IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 4 Issue 2, February 2017
ISSN (Online) 2348 – 7968 | Impact Factor (2016) – 5.264
www.ijiset.com

Phenotyping Groundnut Genotypes to Identify Sources of Earliness in Niger

Mamadou A. COULIBALY[1], Bonny R. NTARE[2], Vernon E. GRACEN[3], Eric Y. DANQUAH[4], Kwadwo. OFORI[4] and Abdelkader S. MAHAMANE[1]

[1]Institut National de la Recherche Agronomique du Niger (INRAN), CERRA de MARADI, BP 240, Maradi, Niger
[2]Former Groundnut Breeder at the International Crop Research Institute for the Semi-Arid Tropics BP 320, Bamako, Mali
[3]College of Agriculture and Life Sciences, Cornell University, USA
[4]School of Agriculture, College of Basic and Applied Sciences, University of Ghana, Accra, Ghana

Abstract
Groundnut is an important legume in Africa that complements the major staple cereal. One hundred and fifty genotypes were evaluated under well watered conditions in an alpha lattice design in an unreplicated trial to select early maturing genotypes. Data recorded included: percentage of emergence, days to 50% plants flowering, plant height, biomass, pod yield, and Harvest index. Principal Component Analysis revealed that 79.62% of the total variation among the genotypes was explained by pod yield, biomass, harvest index and days to 50% plants flowering. The genotypes, evaluated were classified into three groups: (i) extra early maturing genotypes (75 to 80 days), (ii) early maturing genotypes (85 days) and (iii) intermediate genotypes ($90 \leq x \geq 110$ days). Two extra early maturing genotypes ICIAR_19BT and Chico (75 days) and 3 early maturing genotypes ICG3584, 796 and ICGV02022 (80 days) genotypes were selected. ICIAR_19BT had the highest pod yield 512g/m^2 and Chico the lowest one 160g/m^2.
Key words: Phenotyping, Groundnut, genotypes , Principal component Analysis, Earliness

1. Introduction

Groundnut (*Arachis hypogaea* L., *Fabaceae*), is the 13th most important food crop of the world (Nigam *et al*., 2005; Mace *et al.*, 2006; Cuc *et al*., 2008). The crop is grown from latitude 40^{o}N to 40^{o}S (Frimpong, 2004; Arunyanark *et al*., 2008, Furlan *et al*., 2012). Groundnut seeds are a rich source of high quality edible oil (45 -56%), easily digestible protein of 12-36% and 10-20 % carbohydrates (Stalker, 1997; Nageswara and Nigam, 2003; Reddy *et al*., 2003a; Reddy *et al*., 2003b). Over two thirds of the global groundnut production occurs in rainfed regions that experience erratic and insufficient rainfall resulting in unpredictable droughts (Arunyanark *et al.*, 2009; Songsri *et al*., 2009). Above 80% of the smallholder farmers are located in areas where rainfall is low and erratic, and soils tend to be infertile (Muzari *et al.*, 2012).
Drought, particularly during the pod and seed forming stages, is a major constraint to productivity that significantly reduces pod yield. Groundnut yield in Niger is frequently severely limited by drought arising from unpredictable rainfall, high evaporative demands and production on low water holding capacity soils.
The relatively shorter growing seasons in semi-arid regions of West Africa, as compared to the southern savannah ecologies, prevent groundnut from maturing properly. Therefore, early maturing groundnut cultivars with higher yield are required for several agro-ecologies of the semi-arid regions of West Africa. However, information on the genetic variability for earliness among candidate parental lines is lacking. Breeding early maturing cultivars is an important objective in most groundnut improvement programmes. Bailey and Bear (1973) demonstrated that the early onset of flowering and early accumulation of a given number of flowers (10 to 30) are important components of early maturity in groundnut. This study was conducted to assess and select early maturing groundnut varieties from 150 genotypes.

2. Materials and methods

The study was conducted at The National Institute of agricultural Research (INRAN) in Niger at its main research station near Maradi (13^o 28'N latitude and 7 ^{o} 10'E longitude). The average daily maximum temperature was 40°C and the average daily minimum temperature was 14°C during the experiment period. The annual rainfall ranges from 230 to 630 mm, typical of a Sahelian climate. The soil has a pH of 6.5, contains 90% sand and 8% clay, has low water holding capacity, low inherent soil fertility and organic matter content (2%).

The experimental materials consisted of 150 entries including 85 genotypes obtained from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Niger and 65 genotypes collected from the National Agricultural Research Institutes of Ghana, Nigeria, Mali, Burkina Faso and Niger. The fertilizers DAP [Diammonium

phosphate $(NH_4)_2HPO_4$] 150kg/ha (Jogloy *et al*., 2011) and farm yard manure 2000 kg/ha (Hamidou *et al*., 2012) were incorporated, the land was disk-ploughed two times, harrowed and leveled .

The expaeriemnt was conducted during the off-season in 2010 (March to May). Entries were arranged in α-lattice unreplicated design with 10 blocks each containing 15 entries. To prevent seed borne diseases, seeds were treated with a combination of fungicide/insecticide Thiram 10% ($C_6H_{12}N_2S_4$) and Imidacloprid 25% ($C_9H_{10}ClN_5O_2$) at 25g for 10kg of seeed before planting: eds. Seeds were hand planted in three rows per plot in a ridge-furrow system, 3 m long, with spacing of 0.5 m between rows and of 0.20 m between plants (Arunyanark *et al*., 2010). The plot size was 1.5 m^2 (0.5 m x 3 m). The trial was surrounded by two buffer rows. The experiment received protection against diseases and insect pests and weeds. The trial was irrigated twice a week during the first month and then once a week up to the harvesting by surface irrigation. The following data were recorded: percentage of plants emerged (% EMERG) recorded from 3 to 7 days after sowing; 50% Plants flowering (50% PF) as the date at which 50% of the plants by plot flowered; Plant height (PH) of five plants selected at random to record plant height 75 days after sowing and days to Maturity (DM) determined at 75 days after sowing by harvesting one plant from each plot to determine the percentage of developed pods; Biomass (BIO) weight: measured as above ground biomass was calculated from weighing plants harvested from $1m^2$ of each plot after 3 weeks air drying; Pod yield (PY) was the weight of pods harvested from $1m^2$ in the middle of each plot after air drying to constant weight for two weeks; and Harvest index (HI) was calculated by using the following formula:

HI= Total pod weight (g) / Total weight of above ground Biomass
(Girdthai *et al*., 2010)

The plots were harvested when at least 75% of the developed pods were mature as determined by the blackening of the internal shell wall (Williams and Drexler, 1981).
Principal component analysis was used to classify the genotypes with GenStat 12th Edition software. The principal components were computed from the *n* eigenvalues and their corresponding eigenvectors calculated from the correlation matrix. Each eigenvector defines a principal component.

3. Results

Principal component analysis showed that the first three eigenvalues which were greater than 1 (2.63, 1.63 and 1.31) accounted for 79.62% of the total variation among the genotypes (Table1). The first PC accounted for 37.59 % whereas the second and the third PC axes accounted for 23.30% and 18.73%, respectively. The first PC (Table1) was positively associated with characters such as days to maturity and pod yield. The second PC was positively associated with days to emergence and negatively associated with harvest index and days to 50% plant flowering. The third PC correlated positively with pod yield and biomass.

Table 1: Eigenvectors from the three PC axes used to classified groundnut genotypes

Component			
Variable	**PC1**	**PC2**	**PC3**
1. % emergence 7 DAS	0.34	0.43	-0.2
2. Harvest index	0.26	-0.63	-0.02
3. Maturity	0.52	0.09	0.17
4. 50% Plant flowering	-0.3	-0.46	0.37
5. Plant height	-0.32	0.27	0.41
6. Pod yield	0.49	-0.14	0.45
7. Biomass	0.3	0.29	0.63
Eigenvalues	**2.63**	**1.63**	**1.31**
Percentage of variance explained	**37.59%**	**23.30%**	**18.73%**

PC: Principal Component, **DAS**: Days after sowing
The genotypes were classified into three groups based on the maturity:

- First group: 5 extra, early maturing genotypes (75 to 80 days),
- Second group: 29 early maturing genotypes (85 days),
- Third group: 105 intermediate genotypes ($90 \leq x \leq 110$ days).

Eleven remaining from the 150 genotypes had poor seed quality and didn't germinate. The top five genotypes selected as early maturing genotypes were Chico, ICGV 02022, 796, ICG 3585 and ICIAR_19BT. The genotype ICIAR19 BT had the highest pod yield of 512g/m^2 followed by ICGV 02022 and ICG 3584 with 230g /m^2 and 206g/m^2, respectively. Chico had the lowest pod yield (160g/m^2). All the selected genotypes reached 50% flowering in 24 days after sowing. Seven days after sowing, the selected genotypes had over 70% of emergence. The harvest indices ranged from 0.26 to 0.51. From this evaluation two extra early maturing genotypes ICIAR_19BT and Chico (75 days) and 3 early maturing genotypes ICG 3584, 796 and ICGV 02022 (80 days) were identified.

Table 2: The top 20 genotypes based on their days to maturity and their performance for other traits

Ranking	**Genotypes**	**% EMERG 7DAS**	**ND 50% PF**	**DM** (days)	**PY** (g/m^2)	**BIO** (g/m^2)	**HI**	**PH** (cm)
1	ICIAR _19BT	100	24	75	512	1004	0.51	54.66
2	Chico	75	24	75	160	525	0.30	39.33
3	ICG 3584	96	24	80	206	748	0.27	49.66
4	ICG 02022	83	24	80	230	600	0.38	50.33
5	796	100	24	80	174	580	0.30	52.33
6	T127 - 83	58	26	85	160	446	0.35	51.33
7	ICG-3736	67	26	85	210	416	0.50	48.66
8	ICG 1415	75	26	85	240	1760	0.41	48.66
9	ICG 15236	67	28	85	180	856	0.21	50
10	T44 - 88	83	28	85	176	515	0.34	44.66
11	T49-87	46	28	85	200	480	0.41	43.33
12	ICG 3312	92	26	85	140	334	0.38	48.66
13	ICGV-IS 01827	92	26	85	80	276	0.28	47.33
14	T131 - 83	79	26	85	160	328	0.48	49.33
15	ICG 1519	79	24	85	100	520	0.19	47
16	ICG 9315	75	24	85	134	453	0.29	49.33
17	TX 903652	62.5	26	85	164	554	0.29	45.33
18	J 11 Niger	100	24	85	194	644	0.30	45.33
19	ICG 15380	87.5	22	85	184	773	0.23	42.66
20	ICG 9315	75	24	85	156	840	0.18	55.33

% EMERG: Percentage of emergence, **50% PF:** 50% plant flowering, **DM:** Date to maturity, **PY:** Pod yield, **BIO:** Biomass, **HI:** Harvest index, **PH:** Plant height

4. Discussion

Two extra early maturing varieties, Chico and ICIAR_19 BT, which matured in about 75 days after sowing and three early maturing genotypes , ICG3584, ICGV02022 and 796, that matured in 80 days after sowing were selected. All selected early maturing varieties reached 50% flowering within 24 days after sowing. Chico is the most widely used source of earliness in several breeding programmes. It was used 1,180 times as a parent in developing early maturity lines at ICRISAT between 1976 to 2002 (Upadhyaya *et al.*, 2006). Several studies reported Chico as the early maturing variety used to develop new early maturing varieties (N'Doye and Smith, 1993; Ali and Wynne, 1994; Upadhyaya and Nigam, 1994). The genotype ICIAR_19 BT was released under the name SAMNUT 24 in 2011 in Nigeria as an extra early, high yielding and rosette resistant variety. The most popular varieties grown in Niger (55-437, RRB and JL24) identified through participatory rural appraisal (Coulibaly *et al*., 2017) are intermediate maturing varieties that mature between 90 to 95 days after sowing. Genes for earliness from the extra early maturing varieties identified in this study should be introgressed into farmers' preferred varieties to develop new early maturing varieties. Days to maturity affects differences in pod yield. In general, late maturing genotypes yield better than early maturing genotypes (Culbreath *et al*., 1999; Padi, 2008). Kotzamanidis *et al*. (2006) found that early maturity in groundnut is associated with narrow pod distance from the main stem, leading to more synchronous maturity of the pods. Jogloy *et al*. (2011) reported that extremely early maturity is not desirable because it is generally associated with yield reduction. However, in this study, the selected early maturing varieties exhibited good performance for pod yield. These varieties included ICIAR_19BT (512 g/m^2) and ICGV 02022 (230 g/m^2). Chico was the lowest pod yielding varieity (160g/m^2) which is consistent with all the studies that used Chico as a parent in developing new early maturing varieties. The one hundred and fifty genotypes evaluated for earliness were classified into three maturity groups that are extra early (5), early (29) and intermediate (105). Eleven of the genotypes evaluated did not germinate. The results are very useful for groundnut improvement in Niger; because there is a significant difference in terms of days to maturity (15 days) between 55-437, which is the earliest and most adapted variety in the sahel agroecology and the identified extra early variety ICIAR_19BT. In addition the oil content of ICIAR_19BT is higher that the oil content of 55-437.

5. conclusion

From the evaluation of 150 groundnut genotypes, ICIAR_19BT, Chico, ICG 3584, 796 and ICGV 02022 were selected based on maturity date, yield performance and number of days to 50% flowering. These materials can be used as parental lines to establish a breeding program for developing new early maturing groundnut varieties. ICIAR_19BT could be recommended to farmers in the short term in the groundnut "bassin" as an extra early, high yielding, rosette resistant and high yielding variety. It could be called "ideal" variety.

Acknowledgements

Alliance for Green Revolution of Africa (AGRA) funded the study and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and NARs which provided groundnut germplasm and INRAN for providing the experiment facilities are highly acknowledged.

References

Ali, N. & Wynne, J.C. Heritability estimates and correlations studies of early maturity and other agronomic traits in two crosses of peanut (*Arachis hypogaea* L.), *Pakistan Journal of Botany*, Vol. 26, 1994, 75-82.

Arunyanark, A., Jogloy, S., Akkasaeng, C., Vorasoot, N., Kesmala, T., Nageswara, R.R.C., Wright, G.C., & Patanothai, A. Chlorophyll stability is an indicator of drought tolerance in peanut. *Journal of Agronomy and Crop Science*, Vol. 194, 2008, 113-125.

Arunyanark, A., Jogloy, S., Wongkaew, S., Akkasaeng, C., Vorasoot, N., Wright, G.C., Rachaputi Rao, C.N., & Patanothai, A. Association between aflatoxin contamination and drought tolerance traits in peanut. *Field Crops Research*, Vol. 114, 2009, 14-22.

Arunyanark, A., Jogloya, S., Wongkaewb, S., Akkasaenga, C., Vorasoota, N., Kesmalaa, T., & Patanothaia, A. Heritability of aflatoxin resistance traits and correlation with drought tolerance traits in peanut. *Field Crops Research*, Vol. 117, 2010, 258-264.

Bailey, W.K. & Bear, J.E. Components of earliness of maturity in peanuts, *Arachis hypogaea* L. *Journal American Peanut Research and Education Association.* Vol. 5, 1973, 32-39.

Coulibaly A.M., Bonny N.R., Gracen V.E., Danquah E. & Ofori K., Groundnut Production Constraints and Farmers' Preferred Varieties in Niger, *International Journal of Innovative Science, Engineering & Technology*, Vol. 4, 1, 2017, 202-207.

Cuc, M .L., Mace E.S., Crouch J.H., Quang V.D., Long D.T. & Varshney R.K. Isolation and characterization of novel microsatellite markers and their application for diversity assessment in cultivated groundnut (*Arachis hypogaea L*). *Plant Biology*, Vol. 8, 2008, 55-59.

Culbreath, A.K., Todd, J.W., Gorbet, D.W., Brown, S.L., Baldwin, J.A., Pappu, H.R., Holbrook, C.C. & Shokes, F.M. Response of early, medium, and late maturing peanut breeding lines to field epidemics of tomato spotted wilt. *Peanut Science*, Vol. 26, 1999, 100-106.

Frimpong A. Characterization of groundnut (*Arachis hypogaea* L.) in Northern Ghana, *Pakistan Journal of Biological Sciences,* Vol. 7, 2004, 838-842.

Furlan, A., Lianes, A., Luna, V. & Castro, S. Physiological and Biochemical Responses to Drought Stress and Subsequent Rehydration in the Symbiotic Association Peanut-*Bradyrhizobium sp*. *International Scholarly Research Network Agronomy*, 2012, 8p. doi:10.5402/2012/318083.

Girdthai, T., Jogloy S., Vorasoot N., Akkasaeng C., Wongkaew S., Holbrook C.C., & Patanothai A. Heritability of, and genotypic correlations between, aflatoxin traits and physiological traits for drought tolerance under end of season drought in peanut (*Arachis hypogaea* L.). *Field Crops Research*, Vol. 118, 2010, 169-176.

Hamidou, F., Halilou, O. & Vadez, V. Assessment of Groundnut under Combined Heat and Drought Stress. *Journal of Agronomy & Crop Science*, 2012, 1-11.

Jogloy, C., Jaisil, P., Akkasaeng, C., Kesmala T. & Jogloy, S. Heritability and Correlation for Maturity and Pod Yield in Peanut. *Journal of Applied Sciences Research* Vol. 7, 2011, 134-140.

Kotzamanidis, S.T., Stavropoulos N. & Ipsilandis, C.G. Correlation studies of 21 traits in F_2 generation of groundnut (*Arachis hypogaea* L.). *Pakistan Journal of Biological Sciences*, Vol. 9, 2006, 929-934.

Mace E. S., Yuejin W., Boshou L., Upadhyaya H., Chandra S. and Crouch J. H., Simple sequence repeat (SSR)-based diversity analysis of groundnut (*Arachis hypogaea* L.) germplasm resistant to bacterial wilt, *Plant Genetic Resource*, Vol. 5, 2006, 27-36.

Muzari, W., Gatsi, W. & Muvhunzi, S. The Impacts of Technology Adoption on Smallholder Agricultural Productivity in Sub-Saharan Africa: A Review. *Journal of Sustainable Development*, Vol. 5, 2012, 69-77.

Nageswara, R.R.C. & Nigam, S.N. *Genetic Options for Drought Management in Groundnut.* In: Management of Agricultural Drought - Agronomic and Genetic Options. *Science Publishers*, Inc, 2003, 123-141.

N'Doye, O. & Smith, D. A Note on the Earliness of Offspring from Crosses among Five Short Growth-Duration Peanut Lines. *Peanut Science*, Vol. 20, 1993, 132-137.

Nigam, S.N., Chandra S., Srievi K.R., Manohar B., Reddy A.G.S., Nageswara R.R., Wright G.C., Reddy P.V., Deshmukh M.P., Mathur R.K., Basu M.S., Vasundhara S., Varman P.V. & Nagda A.K. Efficiency of physiological trait-based and empirical selection approaches for drought tolerance in groundnut. *Annals of Applied Biology*, Vol. 146, 2005, 433-439.

Padi, F.K. Genotype × environment interaction for yield and reaction to leaf spot infections in groundnut in semiarid West Africa: Genotype × environment interaction and leaf spot resistance in groundnut. *Euphytica*, Vol. 164, 2008, 143-161.

Reddy, T.Y., Reddy V.R. & Anbumozhi, V. Physiological responses of groundnut (*Arachis hypogea* L.) to drought stress and its amelioration: A critical review. *Plant Growth Regulation*, Vol. 41, 2003a, 75-88.

Reddy, T.Y., Reddy V.R. & Anbumozhi, V. Physiological responses of groundnut (*Arachis hypogaea* L.) to drought stress and its amelioration: A review. *Acta Agronomica Hungarica*, Vol. 51, 2003b, 205-227.

Songsri, P., Jogloy, S., Holbrook, C.C., Kesmala T., Vorasoot, N., Akkasaeng, C. & Patanothai, A. Association of root, specific leaf area and SPAD chlorophyll meter reading to water use efficiency of peanut under different available soil water. *Agricultural water management*, Vol. 96, 2009, 790-798.

Stalker, H.T. (1997). Peanut (*Arachis hypogaea* L.). *Field Crop Research*, 53, 205-217.

Upadhyaya, H.D. & Nigam, S.N. Inheritance of two components of early maturity in groundnut (*Arachis hypogaea* L.). *Euphytica*, Vol. 78, 1994, 59-67.

Upadhyaya, H.D., Reddy, L.J., Gowda C.L.L. & Singh, S. Identification of diverse groundnut germplasm: Sources of early maturity in a core collection. *Field Crops Research*, Vol. 97, 2006, 261-271.

Williams, E.J. & Drexler J.S. A non-destructive method for determining peanut pod maturity, pericarp, mesocarp, color, morphology, and classification. *Peanut Science*, Vol. 8, 1981, 134-141.