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Genetic variability and heritability of agromorphological traits in groundnut (*Arachis hypogaea* L.): implications for varietal selection in Cameroon

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Abstract— *Groundnut (Arachis hypogaea L.) is a major food and cash crop for family farms in the Sudano-Guinean Zone of Cameroon, grown on about 400 000 hectares, yet yields remain below genetic potential due to the use of varieties poorly adapted to local water constraints. This study assessed, over three growing seasons (2019-2021) in a randomized complete block design, the agromorphological variability and broad-sense heritability of ten traits in thirteen ICRISAT genotypes, aiming to identify material of direct value to farmers. Analysis of variance revealed highly significant differences among genotypes for all traits ($p<0.05$). Germination rate ranged from 80 to 100%, and maturation time from 90 to 95 days after sowing. Genotype ICG1439 showed the highest leaf area (31.09 cm²) and seed number (30.5 seeds/plant). Broad-sense heritability ranged from 0.21 (leaf number) to 0.69 (stem height), with high values in ICG3365, ICG1471 and ICG3750 (0.85-0.78 and 0.79, respectively) for stem height. Five genotypes (ICG1439, ICG3365, ICG1471, ICG3621, ICG1988) combined high performance and heritability, providing a concrete basis for dissemination to farmers and for groundnut breeding programs in Cameroon.*

Keywords— ***Arachis hypogaea, agromorphological variability, heritability, varietal selection, Cameroon.***

I. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the main oilseed crops of tropical regions. In Cameroon, it plays a central role in food security and rural household income, particularly in the Sudano-Guinean Zone, a production basin favourable to this crop [9]. From a socio-economic position, groundnut is cultivated on about 400 000 hectares in Cameroon and mobilizes a predominantly female workforce, both for field operations and post-harvest processing. It constitutes both a source of protein for household consumption and a cash crop generating direct monetary income. Any varietal improvement benefiting this crop therefore has concrete repercussions on the food security and income of family farms in the region.

Despite this importance, observed yields remain below expectations, owing to the use of varieties poorly adapted to local water and photoperiodic constraints. Several studies have shown substantial genetic diversity within *Arachis hypogaea* [2], and estimating the heritability of agromorphological traits makes it possible to assess the proportion of genetic variability transmissible to progeny, thereby guiding selection strategies[5] ; [10] .

This study aims to evaluate the agromorphological variability of thirteen groundnut genotypes grown in the Sudano-Guinean Zone of Cameroon, to estimate the broad-sense heritability of the main traits, and to identify the genotypes most favourable for direct use by farmers or as parents in varietal improvement programmes.

II. MATERIALS AND METHODS

2.1. Study site and plant material

The study was conducted in the Sudano-Guinean Zone of Cameroon (Figure 1) from 2019 to 2021, at a site characterized by a short dry season (November-March), a rainy season (April-December, with peaks in August-September), an annual rainfall of 1 539 mm, a mean temperature of 22°C, and clay-loam soils (pH 6.2-6.8) [6] . The plant material consisted of thirteen groundnut genotypes supplied by ICRISAT, originating from nine countries (India, Brazil, Argentina, USA, Bolivia, Indonesia, West Africa), with erect, semi-erect or flat growth habit, and a cycle of 79 to 110 days according to the ICRISAT variety descriptor.

2.2. Experimental design

The trial was laid out in a randomized complete block design with three replications (13 genotypes × 3 blocks = 39 elementary plots of 6 m², approximately 350 m² including pathways). Cultural practices (tilling, manual sowing at one seed per hole, weeding, earthing-up at flowering) were applied uniformly, under rainfed conditions, without irrigation or chemical treatment.

2.3. Measured parameters and statistical analysis

Ten agromorphological parameters were observed at regular intervals (30 to 90 days after sowing, DAS): germination date and rate, stem height, number of leaves and stems, leaf area [11] ; [12] , flowering dates, number of seeds per plant [13] , and maturation time.

Data were subjected to analysis of variance (ANOVA, model $Yij = \mu + Gi + Bj + \varepsilon ij$) using STATGRAPHICS Plus v 5.0, with mean separation by Duncan's test (5%). Broad-sense heritability (h^2) was calculated according to [1]: $h^2 = \sigma^2 g / (\sigma^2 g + \sigma^2 e)$. Values of $h^2 > 0.60$ indicate potentially effective selection, and values of $h^2 < 0.40$ a strong environmental influence.

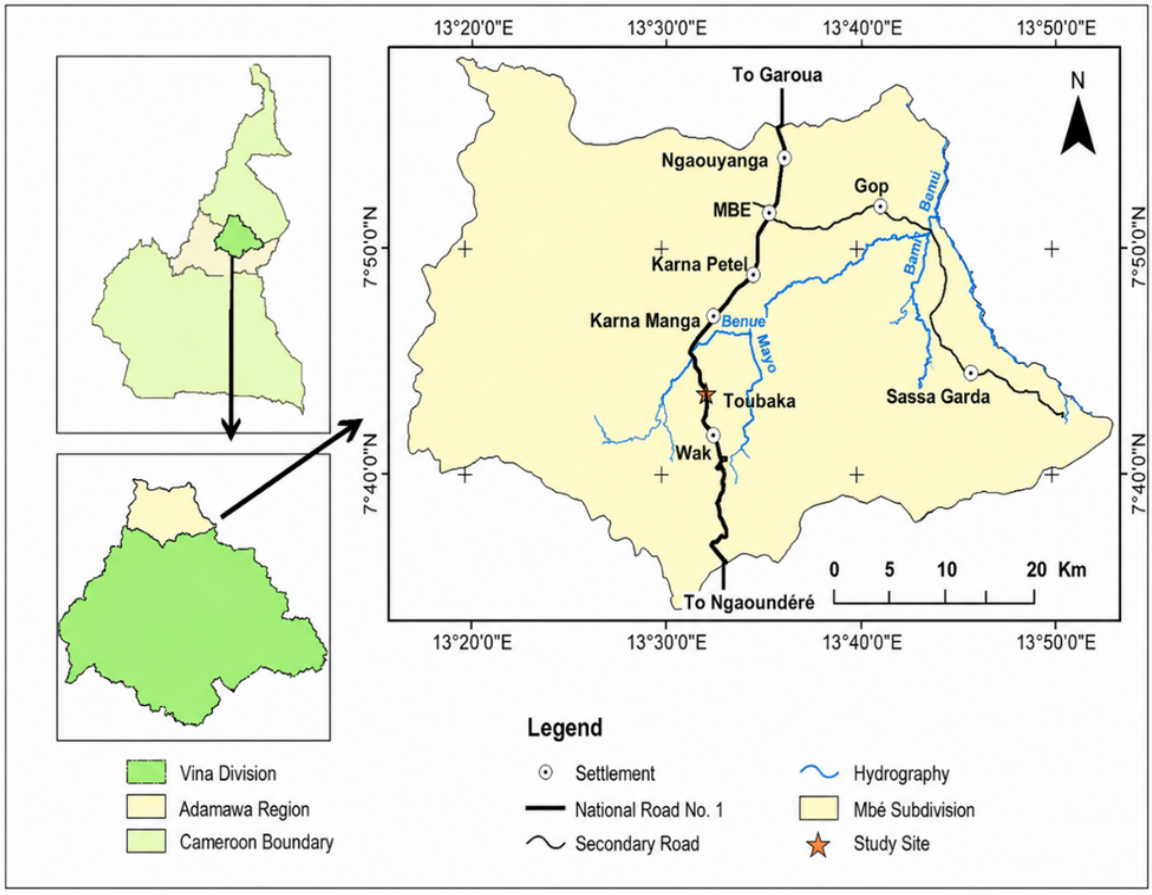


Fig.1. Location map of the study site.

III. RESULTS

3.1. Germination, flowering and maturation

Germination date ranged from 6 to 8 DAS (mean 7.15 DAS), with earliness observed in ICG1471 and ICG3365 (6 DAS). The germination rate was generally high (80 to 100%, mean 93.84%), with six genotypes reaching 100%. Flowering dates varied little (28 to 32 DAS), reflecting homogeneous photoperiodic adaptation. Maturation time ranged from 90 to 95 DAS: nine genotypes (69%) reached maturity at 90 DAS, versus 95 DAS for the other four (Table 1).

Table 1. Germination, flowering and maturation of the 13 groundnut genotypes.

Genotype	Germination (d)	Germ. rate (%)	First flow. (d)	50% flow. (d)	Maturation (d)
ICG3312	8	85	29	31	95
ICG3750	7	95	29	31	90
ICG1988	7	100	28	32	90
ICG3294	7	100	29	32	90
ICG3786	8	100	29	31	95
ICG3621	7	95	28	32	90
ICG1439	8	90	28	32	95
ICG3487	7	85	28	32	90
ICG1471	6	100	28	29	90
ICG2378	7	90	28	30	90
ICG330	7	80	28	31	90
ICG3365	6	100	29	30	90
ICG3260	8	100	28	31	95
Mean	**7.15**	**93.84**	**28.38**	**31.07**	**91.53**

3.2. Vegetative growth and leaf area

Highly significant differences ($p<0.001$) were observed among genotypes for all growth parameters (Table 2). Heritability was low for leaf number ($h^2=0.21$) and stem number ($h^2=0.32$), reflecting a strong environmental influence, but high for stem height ($h^2=0.69$, up to 0.85 in ICG3365), indicating predominant genetic control for this trait. Genotype ICG1439 stood out with a leaf area markedly above the mean (31.09 cm² against 9.53 cm²), while ICG3487 showed the maximum stem height (28.30 cm) and ICG3621 the highest number of leaves and stems.

Table 2. Vegetative growth, leaf area and heritability (h^2) at 90 days after sowing (DAS).

Genotype	Leaves/90d	h^2	Stem ht./90d (cm)	h^2	Stems/90d	h^2	Leaf area/90d (cm²)	h^2
ICG3312	12.80	0.16	15.60	0.33	4.80	0.33	4.94	0.43
ICG3750	14.00	0.06	12.25	0.79	5.70	0.29	6.66	0.52
ICG1988	26.10	0.02	13.45	0.81	5.70	0.37	6.24	0.23
ICG3294	18.90	0.17	15.35	0.51	5.40	0.45	5.61	0.52
ICG3786	22.60	0.22	17.35	0.82	5.60	0.30	8.85	0.37
ICG3621	30.60	0.16	19.50	0.72	6.40	0.16	8.92	0.48
ICG1439	23.60	0.16	14.20	0.79	5.80	0.12	31.09	0.20
ICG3487	26.20	0.19	28.30	0.63	5.70	0.28	8.88	0.15
ICG1471	24.30	0.29	20.50	0.78	5.00	0.37	9.73	0.52
ICG2378	24.50	0.22	12.85	0.65	5.30	0.49	8.72	0.51
ICG330	23.90	0.31	13.60	0.65	5.50	0.34	8.24	0.56
ICG3365	27.60	0.44	14.20	0.85	5.20	0.31	7.90	0.48
ICG3260	22.60	0.26	16.10	0.62	5.30	0.39	8.19	0.49
Mean	**22.90**	**0.21**	**16.40**	**0.69**	**5.49**	**0.32**	**9.53**	**0.42**

3.3. Yield component: number of seeds per plant

The number of seeds per plant ranged from 12.0 to 30.5 (mean 20.74), with the best performance obtained by ICG1439 (30.5), ICG3621 (26.0) and ICG3786 (25.6). The mean heritability (h^2=0.48) masks substantial heterogeneity among genotypes, with remarkably high values in ICG1988 (0.96) and ICG3487 (0.95), suggesting exceptional genetic stability of this trait in these two genotypes (Table 3).

Table 3. Number of seeds per plant and heritability (h^2).

Genotype	Seeds per plant	h^2
ICG3312	16.60	0.66
ICG3750	12.00	0.61
ICG1988	13.40	0.96
ICG3294	21.50	0.55
ICG3786	25.60	0.14
ICG3621	26.00	0.26
ICG1439	30.50	0.41
ICG3487	19.00	0.95
ICG1471	16.90	0.05
ICG2378	23.00	0.14
ICG330	19.80	0.64
ICG3365	23.60	0.51
ICG3260	21.70	0.44
Mean	**20.74**	**0.48**

IV. DISCUSSION

The moderate genetic variability observed for phenological parameters (germination, flowering) contrasts with the more pronounced heterogeneity of growth and production traits, illustrating differing degrees of genetic control depending on the trait. This variability is consistent with previous work carried out on groundnut in Cameroon and Africa [2]; [15] .

Cross-analysis of performance and heritability makes it possible to distinguish two profiles of genotypes with breeding value. On one hand, genotypes with high heritability for stable traits such as stem height (ICG3365, h^2=0.85; ICG1471, h^2=0.78; ICG3750, h^2=0.79): the low genotype-environment interaction that characterizes them makes them good candidates as parents for pedigree selection programmes, in line with the principles described by [8] and [7]. On the other hand, genotypes combining high agronomic performance with more moderate heritability, as exemplified by ICG1439 (30.5 seeds/plant, leaf area of 31.09 cm^2, but h^2=0.20 for this latter trait): their potential expresses itself strongly but remains sensitive to environmental conditions, illustrating the concept of phenotypic plasticity described by [4] .This contrast has a direct implication for the intended use of each genotype: genotypes with high heritability are better suited to use as parents in crosses aimed at durably fixing the trait, whereas high-performing genotypes with lower heritability, such as ICG1439, would benefit from being disseminated directly to farmers under technical guidance (fertilization advice, water management) enabling their potential to be expressed, rather than being used in isolation as parental lines.

The high heritability values obtained for seed number in ICG1988 (0.96) and ICG3487 (0.95), despite a moderate overall heritability for this trait (h^2=0.48), confirm that the genotype-environment interaction differs markedly from one genotype to another for a given parameter, as observed by [3] in groundnut and by [14] in *Bambara* groundnut; this justifies multilocational evaluation prior to any large-scale dissemination recommendation, rather than generalizing from a single site.

From a practical position, the five best-performing genotypes (ICG1439, ICG3365, ICG1471, ICG3621 and ICG1988) are of direct interest to farmers in the Sudano-Guinean Zone, but their valorisation requires the establishment of a seed multiplication and distribution system, which is currently poorly structured in this region.

Collaboration with national agronomic research institutions and local seed cooperatives would be needed to produce foundation seed from the ICRISAT material evaluated here, and to subsequently disseminate it to farmers through agricultural extension services. The cost of access to these improved seeds, currently poorly documented, is a determining factor for adoption by family farms, for whom the purchase of certified seed represents a non-negligible cost compared with the use of farm-saved seed.

V. CONCLUSION

This study assessed the genetic variability and heritability of agromorphological traits in thirteen groundnut genotypes in the Sudano-Guinean Zone of Cameroon, with a view to their use in the varietal selection programme. Five genotypes stood out: ICG1439, ICG3365, ICG1471, ICG3621 and ICG1988. Depending on their heritability profile, they may be disseminated directly to farmers, with technical support, or integrated as parents in hybridization programmes. Their effective valorisation, however, requires the establishment of a local seed sector, still to be built, involving research institutions, cooperatives and extension services.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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