality, morphological, biochemical characters

INTRODUCTION

It is predicted that in a liberalized economy the cropping pattern will shift in favour of rice, wheat, chickpea, cotton etc. and crops like groundnut face declension in their area expansion (Gulati and Sharma, 1997). It has to be accepted that crop scientists have failed to suggest an alternate crop to the dry land farmer who cannot dispense the cultivation of groundnut even in the near future. As there is no other alternative to groundnut in these areas, breeding for its improvement still shows promise. The liberalization promotes global trade, which warrants the production of quality produce. Though Indian groundnuts are price-competitive, they may not get access to markets of developed countries for non-compliance with the health and safety standards. The quality requirements for groundnut in the world food market are rather rigid and exacting. Natural Resources Institute of the U.K. Ministry for overseas development listed many quality requirements for groundnut pods and kernel and the over-riding consideration with regard to quality is without doubt freedom from aflatoxin. Aflatoxin, a toxic metabolite, contamination is of major concern in confectionary groundnuts. Aflatoxins are now known to be hepatotoxic, carcinogenic and teratogenic (Mehan *et al*., 1991). AFB_1 is the most common and also the most toxic aflatoxin produced by *Aspergillus flavus* and *Aspergillus parasiticum* (Dube, 1990). Semi-arid tropics, of the developing countries from which most of groundnut produce is coming, are considered to be high-risk areas for aflatoxin contamination and India is no exception. Around 50 countries impose aflatoxin regulations and most countries have a separate maximum acceptable level for food and feed (Van Egmond, 1989). The changed scenario adds yet another objective of breeding for quality produce, which includes resistance to aflatoxin content also. Hence, a thorough search in the germplasm and its characterization is essential to pick up the genotypes for breeding for quality improvement in groundnut.

MATERIAL AND METHODS

Fifty-four genotypes were grown in a randomized block design (RBD) with three replications in post rainy season. Each genotype was grown in two rows of 4.5 m length with a spacing of 45 cm between rows and 15 cm between plant to plant in a row. The experimental plot was supplied with fertilizers at the rate of 30 kg N, 60 kg P_2O_5 and 45 kg K_2O per hectare. The crop was provided with irrigation at suitable intervals but was withheld between 80 and 100 days after sowing when the crop was experiencing moisture stress. Necessary plant protection measures were taken during crop growth period on the plant but not as soil application. Five random plants from each genotype per replication were used to record data on morphological and biochemical characters.

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The virulent strain of the pathogen (*Aspergillus flavus)* made available by the Department of Plant Pathology, RARS, Tirupati was considered to be aggressive and toxigenic strain. The mass multiplied inoculum of *A. flavus* was applied at 45 days after sowing by opening a furrow on a side of the plant row. As a matter of fact the fungus was mass multiplied by organic-matrix method as per the modified procedure given by Will *et al*. (1994). The cracked pearl millet seeds treated with *A. flavus* inoculum were applied at the rate of 2.5 g per one-meter length of the crop to facilitate the infection of the pathogen to the crop. Care was taken to keep the soil wet at the time of application of the fungus. After harvest, the pods were shade dried for seven days and stored in a galvanized iron container. Aflatoxin content in groundnut kernels produced by *A. flavus* was estimated after one month of storage by indirect competitive Enzyme Linked Immunosorbent Assay (ELISA) as per the procedure given by Reddy *et al*. (1988).

Shape of kernels, an important quality parameter was recorded as per the scale (1-5) suggested by Misra *et al*. (2000). An elongated shape was considered the best and was accordingly given a rating of 1 while round (spherical shape) was assigned the lowest rating. Seed size uniformity is a quality character and was measured as per the scale (1-10) provided by Misra *et al*. (2000). A rating of 1 was assigned to the genotype, which gave the maximum uniformity in size of kernels and a rating of 10 to that which showed maximum variation in size, i.e., a mixture of small-medium-large kernels. The colour code for testa was assigned to the genotypes by visually comparing the colour of testa with those given by Nigam *et al*. (2004). Pink to light brown testa colours were considered desirable (Nigam *et al*., 1989) and were given a rating of 1, where as dark red to purple as undesirable and were assigned a rating of 10. Oil in the seed was estimated with the help of NMR (Nuclear Magnetic Resonance, Model New Port Analyser, Oxford Analytical Instruments, England) analyzer. The genotypes with low oil percentage were assigned the highest score. The method of Lowry *et al*. (1951) was adopted for estimating protein content with Folin-Ciacalteu reagent. Non-reducing sugars, which include sucrose, were extracted from alcohol and estimated by the method of Nelson (1944).

RESULTS AND DISCUSSION

Besides high yield, the kernels of confectionary types should possess good morpho-biochemical characters. Higher values for 100 seed weight, kernels with elongated shape, tapering ends, and pink to light brown testa colours were considered desirable by Nigam *et al*. (1989). Misra *et al*. (2000) opined that high uniformity in kernel size, low oil, high protein and high sucrose contents were desirable to assess the export worthiness of hand picked and selected (HPS) genotypes. They also reported that tapering ends of kernels for easy blanching, low oil for better health, higher protein for more nutritional food value, sucrose (non-reducing sugar) from organoleptic point of view, were the most desirable attributes to the end user of confectionery groundnuts. As per the recommendations of Natural Resources Institute of UK Ministry for Overseas Development (Chandrasekhar, 1991) freedom from aflatoxin (< 5 ppb) was considered as the overriding principle in deciding the quality in groundnut.

With this back ground a comprehensive evaluation of genotypes for their net handpicked and selected worth with an integrated evaluation of morphological and biochemical characters were carried out. For this evaluation each genotype was ranked according to numerical value and desirability of the character. Among the morphological characters, high kernel yield, high shelling percentage, high 100-seed weight, maximum uniformity in seed size, light pink or light brown colour testa and elongated shape of kernels with tapering ends were considered desirable characters while among the biochemical characters, low aflatoxin content, low oil percentage, high protein content, and high non-reducing sugar content were considered desirable and accordingly the ranks were assigned (Table 1 and 2).

The genotype, TPT 4 with a rank total of 42 was adjudged the best for morphological characters. Furthermore, its kernel yield was the highest among the 54 genotypes tested. With a rank total of 43, the genotype ICGV 86584 ranked second. Next in order were TG 40, M 13, and ICG 7633 with rank totals of 50, 57 and 59, respectively. The genotype, M 13 recorded the second highest kernel yield per plant. Among the best five, except TG 40 all the genotypes recorded significantly higher kernel weight. Kernel weight was significantly higher in all the best five genotypes evaluated for morphological characters related to quality except TG 40 whose kernel weight was higher than mean but not significant. The best 18 (1/3 proportion of total genotypes) genotypes were superior for both kernel weight and the rest of the morphological characters related to quality.

Table 1. Mean values and ranks for morphological quality characters in groundnut

S. No.	Genotypes	Kernel weight per plant		Shelling percentage		100-seed weight		Seed size uniformity score	Testa colour score	Shape of kernel score	Rank total for morphological characters
		(g)	rank	(%)	rank	(g)	rank				
1	**ICG 50**	12.03	21	67.69	22	33.56	34	1	7	2	87
2	**ICG 1326**	10.93	35	70.49	9	34.49	30	1	1	4	80
3	**ICG 1416**	9.03	50	68.39	17	34.10	32	2	8	4	113
4	**ICG 2184**	8.83	51	68.50	16	27.60	54	2	1	5	129
5	**ICG 2411**	10.63	42	71.22	5	31.09	46	3	1	4	101
6	**ICG 3245**	10.00	48	70.73	7	29.21	51	4	1	4	115
7	**ICG 3509**	10.33	44	65.58	33	36.33	27	1	8	4	117
8	**ICG 3542**	13.74	10	72.68	1	31.29	45	2	1	4	63
9	**ICG 3643**	10.11	46	68.66	15	28.03	53	1	1	4	120
10	**ICG 4749**	10.69	41	70.25	11	31.51	44	2	1	4	103
11	**ICG 4893**	12.47	17	72.11	2	32.15	40	1	1	5	66
12	**ICG 5502**	10.38	43	57.84	52	32.96	39	5	10	3	152
13	**ICG 6690**	7.78	54	60.99	47	30.27	48	3	8	3	163
14	**ICG 7332**	11.26	26	65.72	32	47.00	17	2	10	4	91
15	**ICG 7633**	14.24	8	70.83	6	32.03	41	1	1	2	59
16	**ICG 7637**	10.72	40	61.21	45	36.71	26	7	3	3	124
17	**ICG 7749**	10.97	33	63.95	38	40.74	23	6	3	3	106
18	**ICG 8325**	10.07	47	59.72	49	66.75	1	9	4	1	111
19	**ICG 8666**	11.08	30	62.85	39	33.22	37	2	3	4	115
20	**ICG 10352**	10.31	45	71.36	4	29.29	50	1	1	5	106
21	**ICG 11386**	13.83	9	59.60	50	47.59	16	2	2	3	82
22	**ICG 13938**	11.71	24	67.47	24	30.65	47	1	1	5	102
23	**ICGV 86031**	10.94	34	61.60	44	43.53	19	4	4	3	108
24	**ICGV 86552**	12.28	20	65.53	34	33.36	35	3	1	4	97
25	**ICGV 86564**	14.99	4	60.39	48	55.61	5	4	2	1	64
26	**ICGV 86584**	14.83	5	71.54	3	40.59	24	5	2	4	43
27	**ICGV 88448**	11.33	25	68.95	13	28.89	52	3	1	4	98
28	**ICGV 89214**	15.13	3	55.27	54	51.26	11	7	3	1	79
29	**ICGV 96234**	12.32	19	70.39	10	33.23	36	3	2	3	73
30	**ICGV 96235**	11.09	29	61.71	43	48.33	15	8	2	3	100
31	**ICGS11**	13.08	14	67.03	27	38.81	25	2	1	4	73
32	**ICGS 21**	11.25	27	64.28	37	33.83	33	3	2	3	105
33	**BAU13**	11.06	31	56.34	53	66.29	2	9	8	2	105
34	**TG 39**	10.86	36	65.99	31	52.17	10	5	2	2	86
35	**TG 40**	13.11	12	67.97	21	49.83	12	3	1	1	50
36	**TG 41**	10.75	39	67.38	25	49.76	13	6	2	3	88
37	**TG 42**	11.78	23	66.80	29	63.87	3	4	1	2	62
38	**TG 45**	9.58	49	67.54	23	53.01	8	5	1	2	88
39	**TG 49**	10.79	38	62.64	41	52.97	9	4	1	2	95
40	**M13**	15.16	2	65.08	35	53.26	7	9	2	2	57
41	**JL 24**	12.38	18	66.86	28	35.21	29	1	1	4	81
42	**K 134**	11.22	28	70.56	8	29.48	49	1	1	3	90
43	**TPT 1**	12.81	16	68.11	20	34.48	31	1	1	4	73
44	**TPT 2**	10.82	37	68.36	19	35.55	28	1	1	4	90
45	**TPT 4**	15.23	1	69.43	12	41.11	22	2	1	4	42
46	**TCGS 29**	14.45	6	67.11	26	42.89	20	1	8	4	65
47	**TCGS 61**	14.29	7	59.29	51	54.29	6	4	2	2	72
48	**TCGS 91**	10.97	32	68.89	14	31.77	42	3	1	4	96
49	**TCGS 320**	13.10	13	68.37	18	31.54	43	2	9	3	88
50	**TCGS 407**	7.91	53	64.37	36	33.01	38	3	9	4	143
51	**TCGS 584**	8.68	52	66.79	30	46.78	18	2	2	4	108
52	**TCGS 596**	12.83	15	62.59	42	49.23	14	7	3	3	84
53	**TCGS 617**	13.59	11	62.84	40	58.85	4	8	1	1	65
54	**TCGS 634**	11.81	22	61.07	46	42.11	21	1	2	5	97

Table 2. Means and ranks for biochemical quality characters with overall ranking

S. No.	Genotypes	Aflatoxin content		Oil percentage		Protein content		Non-reducing sugar content		Rank total for biochemical characters	Combined rank total
		(ppb kg^{-1})	rank	(%)	rank	(mg g^{-1})	rank	(mg g^{-1})	rank		
1	**ICG 50**	88.33	50	51.97	32	179.92	44	10.80	31	157	244
2	**ICG 1326**	2.83	1	52.13	34	210.90	23	26.65	9	67	147
3	**ICG 1416**	34.00	43	50.70	16	247.72	1	4.37	46	106	219
4	**ICG 2184**	4.00	11	51.83	29	195.90	32	14.01	23	95	224
5	**ICG 2411**	4.83	14	52.77	42	212.99	22	25.27	10	88	189
6	**ICG 3245**	3.67	9	50.33	13	180.53	42	24.81	12	76	191
7	**ICG 3509**	75.50	48	49.73	7	238.61	4	21.82	14	73	190
8	**ICG 3542**	78.33	49	50.73	17	173.12	49	30.10	6	121	184
9	**ICG 3643**	8.83	22	50.17	11	235.76	8	12.18	30	71	191
10	**ICG 4749**	4.00	10	53.43	46	236.33	7	17.69	18	81	184
11	**ICG 4893**	5.00	17	53.90	50	220.96	16	12.41	29	112	178
12	**ICG 5502**	600.00	53	48.77	3	205.58	27	8.96	38	121	273
13	**ICG 6690**	21.67	38	49.90	8	178.82	46	10.57	32	124	287
14	**ICG 7332**	65.00	46	50.60	15	232.35	11	13.09	25	97	188
15	**ICG 7633**	12.00	30	52.23	36	194.76	35	38.59	4	105	164
16	**ICG 7637**	35.83	44	53.13	43	219.82	17	67.54	1	105	229
17	**ICG 7749**	20.00	35	50.37	14	206.72	25	27.57	8	82	188
18	**ICG 8325**	96.67	51	52.50	39	192.49	37	16.08	20	147	258
19	**ICG 8666**	3.67	8	51.47	23	190.21	39	2.76	53	123	238
20	**ICG 10352**	5.00	16	52.43	38	224.94	14	12.86	27	95	201
21	**ICG 11386**	12.00	29	53.53	47	230.07	12	5.97	44	132	214
22	**ICG 13938**	10.00	27	51.03	19	178.25	47	29.63	7	100	202
23	**ICGV 86031**	9.67	26	53.63	48	206.15	26	13.09	24	124	232
24	**ICGV 86552**	6.17	19	52.00	33	165.15	53	15.62	22	127	224
25	**ICGV 86564**	17.67	32	49.93	9	193.62	36	42.96	3	80	144
26	**ICGV 86584**	19.33	34	53.20	44	238.61	5	12.63	28	111	154
27	**ICGV 88448**	3.67	7	51.53	24	191.34	38	7.81	41	110	208
28	**ICGV 89214**	69.00	47	48.60	2	162.30	54	19.07	16	119	198
29	**ICGV 96234**	9.67	25	51.87	30	195.90	31	2.30	54	140	213
30	**ICGV 96235**	7.17	21	51.03	18	185.65	41	3.91	49	129	229
31	**ICGS11**	6.33	20	51.63	28	179.96	43	8.73	40	131	204
32	**ICGS 21**	269.67	52	52.23	35	206.72	24	16.77	19	130	235
33	**BAU13**	33.33	42	50.17	10	167.43	52	8.73	39	143	248
34	**TG 39**	5.67	18	52.63	41	233.49	9	4.37	45	113	199
35	**TG 40**	4.50	13	51.20	21	194.76	34	3.22	52	120	170
36	**TG 41**	9.67	24	54.40	53	239.75	3	3.45	50	130	218
37	**TG 42**	20.83	36	51.07	20	171.98	50	4.14	48	154	216
38	**TG 45**	3.67	6	54.00	51	216.97	20	9.19	35	112	200
39	**TG 49**	3.67	5	51.33	22	194.76	33	22.97	13	73	168
40	**M13**	3.67	4	51.63	27	215.83	21	15.62	21	73	130
41	**JL 24**	4.50	12	51.93	31	218.11	19	19.30	15	77	158
42	**K 134**	3.67	3	51.60	26	203.88	28	6.20	43	100	190
43	**TPT 1**	28.33	40	48.53	1	246.01	2	18.84	17	60	133
44	**TPT 2**	11.00	28	50.20	12	189.64	40	9.65	34	114	204
45	**TPT 4**	3.67	2	49.60	5	232.35	10	6.66	42	59	101
46	**TCGS 29**	50.33	45	49.30	4	178.82	45	12.86	26	120	185
47	**TCGS 61**	626.67	54	52.27	37	169.14	51	25.27	11	153	225
48	**TCGS 91**	25.83	39	51.60	25	203.30	29	45.95	2	95	191
49	**TCGS 320**	21.50	37	52.63	40	173.69	48	3.22	51	176	264
50	**TCGS 407**	9.25	23	56.47	54	219.25	18	4.14	47	142	285
51	**TCGS 584**	5.00	15	49.63	6	238.04	6	9.65	33	60	168
52	**TCGS 596**	30.50	41	54.27	52	197.61	30	8.96	37	160	244
53	**TCGS 617**	12.92	31	53.27	45	226.08	13	30.32	5	94	159
54	**TCGS 634**	18.67	33	53.80	49	224.37	15	8.96	36	133	230

For biochemical characters, TPT 4 with a rank total of 59 was identified as the best genotype. Its kernel weight was also the highest. It has recorded the second lowest aflatoxin content. The second best genotype, TPT 1 with a rank total of 60 recorded moderate kernel weight, which was at par with the average. Similarly, the genotype TCGS 584 stood third (60) but its kernel weight was inferior. However, both TPT 1 and TCGS 584 were susceptible to *A. flavus*. The genotypes, ICG 1326 and ICG 3643 ranked 4th and 5th respectively. Among these two genotypes, ICG 1326 has recorded the lowest aflatoxin content but their kernel weights were not significantly superior over mean. Hence TPT 4 was adjudged as the best genotype for biochemical characters related to quality. It was also observed that most of the high yielders were not superior for biochemical characters.

On the basis of a combined evaluation of genotypes for morpho-biochemical characters, the genotype, TPT 4 with a combined rank total of 101 and M 13 with 130 were identified as the I and II best genotypes respectively. Incidentally the former was the highest kernel yielder and the later also produced significantly higher kernel weight per plant. TPT 1 was identified as the third, ICGV 86564 the fourth and ICG 1326 as the fifth best genotypes with combined rank totals of 133, 144, and 147 respectively. However the kernel weight of ICG 1326 was low though resistant to aflatoxin production, that of TPT 1 was at par with mean but susceptible to aflatoxin production and that of ICGV 86564 was significantly superior over the average.

Thus a combination of kernel yield as well as superior quality characters was difficult to find. In view of the relative desirability of quality characters vis-à-vis kernel weight per plant, the genotypes TPT 4, M 13 and ICGV 86564 were identified for cultivation and trading as HPS varieties. The worthiness of M 13 (Varman and Senthil, 1998) and ICGV 86564 (Venkataravana *et al*., 2000) for many characters were also reported earlier. The best genotype that had recorded the lowest aflatoxin content was ICG 1326. The next best genotypes for aflatoxin resistance were TPT 4, K 134 and M 13. The other genotypes found superior for respective quality characters might be used in the breeding programs for gene pyramiding to produce genotypes with high yield and quality as well.

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