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Characterization of Groundnut (*Arachis hypogaea* L.) in Northern Ghana

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Abstract: In the present study twenty -three accessions of groundnuts collected from four ecological zones: Costal savanna zone (CSZ); of Grater Accra and Volta regions (10); Forest-Savanna Transition Zone (F-STZ) of Eastern region (9); Transitional Zone (TZ) of Ashanti (3) and the Guinea Savanna Zone (GSZ) of the Northern region (1) were characterized and evaluated in a three-replicated trial under field conditions during the 2003 season at Nyankpala lying in the Guinea savanna zone of Northern Ghana. Great variabilities were observed among the accessions for the quantitative traits studied. Significant positive relationship existed among plant spread, pod yield, grain yield, haulm yield, CGR, PGR, ρ and HI. Accessions from the TZ and F-STZ had the greatest plant height, plant spread, pod and grain yields and those from the CSZ were the least. There was a significant negative correlation between days to 50% flowering and the vegetative characters (except branches per plant) on one hand and pod and grain yield on the other hand. CGR, PGR, HI and ρ were the best or had the most discriminatory power for characterization and selection. Most productive genotypes do not necessary possess the most desirable traits for yield hence genotypes must be characterized for nodulation, confectionery status, oil and protein contents as well.

Key words: *Arachis hypogaea*, groundnuts, quantitative traits, physiological characters, characterization

INTRODUCTION

The cultivated groundnut (*Arachis hypogaea* L.) is an important grain legume in Ghana in terms of production and consumption. It is generally agreed to have originated from southern Bolivia-North West Argentina in the eastern foothills of the Andes in South America[1]. The Portuguese brought the crop to West Africa from Brazil in the 16th century[2].

Arachis hypogaea and one of its wild relatives, *A. monticola* Krapovickas and Rigoni, are the only known tetraploid species (2n =4x=40) in section *Arachis*, one of seven sections within the genus *Arachis* . The crop is now popular and successfully grown in all tropical and sub-tropical countries of the world as a result of its adaptability to a wide range of soil and climatic conditions (Latitude 40°N to 40°S).

It is thus adaptable to the varied biotic and abiotic factors resulting in the development of unique characteristics for survival in these ecological zones. These varied environmental and edaphic factors in the ecological zones would modify the landraces as well as the inherent allelic frequencies of desirable traits, which ensure genetic variability necessary for improvement[3,4]. Dependence of growth and development on the genotype and environmental conditions has been reported[5]. According to Debrah and Waliyar[6] 25.7 million tons are produced annually from 21 million hectares of land worldwide with Asia alone accounting for about 70% and Africa, 20% of this production.

In Ghana, groundnut is predominantly grown in the three northern regions which together account for over 85% of national output[7]. Replenishment of farmer's seed stock is rare due to cultural or economic reasons and thus landrace are still being cultivated.

Since collection of germplasm and the search for desirable cultivars are of utmost importance in practical crop breeding, there is, therefore, the need for full exploitation of these landraces by identify agronomic and physiological characters that correlate significantly to seed yield and to provide the basis for selection.

The present endeavor estimates the natural variation present in growth, yield and physiological traits among different cultvars collected from Ghana, identify characters contributing significantly to yield and select parents for hybridization aimed at improving seed yield.

MATERIALS AND METHODS

Nyankpala, the study site is located on latitude 9° 22′4″ N and longitude 0° 58′ 42″ W; 180 m above sea level. The ecological zone is characterized by erratic rainfall and poor soils. The topsoil has a coarse loamy structure and is locally referred to as Tingoli series, derived from sandstone or shale and falls into the

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Chromic Luvisol group (FAO classification). Organic matter content is generally low, usually less than 1%, cation exchange capacity between 3-4 $cmol_c$ kg^{-1}. Average N, P and K contents are 400, 2-3 and 60 ppm, respectively. The soils are generally acidic (pH of 5.5-6.0).

Twenty-three accessions of groundnuts were collected from May to June 2003 during exploration missions. They were registered as Savanna Agricultural Research Groundnut Varieties Collected in the year 2003 (SARGV 03). The ploughed and harrowed land was treated with 45 kg P_2O_5 ha^{-1} as single super phosphate before planting. Seeds of these genotypes were sown on 29 June 2003 in a randomized complete block design with three replications. The planting distance was 60x20 cm within row with plot length of 4 m, each plot having four rows of plants.

Galex, a pre-emergence weedicide was applied at 5l ha^{-1} soon after planting to delay first weeding. First weeding was mechanically done 6-7 weeks after planting. Harvesting was done at physiological maturity stage. Data were recorded from the two inner rows and on ten agro-morphological characters: days to 50% flowering, number of plants per plot, days to maturity, pod yield, grain yield, haulm yield, *cercospora* score on ICRISAT 1-9 point scale, hundred seed weight, number of pods per plant, number of pegs per plant, plant height, number of branches per plant, plant spread, leaf length and leaf width. Fertility co-efficient was computed by expressing the ratio of number of pods per plant to number of pegs per plant as a percentage.

Crop growth rate (C), pod growth rate (R) and the partition coefficient (ρ) were estimated for each of the plots of the experiment using the energy adjusted final biomass and energy adjusted reproductive yield, and the timing of flowering and maturity[8] Although growth is known to be a non-linear function it is possible to use a linear approximation over the whole crop life since this will maintain relative differences between treatments. The linear estimations for the growth rates were:

$$C = \frac{HWT + (PWT * 1.65)}{DM\ (t_2)}$$

$$R = \frac{(PWT * 1.65)}{(T_2 - T_1 - X)}$$

where HWT is the haulm weight, PWT is the pod weight, T_2 is the days to harvest, T_1 is the days to flowering, and X is the time between flowering and the expansion of the pods (at Nyankpala this interval was 10 days). Partition coefficient is the ratio of R to C. Harvest index was estimated as the ratio of PWT to (PWT + HWT). Analysis of variance was performed on agronomic, yield and physiological parameters using statistical analysis systems (SAS), version 8.

RESULTS AND DISCUSSION

With the exception of SARGV 0307, SARGV 0312, and SARGV 0319, which were of decumbent-3 growth habit and sequential in branching pattern, all the others were of decumbent-2 growth habit and irregular with flowers in branching pattern. These growth habits would affect their development, adaptation and compatibility in the farming systems[9]. Those with stem pigmentation were SARGV 0301, SARGV 0305, SARGV 0309, SARGV 0319, SARGV 0321 and SARGV 0323. Thus growth, yield and physiological characters displayed a wide range of variation and showed significant differences (p=0.01; except hundred seed weight) among genotypes (Table 1 and 2).

Branches per plant ranged from 10 in SARGV 0308 to 32 in SARGV 0319 with mean of 15.

Generally genotypes with high number of branches per plant had this translated into higher haulm production (Tables 1 and 2). Plant height ranged from 25 to 37 with mean of 35. Taller plants spread most according to the results and this implies each will have a relative advantage in the various farming systems in terms of weeding, erosion control and planting density. All the germplasm were broad leafed except SARGV 0312.

SARGV 0306, SARGV 0310, SARGV 0311, SARGV 0318, SARGV 0322, SARGV 0323 flowered exceptionally and significantly (p=0.01) earlier. Pegs per plant ranged from 28 to 46 with a mean of 39. Pods per plant also ranged from 17 to 30 with a mean of 24. Fertility coefficient, a measure of how fertile a genotype is in terms of seed production, on plant basis had a mean of 62 with a range of 52 to 78. Plant stand per plot (4.8 m^2) ranged from 9 to 48 with mean of 25. The number of plants that are able to survive biotic and abiotic stress till maturity determines the robustness of a genotype. It implies that SARGV 0301 was the most robust. This was not surprising since SARGV 0301 is a cultivar collected from the environs of Nyankpala (Table 1).

All the genotypes can be classified as early maturing since they all matured between 94 days and 103 days (Table 2). However, significant differences (p=0.01) existed among genotypes.

Four and nine genotypes out-yielded SARGV 0301, the adapted cultivar in terms of pod yield and grain yield, respectively. Six out of the nine genotypes produced grains significantly higher than SARGV 0301. Haulm yield ranged from 1598 kg ha^{-1} (SARGV 0309) to 3220 kg ha^{-1} (SARGV 0301) with mean of 2216 kg ha^{-1}.

Table 1: Variability in vegetative and reproductive structures of groundnuts tested in Guinea Savanna zone of Ghana

Genotype	B/ plant	Plant height*	Plant spread*	Leaf width*	Leaf length*	Dff	Pegs plant^{-1}	Pods plant^{-1}	Fert co.ef	Plants plot^{-1}
SARGV0301	15	35	78	3.5	6	26	39	24	62	48
SARGV0302	17	28	81	3.5	7	28	44	28	64	11
SARGV0303	15	31	71	3.5	6	28	45	29	64	15
SARGV0304	13	39	76	4.0	6	28	37	21	57	29
SARGV0305	12	31	67	3.8	6	27	45	28	62	19
SARGV0306	13	41	80	3.3	5	24	34	22	65	28
SARGV0307	12	35	77	3.5	6	28	35	24	69	32
SARGV0308	10	32	66	3.3	6	27	46	26	57	28
SARGV0309	14	34	80	3.5	6	28	39	27	69	9
SARGV0310	14	42	86	3.8	7	23	33	19	58	22
SARGV0311	13	34	78	3.5	6	24	32	20	63	32
SARGV0312	25	27	62	3.0	4	30	28	17	61	26
SARGV0313	18	33	75	3.3	6	27	37	29	78	29
SARGV0314	15	34	75	3.8	6	27	52	30	58	13
SARGV0315	14	35	78	4.0	7	26	35	23	66	26
SARGV0316	13	35	90	3.5	6	26	39	24	62	32
SARGV0317	12	33	91	3.3	7	27	42	28	67	28
SARGV0318	14	34	76	4.0	6	24	45	29	64	33
SARGV0319	32	25	55	3.3	5	33	40	21	53	22
SARGV0320	12	31	68	3.3	7	26	43	25	58	21
SARGV0321	13	40	97	4.0	8	25	38	23	61	28
SARGV0322	12	47	103	3.5	7	23	30	18	60	34
SARGV0323	11	42	93	3.3	6	23	35	24	69	42
Mean	15	35	78	3.5	6	26	39	24	62	25
Range	10-32	25-37	55-103	3.0-4.0	4-8	23-33	28-46	17-30	53-78	9-48
LSD@ 1%	7	6	17	0.74	1	1.2	11	7	16	8
CV %	30	12	13	13.2	12	3	19	21	13	22

* = All parameters measured in cm, B/plant= Branches per plant, Dff = Days to 50% flowering, Fert co.ef = Fertility coefficient

Table 2: Performance of 23 genotypes of groundnuts tested in Guinea savanna zone of Ghana

Genotype	Dtm	Pod yield*	Grain yield*	Haulm yield*	Hsw	Cs	CGR	PGR	ρ	HI
SARGV0301	103	1243	725	3220	48	2.10	51	31	0.61	0.28
SARGV0302	100	670	454	1785	38	1.72	29	18	0.62	0.27
SARGV0303	100	792	538	1733	37	1.87	30	21	0.70	0.31
SARGV0304	97	838	565	2468	35	1.87	40	24	0.60	0.25
SARGV0305	96	746	569	2022	37	1.87	34	21	0.88	0.27
SARGV0306	95	878	620	2394	36	1.87	41	28	0.68	0.27
SARGV0307	95	1000	725	2300	36	1.87	42	29	0.69	0.30
SARGV0308	94	956	681	1915	34	1.87	37	28	0.76	0.33
SARGV0309	98	292	207	1598	31	1.87	21	8	0.38	0.16
SARGV0310	97	737	519	1890	36	1.87	32	19	0.59	0.28
SARGV0311	99	1252	946	2625	39	1.80	47	32	0.68	0.32
SARGV0312	101	1061	740	2730	42	1.58	44	29	0.66	0.28
SARGV0313	102	1287	931	2442	42	1.87	45	33	0.73	0.35
SARGV0314	99	716	505	1943	40	1.87	32	19	0.59	0.27
SARGV0315	98	1180	852	2184	43	1.87	42	31	0.74	0.35
SARGV0316	97	1128	817	2153	36	1.87	41	31	0.76	0.34
SARGV0317	98	993	815	2127	34	1.87	38	27	0.71	0.32
SARGV0318	102	876	649	2006	36	1.80	34	21	0.88	0.30
SARGV0319	99	485	383	2709	34	1.73	36	14	0.39	0.15
SARGV0320	96	874	640	1943	34	1.87	35	24	0.69	0.31
SARGV0321	95	1222	907	2545	42	1.87	48	34	0.71	0.32
SARGV0322	95	1262	920	2657	36	1.87	50	34	0.68	0.32
SARGV0323	94	1306	1005	2598	37	1.87	51	35	0.69	0.33
Mean	98	935	681	2216	37	1.84	38	25	0.66	0.30
Range	94-103	292-1306	207-1005	1598-3220	31-48	1.58-2.1	21-51	8-35	0.38-0.88	0.15-0.35
LSD @ 1%	2.5	135	114	277	NS	0.11	2	1.1	0.01	0.01
CV %	1.8	21	25	19	15	4	15	22	17	19

*= All parameters measured in kg^{-1}, Dtm= Days to maturity, Hsw= Hundred seed weight, Cs= *Cercospora* score transformed by square root transformation $(n + 0.5)^{1/2}$, CGR= Crop growth rate, PGR= Pod growth rate, ρ= Partition coefficient, HI= Harvest index

Table 3: Pearson Correlation Coefficients of the traits studied

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1 Dff	1																			
2 Pltsplot-	0.32*	1																		
3 Dtmat	0.28-	0.17	1																	
4 Podyld	-0.33*	0.34	0.03	1																
5 Grainyld	-0.41*	0.60*	-0.04	0.47*	1															
6 Hlmyld	0.08	0.4*	-0.10	0.22	0.38	1														
7 Cercos	-0.39*	0.04	-0.45*	0.08	0.10	-0.13	1													
8 Hsw	-0.05	-0.04	0.09	0.08	0.42*	0.19	-0.11	1												
9 Pdsplt	0.02	-0.27	0.16	-0.09	0.01	-0.41*	0.21	0.04	1											
10 Pgsplt	0.10	-0.38*	0.09	-0.14	-0.16	-0.37*	0.20	-0.04	0.86*	1										
11 Pltht	-0.64*	0.34*	-0.48*	0.21	0.37*	0.07	0.58*	0.03	0.004	-0.05	1									
12 Bplt	0.58*	-0.10	0.40*	-0.29**	-0.23**	0.23*	-0.33*	-0.03	-0.06	-0.09	-0.35*	1								
13 Pltspd	-0.51*	0.28**	-0.27**	0.34*	0.30*	-0.03	0.31**	-0.05	0.00	-0.12	0.52*	-0.29*	1							
14 LL	-0.39*	-0.09	-0.21	0.13	0.05	-0.34*	0.33*	-0.07	0.09	0.10	0.21	-0.43*	0.33*	1						
15 LW	-0.23**	0.03	-0.03	-0.08	-0.14	-0.29**	0.03	-0.08	0.05	0.01	0.16	-0.22	0.17	0.39*	1					
16 Cgr	-0.17	0.47*	-0.15	0.78*	0.48*	0.75*	0.01	0.17	-0.31**	-0.30**	0.26**	-0.06	0.19	-0.20*	-0.23	1				
17 Pgr	-0.27**	0.32*	-0.06	0.99*	0.43*	0.21	0.10	0.07	-0.10	-0.15	0.21	-0.27	0.33*	0.10	-0.03	0.79*	1			
18 Part	-0.27**	0.05	-0.02	0.83*	0.19	-0.29**	0.17	-0.03	0.13	0.09	0.10	-0.38*	0.30**	0.35*	0.14	0.37*	0.84*	1		
19 Hi	-0.36*	0.09	-0.01	0.84*	0.24**	-0.29**	0.18	-0.02	0.14	0.10	0.16	-0.43*	0.34*	0.38*	0.14	0.37*	0.84*	0.99*	1	
20 Fertco	-0.11	0.12	0.15	0.06	0.26**	-0.13	0.07	0.19	0.42	-0.09	0.07	0.04	0.20	-0.04	0.10	-0.06	0.06	0.07	0.1	1

* and ** :Significant at 1 and 5%, respectively.

Dff= Days to 50% flowering, Pltsplot= plants per plot, Dtmat= days to maturity, Podyld= pod yield, Grainyld= grain yield, Hlmyld= haulm yield, Cercos= cercospora score, Hsw= hundred seed weight, Pdsplt= pods per plant, Pgsplt= pegs per plant, Pltht= plant height, Bplt= branches per plant, Pltspd= plant spread, LL= leaflet length, LW= leaflet width, Cgr= crop growth rate, Pgr= pod growth rate, Part= partition coefficient, Hi= harvest index, Fertco= fertility coefficient

Eight of the genotypes were promising since they combined high grain yield with good haulm yield.

Hundred seed weight ranged from 31g in SARGV 0309 to 48 g in SARGV 0301 with average of 37 g. No significant difference was observed among genotypes for this trait.

All the germplasm significantly out-performed SARGV 0301 in *Cercospora* score. CGR ranged from 21 in SARGV 0309 to 51 in SARGV 0301 and SARGV 0323 with mean of 38.

Partition coefficient values were encouraging ranging form 0.38 to 0.88 having an average of 0.66. The distribution of this data classifies 70% of the genotypes as high yielding[10] with ρ between 0.66 and 0.88. According to Williams and Sexana[8] the modeling approach has a number of advantages over the analysis of yield determination by harvest index because it introduces a measure of the extent of indeterminate growth (ρ), and evaluates the processes rather than final result of these. The exclusion of the adapted genotype, SARGV 0301 from this group provides some measure of confidence in the yield potentials of the assembled accessions.

Days to 50% flowering was significantly negatively related to plants per plot, pod yield, grain yield, *cercospra* score, plant height, plant spread, leaflet length, leaflet width, PGR, ρ, and HI (Table 3). This agreed with Bennett-Lartey *et al.*[11] and not Aboagye and Bennett-Lartey[12]. This could be attributable to all the genotypes being early maturing and determinate in growth.

However, 50% flowering correlated positively (p=0.01) with branches per plant. This corroborated the findings of Adams[13], implied as many branches that were produced had early profuse flowers. Number of plants per plot correlated significantly positively with grain yield, haulm yield, plant height, and plant spread, CGR and PGR. This is an indication of assemblage very good and promising materials. Though plant stand may increase to some extent, competition among plants will result in the production of more vegetative structures (superior CGR) combined with high PGR.

Days to maturity correlated significantly negatively with *Cercospora* score, plant height and plant spread since infected plants reacted by an advancement of ripening or premature ripening.

There were also significant positive relationships among pod yield, grain yield, haulm yield, plant spread, CGR, PGR, ρ and HI. Since the zone of characterization was different from the collection zones, the true potential of the germplsm may not yet be expressed.

Accessions studied were collected from the Costal Savanna Zones (CSZ), Transitional Zones (TZ), Forest Savanna Transitional Zones (FSTZ) and Guinea Savanna Zones (GSZ) and therefore might have developed traits adaptable to their respective areas. Genotypes differed with respect to growth, yield and physiology.

Generally the favorable conditions prevailing in the TZ and FSTZ would have given the accessions from these zones the tendency for continuous growth of vegetative components at the expense of reproductive structures resulting in lower yields. On the contrary accessions from these zones produced optimum vegetative structures and more assimilates were channeled to the reproductive structures and hence higher yields. Genotypes had considerable genetic variability as was observed in the traits studied but further evaluations and characterization are needed especially at the nodule, oil, protein and molecular levels to allow full exploitation and utilization of the groundnut germplasm.

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