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Screening and Selection of Groundnuts (*Arachis hypogaea*L., Fabaceae)for Earliness

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Abstract:
Breeding for early-maturing cultivars has always formed a significant part of the objectives in any crop improvement programme, particularly groundnuts. Information about earliness in groundnutsis limited. Genetic development of varieties that are early-maturing and escape drought is needed. The current study generally sought to exploit groundnut varieties, both landraces and improved, by screening and selecting early-maturing varieties based on yield and other traits. Simple ranking and cluster analysis was used to classify the genotypes based on date of maturity (earliness) and performance for other traits. Means, standard deviation and coefficient of variation were computed for the measurement data. Quantitative data were subjected to analysis of variance (ANOVA) using STATA edition 12.0. Means were separated by Least Significant Difference at 95% confidence level. Pearson's Correlation (r) analyses between pairs of quantitative parameters were performed using SPSS version 22.0, with reference to yield parameters. Combined analysis of variance was computed for the groundnut entries across water regimes (Gomez and Gomez, 1984) for yield and yield components data using STATA pc software version 12.0. SPSS pc software (version 22.0) programme was used to generate dendrograms for the groundnut accessions using growth and yield performance data, based on Euclidian distance. Simple scoring and ranking was used to assess disease incidence based on the scale of 1-5. The groundnut genotypes; 'Ndogba', 'Chinese', 'Yenyawoso', 'Simpelgu' and 'Kpach-Isah' were selected as early-maturing varieties based on flowering and maturity periods (28 days to 50% flowering; 85-90 DAP). Groundnut varieties that exhibited early maturity, also showed good performance for pod yield. These varieties include 'Chinese' (263 pods/10 plants), 'Yenyawoso' (259/10 plants), 'Simpelgu' (225/10 plants), 'Ndogba' (193/10 plants) and 'Kpach-Isah' (126/10 plants). They also recorded relatively high harvest indices; Chinese (0.4847), Yenyawoso (0.3912), Simpelgu (0.4854), Ndogba (0.2252) and Kpach-Isah (0.8318). Information generated from this study can be used to develop new groundnut varieties that combine both earliness and higher-yielding traits. Marker assisted selection procedures could help enhance this process based on the availability of QTLs and genes for the traits and markers developed in that regard.

Keywords: *Breeding, drought, earliness, genotypes, groundnut, improved, landraces, screening, traits, varieties, yield*

1. Introduction

Drought, especially during the pod-filling stages of groundnut growth, is a major production constraint, more so in the three Northern Regional savannahs of Ghana, as reported in a PRA study (Oppong-Sekyere *et al*., 2015). Drought causes a significant pod yield reduction and a subsequent reduction in productivity. Groundnut is grown widely under rain-fed conditions in the semi-arid tropics, where drought stress is extensive and unavoidable. The yield of groundnut in Northern Ghana, a major producer, is frequently and severely limited by drought arising from unpredictable rainfall, high evaporative demands and production on low water-holding capacity soils.

There is also the problem of the relatively shorter seasons for growth of most crops in these semi-arid tropics; this has a negative effect on the proper growth, maturity and yield of groundnuts. Notwithstanding, early-maturing groundnut varieties with improved yield are essential for several agro-ecological environments of the semi-arid regions of Ghana, including the Northern Region. There is lack of, and in most cases inadequate information regarding the genetic variability for earliness and drought-tolerant groundnut varieties.

An important objective in any groundnut improvement programme has always included breeding for early-maturing cultivars. Early maturity in groundnuts is linked with the early onset of flowering and early production of a given number (10-30) of flowers (Wunna et al., 2009). Jongrungklang*et al*. (2008) reported that, drought affects chlorophyll content and hinders plants' ability and capacity to photosynthesize. An important drought tolerance mechanism in groundnuts is the capacity to maintain chlorophyll density under conditions of water shortage (Arunyanark *et al*., 2010; Wunna et al., 2009). Superior yield performance under moisture stress conditions is an important and reliable index of drought tolerance (Varshney et al, 2006).

The objectives of this research wereto screen and select early-maturing groundnut genotypes based on yield and performance for other traits such as maturity period (number of days from sowing to maturity) and days to 50% flowering. This phase of research is to provide an important first step at improvement of the crop, especially in the area of drought tolerance and yield,in future.

2. Materials and Methods

2.1. Source of Genetic Materials

The groundnut genotypes used in this study (Table 1) included a total of 16 accessions of which eight (8) were landraces (local varieties) collected mainly from the three Northern Regions of Ghana, and five (5) from CSIR-SARI, Tamale, and the remaining three (3) from CSIR-CRI, Kumasi, Ghana.

№.	Genotype	*Sub-Species	Source	Days to Maturity, days	Phenotypic Characteristics and Other Trait			
					Drought Characteristics	Early Leaf Spot disease	Late Leaf Spot disease	Oil Content and Other Traits
1	Nkatie-sari	Hypogaea (Virginia)	CSIR-SARI, Ghana	100-115 (110)	Tolerant	Highly Tolerant	Highly Tolerant	Oil Content: 46%, Seed Colour: Light tan testa colour
2	Chaco – pag	Fastigiata	Landrace, Ghana	100-115	Tolerant	Moderately Tolerant	Moderately Tolerant	Seed colour: Red
3	F – mix	Hypogaea (Spanish)	CSIR-SARI, Ghana	100-115 (120)	Tolerant	Highly Tolerant	Highly Tolerant	Oil Content: 49% Seed colour: Tan with red/brown shades Av. Yield: 2500kg/ha Highly Tolerant to Rosette and Rust
4	Sinkara	Hypogaea (Spanish)	Landrace, Ghana	100-115 (120)	Tolerant	Tolerant	Tolerant	Oil Content: 45% Seed colour: Red Yield Potential: 2.2t/ha
5	Agric-Manipinta	Hypogaea (Spanish)	Landrace, Ghana	100-115 (110-120)	Tolerant	Tolerant	Tolerant	Oil Content: 47% Seed colour: red teste High yield potential
6	Ndogba	Fastigiata	Landrace, Ghana	85-90	Moderately Tolerant	Moderately Susceptible	Moderately Susceptible	Seed colour: Tan red
7	Sumnut – 23	Hypogaea	CSIR-SARI, Ghana	100-115	Tolerant	Moderately Tolerant	Moderately Tolerant	Seed colour: tan red Rosette disease Tolerant
8	Sokan-donworor	Fastigiata	Landrace, Ghana	100-115	Tolerant	Moderately Susceptible	Moderately Susceptible	Seed colour: Red to whitish
9	Sumnut – 22	Hypogaea	CSIR-SARI, Ghana	100-115 (110-120)	Tolerant	Moderately Tolerant	Moderately Tolerant	Seed colour: Tan red Rosette disease Tolerant
10	Chinese	Hypogaea (Spanish)	Landrace, Ghana	85-90 (100)	Tolerant	Susceptible	Susceptible	Oil Content: 35% Early maturing Use: Soup and Confectionery
11	Yenyawoso	Fastigiata (Spanish)	CSIR-CRI, Ghana	85-90 (90)	Moderately Susceptible	Moderately Susceptible	Moderately Susceptible	Oil content: 50% Resistant to Rust Seed colour: Dark red Yield Potential: 2700kg/ha Days to 50% flowering: 23DAP

№.	Genotype	*Sub-Species	Source	Days to Maturity, days	Phenotypic Characteristics and Other Trait			
12	Simpelgu	Fastigiata	Landrace, Ghana	85-90	Tolerant	Moderately Susceptible	Moderately Susceptible	Seed colour: Deep red
13	Oboshie	Fastigiata (Spanish)	CSIR-CRI, Ghana	100-115 (105-110)	Moderately Susceptible	Moderately Susceptible	Moderately Susceptible	Oil Content: 46.49% Seed Colour: Brown Days to 50% flowering: 26 Shelling %: 67 Good flavour, sweet taste (Confectionery) Yield: 2.6tons/ha Days to Flowering: 26DAP Shelling%: 67% Growth Habit: Semi-erect
14	Kpach – Isah	Fastigiata	Landrace, Ghana	85-90	Tolerant	Moderately Susceptible	Moderately Susceptible	Seed colour: Light red
15	Kpanieli	Hypogaea (Spanish)	CSIR-SARI, Ghana	100-115 (120)	Tolerant	Tolerant	Tolerant	Oil Content: 51% Yield Potential: 2.5t/ha Seed colour: red testa
16	Obolo	Fastigiata (Spanish)	CRI, Ghana SARI	100-115 (105-110)	Moderately Susceptible	Moderately Susceptible	Moderately Susceptible	Seed colour: Brown Days to 50% flowering: 25 Shelling %: 70 Has sweet taste and flavour (Confectionery)

Table 1: Source, Sub-Species, Days to Maturity and Phenotypic Characteristics of Groundnut Genotypes Studied
**Sub-Species, *Oil Content and Other Traits; Were Obtained from CSIR-SARI, CRI and MoFA Published Data*
CSIR-Council for Scientific and Industrial Research, SARI – Savanna Agriculture Research Institute, Ghana, CRI – Crops Research Institute, MoFA-Ministry of Food and Agriculture, 'Landrace'- Farmers' Popular Locally Adapted Variety

2.2. Experimental Site, Field Operations and Screening for Earliness

The experiment was conducted at the experimental field of CSIR - Savanna Agricultural Research Institute (SARI, Nyankpala, Tamale), located in the Tolon-Kumbungu District of the Northern Region of Ghana (N9º 30' and N 10º 00' latitude and W 0º 51' and W 1º 00' longitude), in April, 2015 major season and repeated the same year at the experimental fields of the Department of Ecological Agriculture, Bolgatanga Polytechnic, Bolgatanga, Upper East Region of Ghana.

Tamale-Nyankpala has a mean elevation of 149 m above mean sea level (Getamap, 2006); www.getamap.com). The mean annual rainfall of the region is between 750 mm and 1050 mm; located in the Guinea-Savannah agro-ecological zone (Cobbinah and Anane, 2015).The average temperature of the region is about 28oC but can be as low as 14ºC during the night in December/January and as high as 40ºC in February/March through to April during the day (Brown and Crawford, 2008). The major soils of the region are lixisols, luvisols, acrisols and gleysols (Dedzoe et al., 2001).

The soils at Nyankpala (UDS fields) are sandy with low water holding capacity, low inherent soil fertility and organic matter content. The chemical composition of soil as well as the climatic data at the experimental sites is indicated in Appendices 1a, 1b and 2a, 2b).

The Department of Ecological Agriculture experimental field of the Bolgatanga Polytechnic located on the coordinates; 10.8275° N, 0.9397° W, is classified under the tropical climatic zone and has two distinct seasons; a wet season that runs from May to October and a long dry season that stretches from October to April, hardly experiencing any rains. Mean annual rainfall is about 950mm while maximum temperature is about 45°C in March and April with minimum of about 12°C in December. The natural vegetation is that of Guinea Savannah woodland consisting of short deciduous trees widely spaced and a ground flora, which gets burnt by fire or scorched by the sun during the long dry season.

The land was prepared by slashing off weeds, ploughing and harrowing. The total experimental area was 36 m by 14 m with each plot size measuring 4 m by 3 m. The field experiment was laid out in a Randomized Complete Block Design (RCBD) in4 replications.

2.3. Screeningand Selection of Early Maturing Groundnut Varieties (Earliness Screening)

The sixteen (16) groundnut accessions (Table 1) were cultivated by direct seeding on the plots at a rate of 1 seed per hill at a planting depth of about 5 cm and at a modified spacing of 50 cm × 20 cm (Adu-Dapaah et al., 2007; Naab et al., 2009) in an RCBD lay out, replicated four times.

2.4. Crop Management Practices

After planting the groundnut genotypes, all cultural practices including filling-in, fertilizer application (DAP [Diammonium phosphate (NH4)2HPO4] 150kg/ha) (Jogloy et al., 2011), weed control and earthen up were carried out as recommended. Two weeding regimes were conducted at 2 and 6 weeks after sowing. Weeding was done by hoeing

between rows and hand pulling weeds on top of plots and within rows to reduce damage to developing "pegs". Earthen-up was done along with all the weeding regimes.

3. Data Collection

The following growth and yield data were recorded;

3.1. Growth Parameters

- Days to 50% Emergence (50%E): The percentage of seedlings or plants emerged was recorded from 3 to 7 days after sowing. A plot attains 50% emergence when half the number of seeds sown emerges.
- Days to 50% flowering (50%F): Plots were regularly monitored to record the date at which 50% of the plants by plot flowered. A plot achieves 50% flowering when half of the plants develop flowers.
- Plant Height (PH, cm): Four plants selected at random were used to record plant height 75 days after sowing. Heights of primary stems (middle stem) of the four tagged plants were measured with a meter rule at 75 DAP. Heights were measured from soil level to the primordial leaf node. The heights of each of the four were averaged for a plot.
- Canopy Spread (CSprd, cm): Four plants selected at random were used to record Canopy Spread at 75 days after sowing. Length of spread of primary branches of the four tagged plants were measured with a meter rule at 75 DAP, and the total averaged for each plot.
- Growth Habit (general appearance): Plant growth habit were scored as either the bunch (or erect) types and the runner (or trailing) types. A groundnut plant has a central, upright stem and many lateral branches. When these lateral branches are upright, the plant is designated bunch or erect type. However, when horizontal, the plant is referred to as a runner or trailing type (Chapman and Carter, 2000).
- Days to Plant Maturity (DM): Number of days from sowing to maturity (before harvesting) was recorded. Seventy five (75) days after sowing, one plant was harvested from each plot to determine the percentage of developed pods. 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). The number of days to maturity from each of the plants from the harvestable area of each plot was then averaged for the plot.
- Harvesting: Ten (10) plants from each plot were harvested at maturity for yield determination. Harvesting was done by hoe digging and hand pulling.

3.2. Yield and Yield Components

- Biomass Weight (Bio, g): Above ground biomass (Haulm) weight was calculated from ten (10) plants harvested from the middle of each plot. Haulm weight was taken by weighing the harvest using a Top Pan Balanceafter 3 weeks air drying.
- Pod Yield (PY): Number of Mature (dry) Pods per Plot was determined from ten (10) plants harvested from middle of each plot, after air drying to constant weight for two weeks.
- Pod Weight: Fresh weight of filled pods per harvestable area of each plot was taken; the pods were sun and/or air dried to constant moisture content and their dry weights taken.
- Seed Weight: Pods were shelled by hand at moisture level of 10% to 13% and seed weight per harvestable area of each plot recorded.
- 100 Seed Weight: Seeds (100) were counted and weighed per harvestable area of each plot. Percent seed moisture were taken using a Protimeter moisture metre. All weights were taken using Camry electronic balance.
- Harvest Index (HI): HI was calculated by using the following formula:
- HI= Total Dry Pod Weight (g) (i.e. Economic yield)/Total Biomass (haulm) Weight (Girdthai et al., 2010).
- (www.fao.org/docrep/004/Y3655E/y3655e07.hmt).
- Shelling Percentage (%S): Shelling percentage was calculated by dividing Seed Weight by Dry Pod Weight and expressed in percentage: - (Seed Dry Weight/Pod Dry Weight) x 100.

4. Data Analysis

Simple ranking and cluster analysis was used to classify the genotypes based on date of maturity (earliness) and performance for other traits.

Means, standard deviation and coefficient of variation were computed for the measurement data. Quantitative data were subjected to analysis of variance (ANOVA) using STATA edition 12.0. Means were separated by Least Significant Difference at 95% confidence level. Pearson's Correlation (r) analyses between pairs of quantitative parameters were performed using SPSS version 22.0, with reference to yield parameters. SPSS pc software (version 22.0) programme was used to generate a dendrogram for the groundnut accessions based on maturity period, earliness and performance for other traits, and revealed by the Euclidian distance. Simple scoring and ranking was used to assess disease incidence based on the scale of 1-5.

5. Results

5.1. Mean Agronomic and Yield Performance of Groundnuts in the Earliness Screening

5.1.1.50% Emergence

The mean 50% emergence ranged from 44.50% to 87.25%. At one week after sowing (3-7 days), the following plants had attained 50% emergence; Yenyawoso; 87.25%, Obolo; 82.25%, Ndogba (Landrace); 76.00, Sokan-donworor; 76.25, China (Landrace); 76.50 and Kpach-Isah; 69.25. Kpanieli (SARI) emerged late, recording 44.50% emergence (Table 2).

There was no significant difference ($P \geq 0.05$) among the treatment means for Days to 50% Plant Emergence (Table 2).

5.1.2. Days to 50% Flowering

Days to 50% flowering showed no significant ($P \geq 0.05$) difference among the groundnut varieties (Table 2). Mean number of days to 50% flowering among the varieties ranged from 27.25 – 31.25 DAP. Sumnut-23 flowered first followed by Ndogba (landrace), Yenyawoso (CRI) and F-Mix (SARI) respectively at 27.25, 27.50, 27.50 and 27.75 days. Kpanieli (SARI) flowered late at 31.25 days followed by Sumnut 22 (29.50 days) and Chaco-pag (29.50 days) (Table 2).

5.1.3. Plant Height

Table 2 shows the results for plant height at 75 DAP by all the varieties. Plant height for all treatments increased at all sampled times. There were no significant differences ($P \geq 0.05$) in height among varieties 75 DAP (Table 8). Nkatie-sari (SARI) recorded the highest height (19.68 cm) followed by Kpach-Isah (17.35 cm) and Agric-Manipinta (17.05 cm) in that order; with Kpanieli (SARI) recording the lowest of 10.68 cm followed by Sokan-donworor (11.83 cm) (Table 2).

5.1.4. Canopy Spread (Number of Branches)

Canopy spread, at 75 DAPS among the groundnut varieties showed no statistical significance ($P \geq 0.05$) (Table 2). 77.51% of the variation in canopy spread can be explained by variety, replication, number of weeks after planting and their interactions. Agric-Manipinta (Landrace) recorded the highest canopy spread of 40.33 cm followed by Yenyawoso (37.29 cm) and Ndogba (36.96 cm), Kpanieli (SARI) had 30.85 cm spread followed by Nkatie-sari (32.10 cm) and Chaco-pag (33.10 cm) (Table 2).

5.1.5. Growth Habit (General Plant Appearance)

Generally, groundnut varieties in the current study were either Erect (or semi erect) and bunch or Runner and trailing. The following accessions exhibited erect and bunch general growth appearance; Nkatie-sari, Chaco-pag, F-Mix, Sinkara, Agric-Manipinta, Sumnut-23, Sokan-donworor, Sumnut-22 and Kpanieli. Ndogba, China, Simpelgu and Kpach-Isah were commonly Runner and Trailing types, in terms of growth habit and appearance. Yenyawoso, Oboshie and Obolo showed semi-erect general growth appearance (Table 2).

5.1.6. Daysto Plant Maturity

Days to maturity of groundnut plants in this study recorded as early as 85 DAP to as late as 115 DAP (Table 2). Groundnut accessions that matured between 85-90 days were classified as early-maturing varieties, and these included the following five (5) accessions; Ndogba (Landrace), China (Landrace), Yenyawoso (CRI), Simpelgu (Landrace) and Kpach-Isah (Landrace) (Table 2).

Eleven groundnut accessions attained maturity between 100 to 115 days, and were therefore classified as Intermediate to Late Maturing varieties. These included; Nkatie-sari (SARI), Chaco-pag (Landrace), F-Mix (SARI), Sinkara (Landrace), Agric-Manipinta (Landrace), Sumnut-23 (SARI), Sokan-donworor (Landrace), Oboshie (CRI), Kpanieli (SARI), Obolo (CRI) and Sumnut-22 (SARI) (Table 2).

5.1.7. Biomass (Haulm) Weight

Sumnut-22 (SARI) obtained the highest mean above ground biomass weight of 650.00g followed by Ndogba (landrace) (599.42g) and Oboshie (587.02g), while Sinkara (landrace) recorded the lowest 260.29 g and Kpach-Isah (Landrace) with 274.12g at harvest (Table 2).

5.1.8. Pod Yield

The highest number of matured (dry) pods per plot was recorded by Sinkara (Landrace) (342 pods) followed by Sokan-donworor (340 pods) and Sumnut 22 (334 pods). F-Mix (119 pods), Kpach-Isah (126 pods) and Oboshie (132 pods) produced the lowest number of pods respectively (Table 2).

5.1.9. Pod Weight

Sumnut-22 had the highest mean pod weight (389 g), followed by Sokan-donworor (269 g) and Kpanieli with 259 g. Ndogba recorded the lowest pod weight of 135g followed by Chaco-pag (147g) and Yenyawoso (149g) (Table 2).

5.1.10. Seed Weight

From results of the current study (Table 2), the highest mean seed weight of the groundnut varieties was recorded by Oboshie (182g) followed by Kpanieli (166g) and Sinkara (166g), whereas Simpelgu (72g), Sokan-donworoor (78g) and Sumnut-23 (82g) respectively produced the lowest seed weight (Table 2).

5.1.11. 100 Seed Weight

Results of the study in (Table 2) indicate that Oboshie (135.3g) produced the highest weight of 100 seeds followed by Kpanieli (131.4g) and Sinkara (85.8g). China (landrace) gave the lowest weight of 100 seeds of 50.6g followed by Yenyawoso (58.6g) and Sumnut-23 (60.0g) respectively (Table 2).

5.1.12. Harvest Index

Pod Harvest Index among the groundnut studied in 2015 major season ranged between the highest of 0.8798 to the lowest of 0.2252 (Table 2).

Sinkara recorded the highest mean pod harvest index (0.8798), followed by Sokan-donworoor (0.8739), Kpach-Isah (0.8318) and Kpanieli (0.8016) respectively, while Ndogba had the lowest mean pod harvest index (0.2252) followed by Oboshie (0.2709), Chaco-pag (0.3039) and F-Mix (0.3787) (Table 2).

5.1.13. Shelling Percentage (%)

The greatest mean shelling percentage of 84.02% was attained in Obolo and the lowest of 19.02% for Sokan-donworoor (Table 2). Yenyawoso (83.22%), Ndogba (82.96%), Oboshie (82.81%) and Chaco-pag (78.91%) were among the groundnut varieties that recorded high Shelling Percentage values in a respective order, as opposed to Sumnut-22 (22.62%), Simpelgu (29.15%), Kpach-Isah (30.22%) and Sumnut-22 (31.66%) which recorded low shelling percentage figures respectively (Table 2).

No.	Variety	50% Emergence(50%E), days $\overline{x}$ (S)	Days to 50% Flowering (50%F), days $\overline{x}$ (S)	Plant Height(PlHt), cm (75DAP) $\overline{x}$ (S)	Canopy Spread (CSprd) (57DAP), cm $\overline{x}$ (S)	Growth Habit (GrH)	Days to Maturity (DM), days
1	NkatieSari (SARI)	65.75 (13.96)^a	28.25 (1.26)^a	19.68 (47.47)^a	32.10 (14.90)^a	Erect/Bunch	100-115
2	Chaco-pag (Local)	55.25 (22.25)^a	29.00 (4.08)^a	14.53 (9.51)^a	33.10 (13.42)^a	Erect/Bunch	100-115
3	F-Mix (SARI)	68.50 (18.28)^a	27.75 (1.71)^a	14.01 (9.79)^a	36.11 (16.60)^a	Erect/Bunch	100-115
4	Sinkara (Local)	71.50 (19.55)^a	28.00 (2.31)^a	15.13 (10.36)^a	35.77 (15.73)^a	Erect/Bunch	100-115
5	Agric-Manipinta (Local)	55.25 (15.95)^a	28.50 (1.91)^a	17.05 (11.93)^a	40.33 (18.60)^a	Erect/Bunch	100-115
6	Ndogba (Local)	76.00 (14.90)^a	27.50 (1.00)^a	16.01 (10.69)^a	36.96 (17.40)^a	Semi-Erect/Bunch	85-90
7	Sumnut-23 (SARI)	77.75 (22.49)^a	27.25 (0.96)^a	13.99 (9.13)^a	33.52 (13.82)^a	Erect/Bunch	100-115
8	SokanDonworor (Local)	76.25 (16.86)^a	28.00 (1.63)^a	11.83 (7.56)^a	31.11 (13.71)^a	Erect/Bunch	100-115
9	Sumnut-22 (SARI)	60.75 (14.24)^a	29.50 (1.29)^a	13.57 (7.43)^a	33.06 (13.12)^a	Erect/Bunch	100-115
10	China (Local)	74.50 (9.88)^a	28.50 (1.73)^a	13.11 (8.25)^a	34.96 (12.94)^a	Erect/Bunch	85-90
11	Yenyawoso (CRI)	87.25 (6.18)^a	27.50 (1.73)^a	15.72 (11.40)^a	37.29 (17.25)^a	Semi-Erect	85-90
12	Simpelgu (Local)	65.75 (17.46)^a	28.75 (2.22)^a	12.73 (10.90)^a	33.64 (16.82)^a	Runner/Trailing	85-90
13	Oboshie (CRI)	76.25 (15.78)^a	28.50 (2.08)^a	16.71 (10.78)^a	35.88 (16.84)^a	Semi-Erect	100-115
14	Kpach-Isah (Local)	69.25 (24.16)^a	28.75 (1.89)^a	17.35 (10.89)^a	36.42 (16.96)^a	Runner/Trailing	85-90
15	Kpanieli (SARI)	44.50 (21.00)^a	31.25 (2.50)^a	10.68 (6.00)^a	30.85 (11.24)^a	Erect/Bunch	100-115
16	Obolo (CRI)	82.25 (4.65)^a	28.25 (1.50)^a	13.29 (9.40)^a	33.55 (14.77)^a	Semi-Erect	100-115

Table 2: Mean Performance of Groundnuts Studied

*NB: *(S): Sample Standard Deviation, Growth Habit: (Erect and Bunch, Semi-Erect or Runner and Trailing), CSIR: Council for Scientific and Industrial Research, SARI: Savanna Agriculture Research Institute, Ghana, CRI: Crops Research Institute, 'Local'= Landrace: Farmers' Popular and Locally Adapted Groundnut Variety. LSD (Means Sharing a Letter in a Group Label are Not Significantly Different at the 5% Level)*

No.	Variety	Pod Yield (PY), g/plot	Pod Weight (PdWt), g	Seed Weight (SdWt), g	100 Seed Weight (SW_{100}), g	Biomass Weight (Bio), g	Harvest Index (HI)	Shelling % (%S), %
1	Nkatie-Sari (SARI)	293^{a}	258^{a}	84^{c}	65.7^{b}	351.18^{bc}	0.7347^{a}	32.56^{b}
2	Chaco-pag (Local)	157^{b}	147^{c}	116^{b}	73.7^{b}	483.64^{ab}	0.3039^{c}	78.91^{a}
3	F-Mix (SARI)	119^{c}	221^{b}	92^{c}	75.2^{b}	583.5^{d}	0.3787^{c}	41.63^{ab}
4	Sinkara (Local)	342^{a}	229^{b}	166^{b}	85.8^{b}	260.29^{a}	0.8798^{a}	55.7^{ab}
5	Agric-Manipinta (Local)	217^{b}	228^{b}	126^{b}	70.7^{b}	512.13^{c}	0.4452^{ab}	55.26^{ab}
6	Ndogba (Local)	193^{b}	135^{c}	112^{b}	62.6^{b}	599.42^{d}	0.2252^{c}	82.96^{a}
7	Sumnut-23 (SARI)	204^{b}	259^{a}	82^{c}	60^{b}	482.83^{ab}	0.5364^{ab}	31.66^{b}
8	Sokan-Donworor (Local)	340^{a}	279^{a}	78^{c}	67.6^{b}	307.83^{a}	0.8739^{a}	19.02^{c}
9	Sumnut-22 (SARI)	334^{a}	389^{a}	88^{c}	72^{b}	650^{d}	0.5985^{b}	22.62^{c}
10	China (Local)	263^{a}	226^{b}	106^{b}	50.6^{b}	466.29^{ab}	0.4847^{b}	46.9^{ab}
11	Yenyawoso (CRI)	259^{a}	149^{b}	124^{b}	58.6^{b}	380.86^{bc}	0.3912^{ab}	83.22^{a}
12	Simpelgu (Local)	225^{a}	247^{b}	72^{c}	62^{b}	508.9^{c}	0.4854^{ab}	29.15^{b}
13	Oboshie (CRI)	132^{b}	159^{b}	159^{b}	135.3^{a}	587.02^{c}	0.2709^{c}	82.81^{a}
14	Kpach-Isah (Local)	126^{b}	228^{b}	84^{c}	77.5^{b}	274.12^{a}	0.8318^{a}	30.22^{b}
15	Kpanieli (SARI)	241^{b}	302^{a}	166^{b}	131.4^{a}	321.85^{a}	0.8016^{a}	54.97^{ab}
16	Obolo (CRI)	178^{b}	169^{b}	142^{b}	72.9^{b}	345.73^{a}	0.4888^{ab}	84.02^{a}

Table 3: Mean Performance of Groundnuts Based on Yield and Yield Components in the Earliness Screening
NB: CSIR-Council for Scientific and Industrial Research,SARI – Savanna Agriculture Research Institute, Ghana, CRI – Crops Research Institute, 'Local' = Landrace - Farmers' Popular and Locally-Adapted Groundnut Variety, LSD (Means Sharing a Letter in a Group Label are Not Significantly Different at the 5% Level

5.2. Rankingof Groundnuts for Earliness

Based on the performance of the sixteen (16) groundnut genotypes presented in Tables 2 and 3,the evaluated genotypes were classified (based on simple ranking) into two main groups as per their days to maturity (Table 4):
Group 1: Early maturing genotypes (85 to 90 days) - five (5) varieties
Group 2: Intermediate to late maturing genotypes (100 to 115 days) - Eleven (11) varieties
The top five (5) genotypes selected as early maturing varieties based on maturity period were; Ndogba (landrace), Chinese (Landrace), Yenyawoso (CRI), Simpelgu (Landrace) and Kpach-Isah (Landrace) (Table 4).

No.	Variety	50% Emergence, Days $\overline{x}$ (S)	Plant Height, Cm $\overline{x}$ (S)	Canopy Spread, Cm $\overline{x}$ (S)	Days To 50% Flowering, Days $\overline{x}$ (S)	Growth Habit (Grh)	DAYS To Maturity (DM), Days
1	Ndogba (Local)	76.00 (14.90)[a]	16.01 (10.69)a	36.96 (17.40)[a]	27.50 (1.00)[a]	Erect/Bunch	85-90
2	China (Local)	74.50 (9.88)[a]	13.11 (8.25)a	34.96 (12.94)[a]	28.50 (1.73)[a]	Erect/Bunch	85-90
3	Yenyawoso (CRI)	87.25 (6.18)[a]	15.72 (11.40)a	37.29 (17.25)[a]	27.50 (1.73)[a]	Semi-Erect	85-90
4	Simpelgu (Local)	65.75 (17.46)[a]	12.73 (10.90)a	33.64 (16.82)[a]	28.75 (2.22)[a]	Runner/Trailing	85-90
5	Kpach-Isah (Local)	69.25 (24.16)[a]	17.35 (10.89)a	36.42 (16.96)[a]	28.75 (1.89)[a]	Runner/Trailing	85-90
6	NkatieSari (SARI)	65.75 (13.96)[a]	19.68 (47.47)a	32.10 (14.90)[a]	28.25 (1.26)[a]	Erect/Bunch	100-115
7	Chaco-pag (Local)	55.25 (22.25)[a]	14.53 (9.51)a	33.10 (13.42)[a]	29.00 (4.08)[a]	Erect/Bunch	100-115
8	F-Mix (SARI)	68.50 (18.28)[a]	14.01 (9.79)a	36.11 (16.60)[a]	27.75 (1.71)[a]	Erect/Bunch	100-115
9	Sinkara (Local)	71.50 (19.55)[a]	15.13 (10.36)a	35.77 (15.73)[a]	28.00 (2.31)[a]	Erect/Bunch	100-115
10	Agric-Manipinta (Local)	55.25 (15.95)[a]	17.05 (11.93)a	40.33 (18.60)[a]	28.50 (1.91)[a]	Erect/Bunch	100-115
11	Sumnut-23 (SARI)	77.75 (22.49)[a]	13.99 (9.13)a	33.52 (13.82)[a]	27.25 (0.96)[a]	Erect/Bunch	100-115
12	SokanDonworor (Local)	76.25 (16.86)[a]	11.83 (7.56)a	31.11 (13.71)[a]	28.00 (1.63)[a]	Erect/Bunch	100-115
13	Sumnut-22 (SARI)	60.75 (14.24)[a]	13.57 (7.43)a	33.06 (13.12)[a]	29.50 (1.29)[a]	Erect/Bunch	100-115
14	Oboshie (CRI)	76.25 (15.78)[a]	16.71 (10.78)a	35.88 (16.84)[a]	28.50 (2.08)[a]	Semi-Erect	100-115
15	Kpanieli (SARI)	44.50 (21.00)[a]	10.68 (6.00)a	30.85 (11.24)[a]	31.25 (2.50)[a]	Erect/Bunch	100-115
16	Obolo (CRI)	82.25 (4.65)[a]	13.29 (9.40)a	33.55 (14.77)[a]	28.25 (1.50)[a]	Semi-Erect	100-115

Table 4: Ranking of Groundnut Genotypes Based on Maturity and Mean Performance for Other Traits
Note: Means Sharing Letter in the Group Label is not significantly different at the 5% Level.
**(S): Sample Standard Deviation,Growth Habit, GRH: (Erect/Bunch Or Runner/Trailing), CSIR-Council For Scientific and Industrial Research, SARI – Savanna Agriculture Research Institute, Ghana, CRI – Crops Research Institute, 'Local'- Farmers' Popular and Locally-Adapted Landrace, 'China' = 'Chinese'*

5.3. Clustering of Groundnuts Based on Earliness and Performance for Other Traits

Based on days to maturity, percentage emergence and days to 50% flowering, the groundnut genotypes were used to draw a cluster diagram (dendrogram) (Figure 8). At a relative rescaled Euclidian distance of 20, the dendrogram showed two major clusters, 'I' and 'II', with cluster 'I' producing two sub-clusters; Ia and Ib. Sub-cluster group Ia contained seven (7) groundnut genotypes, and Ib had six (6) genotypes. Out of the sixteen groundnut accessions evaluated, all the five (5) early maturing varieties selected (Ndogba, Chinese, Yenyawoso, Simpelgu, Kpach-Isah), that matured between 85 and 90 DAP clustered under cluster group 'I'. Sub-cluster group Ia contained three (3) early maturing genotypes, Ndogba, Chinese and Yenyawoso, whereas sub-cluster group Ib also contained two early-maturing genotypes, Simpelgu and Kpach-Isah. The early-maturing groundnut genotypes are indicated on the dendrogram by the arrows labeled 1-5. The smallest cluster, II, contained three late maturing (100-115DAP) groundnut genotypes; Chaco-pag, Agric-Manipinta and Kpanieli (Figure1).

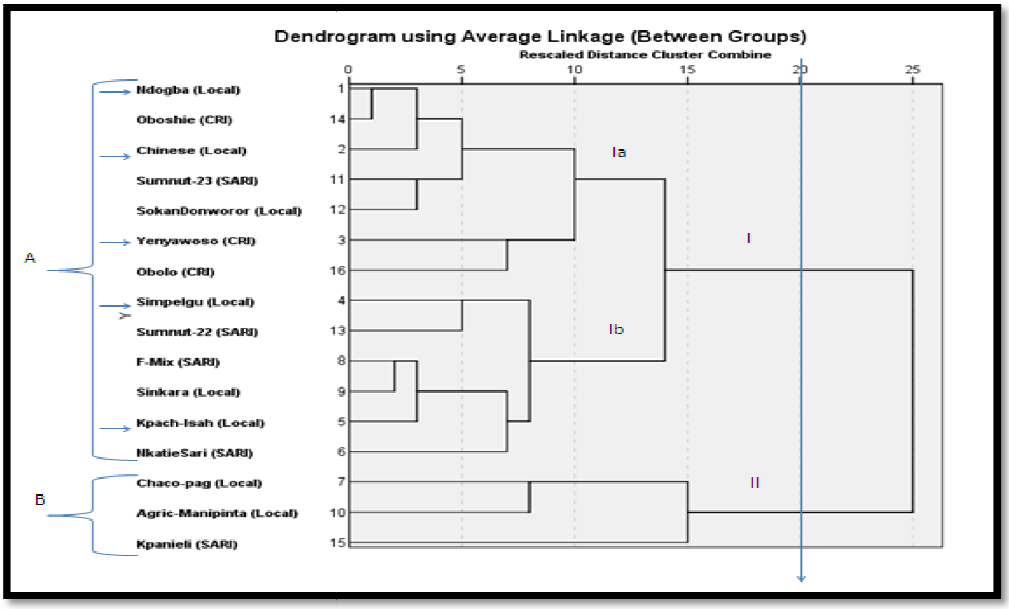

Figure 1: Dendrogram of Groundnut Accessions Generated by SPSS Vs12 Pc Software Based on Euclidean Distance
NB: Arrow Shows Groundnut Varieties with Early Maturity (85-90 Days; Numbered 1 to 5)

5.4. Disease Score and Ranking – (Visual Ratings)

Diseases that were scored among the groundnut varieties include Early Leaf Spot, Late Leaf Spot, Rust and Rosette diseases (Table 5).

Severity of each disease incidence which was scored on a scale of 1-5, as defined in Section 4.3.4.c (Oluronju et al., 1991),is presented in(Table 5).

From the current study, and based on the scoring scale under Table 5;

- Four (4) Early Leaf Spot tolerant and Nine (9) moderately tolerant varieties were recorded.
- Nine (9) moderately tolerant and Four (4) Tolerant Late Leaf Spot varieties were scored.
- Ten (10) varieties were highly tolerant and ten (10) were tolerant to the Rust disease of groundnut.
- Generally, all the groundnut varieties were tolerant to Rosette disease of groundnut. Fourteen (14) varieties were scored highly tolerant while two (2) exhibited tolerance to Rosette (Table 5).

No.	Variety	Early Leaf Spot	Late Leaf Spot	Rust	Rosette
1	NkatieSari (SARI)	1	1	1	1
2	Chaco-pag (Landrace)	3	3	1	2
3	F-Mix (SARI)	1	1	1	1
4	Sinkara (Landrace)	2	2	1	1
5	Agric-Manipinta (Landrace)	1	1	1	1
6	Ndogba (Landrace)	3	3	2	2
7	Sumnut-23 (SARI)	3	3	2	1
8	SokanDonworor (Landrace)	3	3	2	1
9	Sumnut-22 (SARI)	3	3	2	1
10	China (Landrace)	3	3	2	1
11	Yenyawoso (CRI)	3	2	1	1
12	Simpelgu (Landrace)	2	3	1	1
13	Oboshie (CRI)	2	2	1	1
14	Kpach-Isah (Landrace)	3	3	2	1
15	Kpanieli (SARI)	1	1	1	1
16	Obolo (CRI)	3	3	1	1

Table 5: Disease Score and Ranking, based on Visual Rating Assessment

Disease Score (Scale: 1-5): Key: Highly Tolerant (1), Tolerant (2), Moderately Tolerant (3), Susceptible (4), Highly Susceptible (5).CSIR-Council for Scientific and Industrial Research, SARI – Savanna Agriculture Research Institute, Ghana, CRI – Crops Research Institute, Landrace - Farmers' popular locally-adapted groundnut variety

5.5. Correlation Coefficients for Growth Parameters

From Table 6, growth parameters measured among the groundnut genotypes revealed significant but negative correlation ($p \leq 0.05$) between days to emergence and days to 50% flowering ($r = -0.7962$). Plant height among the groundnuts correlated positively and significantly ($p \leq 0.05$) with canopy spread ($r = 0.5117$) (Table 6).

	Days to 50% Emergence	Plant Height (Cm)	Canopy Spread	Days to 50% Flowering
Days to 50% Emergence	_			
Plant height (cm)	0.1516	_		
Canopy spread	0.2115	0.5117*	_	
Days to 50% flowering	-0.7962*	-0.3854	-0.4208	_
Days to maturity	0.3158	-0.1810	0.3912	-0.1286

Table 6: Correlation Performance for Growth Parameters
*Significant at *P ≤0.05*

5.6. Correlation Coefficients for Yield and Yield Parameters

The results in Table 7 of the current study indicate that, among the yield and yield components of the groundnut genotypes studied in the 2015 major season, pod yield was correlated positively and significantly ($P \leq 0.05$) with pod weight ($r = 0.5606$) and harvest index ($r = 0.5594$). Pod weight correlated negatively and significantly ($P \leq 0.05$) with

shelling % (r = -0.8132). Seed weight correlated positively and significantly (P ≤ 0.05) with 100 seed weight (r = 0.6752) and shelling percentage (r = 0.6982). Biomass (haulm) weight, however, recorded a negative but significantly (P ≤ 0.05) correlation with harvest index (r = -0.7572). Similarly, there was a negative and significant (P ≤ 0.05) association between shelling percentage and harvest index at r = -0.6216 (Table 7).

	Pod yield	Pod weight	Seed weight	100seed weight	Biomass	Shelling %
Pod yield	-					
Pod Weight	0.5606*					
Seed weight	-0.0475	-0.3189				
100 seed weight	-0.2281	0.0392	0.6752*			
Biomass	-0.2826	-0.0088	-0.1983	-0.0536		
Shelling %	-0.3915	-0.8132*	0.6982*	0.2626	0.0990	
Harvest Index	0.5594*	0.6172	-0.0600	0.0975	-0.7572*	-0.6216*

Table 7: Correlation Performance for Yield and Yield Components

6. Discussion

6.1. AgronomicPerformance of Early Maturity Groundnuts

The mean 50% emergence of the groundnut genotypes ranged from 44.50% to 87.25% after one week of sowing. However, there was no significant difference (P ≥ 0.05) among the treatment means for days to 50% emergence. On the average, most of the varieties showed shorter period of emergence. The early emergence of approximately 7 days maximumcould be attributed to adequate soil moisture coupled with ideal temperatures during the time seeds were sown. Days to 50% flowering showed no significant (P ≤ 0.05) difference among the groundnut varieties. Mean number of days to 50% flowering among the varieties ranged from 27.25 – 31.25 DAP. Differences in average flowering, pegging and podding among the groundnut genotypes could be due to varietal trait differences and genetic potential of the genotypes. Groundnut varieties of Spanish type were early maturing. Podding, however, occurred earlier in all the variety treatments. Boote and Ketring (1990) have reported that the start of flowering as well as pod formation could be delayed by moisture stress. On the other hand, adequate or excess soil moisture during the first two months after planting can trigger excessive vine growth in groundnuts (Wright *et al.*, 2009).

Generally, the differences in rainfall between the two growing locations or environments very likely influenced the phenological development of the groundnut including pegging and podding. Ideal temperature range for groundnut seed germination was reported by De-Waele and Swanevelder (2001) as 20 to 35^{o}C. They indicated that, in moist and warm soils, groundnut seeds germinated within 7 days after sowing. However, in dry and cooler soils, germination took much time, up to two or three weeks. Adu-Dapaah *et al.* (2007), found similar results in a separate study.

Plant height for all treatments at 27 DAP increased at all sampled times. There were significant difference (P ≤ 0.05) in height among varieties 75 DAP. Nkatie-sari (SARI) recorded the highest height (19.68 cm) while Kpanieli (SARI) recording the lowest of 10.68 cm.

Plant height as a quantitative growth parameter is a genetic attribute, but can be influenced by environmental factors, mainly soil moisture and weeds. The influence of variety and plant growth habit on plant height was very significant among the groundnut genotypes. Bunch and erect (or semi-erect) as well as runner or trailing (spreading) groundnut types were two major growth habits or features observed in the current study, and these traits are controlled by genetics. At much closer spacing, plants compete for light and grow taller, a phenomenon common with crowded plants. Ahmed and Mohammad (1997) and ICRISAT (1992) have reported that, differences in plant stand could be attributed to genetic and environmental factors such as amount of soil moisture and temperature as well as soil and disease factors affecting seedling emergence and survival. At much closer spacing, plants compete for light and grow taller, a phenomenon common with crowded plants. This corroborates the research findings of Farnham (2001), who indicated that there is intense competition for light by closely spaced crops compared to widely spaced crops. Mozingo and Steele (1989) also reported earlier that increasing intra-row spacing among five groundnut cultivars resulted in decreased main stem height and lateral branch length which obviously decreased plant height.

Earliness is determined by the number of days from sowing through to flowering to podding. Days to maturity of groundnut plants in this study recorded as early as 85 DAP to as late as 115 DAP. Groundnut accessions that matured between 85-90 days were classified as early-maturing varieties. Eleven groundnut accessions attained maturity between 100 to 115 days, and were therefore classified as intermediate to late - maturing varieties.

Diseases that were scored among the groundnut varieties were Early Leaf Spot, Late Leaf Spot, Rust and Rosette diseases. Severity of each disease incidence was scored on a scale of 1-5. Groundnut rosette disease is reported to be the most destructive disease of groundnut in Sub-Saharan Africa and widely prevalent in Ghana. Olurunju *et al*. (1991 and 1992), in their study of groundnut Rosette disease and its inheritance, in relation to yield, found results that are generally similar to those found in the current study. A study by Adu-Dapaah *et al*. (2007) indicated that, farmers preferred groundnut varieties (such as 'Chinese', 'Nkosour' and 'Nkatie-Sari') to other varieties because of their resistance to rosette and leaf spots (early and late leaf spots). This study however, did not show any significant influence of diseases such as Rust and

Rosette, irrespective of the varieties, spacing and locations used. Indeed, incidence and severity of the disease on all varieties and at all planting location and spacing were low indicating that there was low disease pressure in the study areas. The history of the experimental planting fields at the different locations indicated that they had not been cropped to legumes (including groundnuts), hence, the Rosette or early and late leaf spot disease pathogens or alternate hosts may have wiped out or become extinct.

Analysis of variance (ANOVA) for pod yield indicates that, the genotypes performed significantly different under the two planting locations or environments. This implies that the difference between genotype performances was significantly affected by the two experimental locations, and the differences in the amount of water or rainfall as well as other climatic variables (Songsri *et al*., 2009). Consequently, the genotypes showed varied performances between the two environments, for all tested traits. Significant differences ($p \leq 0.05$) were observed among the genotypes for all the traits measured, chiefly pod yield, biomass and harvest index.

Summarily, five (5) early maturing groundnut varieties, Ndogba (landrace), Chinese (Landrace), Yenyawoso (CRI), Simpelgu (Landrace) and Kpach-Isah (Landrace), which matured in about 85 to 90 days were identified. These selected varieties reached 50% flowering within 27.5 to 28.75 days after planting. The groundnut variety, Chinese (a popular landrace) also identified as early maturing, was identified during a PRA study (Oppong-Sekyere *et al*., 2015) as one of the farmers' preferred varieties. This, among others, could form part of several breeding programmes as an important source of earliness traits. ICRISAT, as part of its several breeding programmes, uses early maturing varieties as source of earliness parents (Upadhyaya *et al.*, 2006). Other eleven varieties identified in this study are intermediate to late varieties which recorded maturity dates between 100 and 115 days after planting. Therefore, genes of earliness from the early maturing varieties identified in this study can be introgressed into farmers' preferred varieties to improve those varieties for earliness through hybridization. Moreover, information generated from this screening is useful for creating a mini-core collection for further breeding studies. The identified early-maturing groundnut varieties were also generally resistant to diseases (early and late leaf spots, Rosette, Rust)**.** These varieties could as well form part of a programme aimed at breeding for diseases resistance in groundnut.

Days to maturity determine differences in pod yield (Culbreath*et al*., 1999; Padi, 2008). In general, late maturing genotypes yield better than early maturing genotypes. Late maturing varieties do take advantage of delayed rains and enjoy full season benefits, hence generally produce higher yields. Extremely early maturity is not desirable because it is generally associated with yield reduction. Earliness in groundnuts can result in germinations in pod (vivipary) in genotypes without fresh seed dormancy. Such crops may not have used all the available resources across the entire growing season (Adu-Dapaah *et al*., 2007). However, in the current study, groundnut varieties that exhibited early maturity also showed good performance for pod yield. These varieties include 'Chinese' (263 pods/10 plants), 'Yenyawoso' (259/10 plants), 'Simpelgu' (225/10 plants), 'Ndogba' (193/10 plants) and 'Kpach-Isah' (126/10 plants). They also recorded relatively high harvest indices; Chinese (0.4847), Yenyawoso (0.3912), Simpelgu (0.4854), Ndogba (0.2252) and Kpach-Isah (0.8318). The relatively high and well distributed rainfall at the two experimental locations may have contributed greatly to the higher pod yield.

7. References

i. Abdullah, T., Rahmianna A. A., Hardaningsih, S and Rozi, F. (2007). Increasing Groundnut Yield on Dry Land Alfisols in Indonesia. Journal of SAT Agricultural Research, 5(1).

ii. Adu-Dapaah, H. K., Asumadu, H., Lamptey, J. N. L., Haleegoah, J and Asafo-Adjei, B. (2007). Farmer Participation in Groundnut Varietal Selection. African Crop Science Conference Proceedings, 8: 1435 – 1439.

iii. Ahmad, N and Mohammad, R. (1997). Evaluation of Promising Groundnut (Arachis hypogaea) Varieties for Yield and other Characters. Crop and Soil Sc., Vol. Pp.251.

iv. Ali, N and Malik, N. S. (1992). Performance of Short Duration Groundnut Lines Suitable to Increase Cropping Intensity in Rainfed Areas of Pakistan. In: Nigam S.N. (ed.), Groundnut - A Global Perspective. International Crop Research Institute for the Semi-Arid Tropics (ICRIAT), Patancheru, India, p. 433.

v. Arunyanark, A., Jogloy, S., Akkasaeng, C., Kesmala, T., Nageswara Rao, R. C., Wright, G and Patanothai, A. (2008). Chlorophyll Stability is an Indicator of Drought Tolerance in Peanut. Journal of Agronomy and Crop Science. 194(2):113-125.

vi. Arunyanark, A., Jogloy, S., Wongkaewb, S., Akkasaenga, C., Vorasoota, N., Kesmalaa, T and Patanothaia, A. (2010). Heritability of Aflatoxin Resistance Traits and Correlation with Drought Tolerance Traits in Peanut. Field Crops Research, 117, 258-264.

vii. Arunyanark, A., Jogloya, S., Wongkaewb, S., Akkasaenga, C., Vorasoota, N., Kesmalaa, T and Patanothaia, A. (2010). Heritability of Aflatoxin Resistance Traits and Correlation with Drought Tolerance Traits in Peanut. Field Crops Research, 117, 258-264.

viii. Banerjee, K., Sounda, G and Mandal, A. (2005). Effects of Different Level of Irrigation and Cobalt on Growth and Nodulation of Summer Groundnut (Arachis hypogaea L.). Journal of Interacademicia, 9(2): 235-241.

ix. Bell, M. J., Harch, G and Wright, G. C. (1991). Plant Population Studies in Peanut (Arachis hypogaea L.) in Sub-Tropical Australia: Growth under Fully-Irrigated Conditions. Australian Journal of Agriculture, 31: 535 – 543.

x. Boote, K. J and Ketring, D. L. (1990). Peanut. In: Stewart B.A and Nielson D.R. (Eds), Irrigation of Agricultural Crops. Asa-Groundnut. A Global Perspective. International Crops Research CSSA-SSSA, Madison, 41(1), pp 75–88.

xi. Brown, O and Crawford, A. (2008). Climate Change: A Threat to Stability in West Africa? Evidence from Ghana and Burkina Faso. African Security Review, 17(3), 39–57.

xii. Camberlin, P and Diop, M. (1999). Inter-relationships between Groundnut Yields in Senegal, Inter Annual Rainfall Variability and Sea Surface Temperatures. Theoretical and Applied Climatology, 63, 163-181.

xiii. Chapman, R. S and Carter, P. L. (2000). Crop Production: Principles and Practices. Surjeet publications, Delhi, India. Pp. 256.

xiv. Cobbinah, P. B and Anane, G. K. (2015). Climate Change Adaptation in Rural Ghana: Indigenous Perceptions and Strategies, Climate and Development, DOI: 10.1080/17565529.2015.1034228.

xv. Collino, D. J., Dandanelli, J. L., Sereno, R and Racca, R. W. (2001). Physiological Responses of Argentine Peanut Varieties to Water Stress. Light Interception, Radiation Use Efficiency and Partitioning Assimilate. Field Crops Research, 70, 177-184.

xvi. De Waele, D and Swanevelder, C. J. (2001). Groundnut (Arachis hypogaea L.) in Crop Production in Tropical Africa. Goikint Graphics nv. - Belgium. pp. 746-763.

xvii. Dedzoe, C. D., Senayah, J. K and Asiamah, R. D. (2001). Suitable Agro-ecologies for Cashew (Anacardiumoccidentale L.) Production in Ghana. West African Journal of Applied Ecology, 2, 102–115.

xviii. Farnham, D. E. (2001). Row Spacing, Plant Density, and Hybrid Effects on Corn Grain Yield and Moisture. Agron. J., 93:1049-1053.

xix. Feng, X., Yang, R., Zheng, X., Zhang, F. (2012). Identification of a Novel Nuclear-Localized Adenylate Kinase 6 from Arabidopsis thaliana as an Essential Stem Growth Factor. Plant PhysiolBiochem,61:180-186.

xx. Getamap (2006). Northern Region/Ghana.: Available from www.getamap.net. [Accessed 22 October, 2016].

xxi. Girdthai, T., Jogloy, S., Vorasoot, N., Akkasaeng, C., Wongkaew, S., Holbrook, C. C and Patanothai, A. (2010). 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, 118, 169-176.

xxii. Girdthai, T., Jogloy, S., Vorasoot, N., Akkasaeng, C., Wongkaew, S., Holbrook, C. C and Patanothai, A. (2010). Associations between Physiological Traits for Drought Tolerance and Aflatoxin Contamination in Peanut Genotypes under Terminal Drought. Plant Breeding,129, 693-699.

xxiii. ICRISAT. (1992). ICRISAT Groundnut: A Global Perspective. Proceedings of an international workshop, 25-29. Nov. 1991, ICRISAT Centre.

xxiv. ICRISAT. (1994). ICRISAT West African Programs' annual report, 1993. Niger: ICRISAT. 345p.

xxv. Jongrungklang, N., Toomsan, B., Vorasoot, N., Jogloy S., Kesmala, T and Patanothai, A. (2008). Identification of Peanut Genotypes with High Water-Use Efficiency under Drought Stress Conditions from Peanut Germplasm of Diverse Origins. Asian Journal of Plant Sciences, 7, 628-638.

xxvi. KANG, Hee Wan; CHO, Yong Gu; YOON, Ung Han and EUN, Moo Young. (1998). A Rapid DNA Extraction Method for RFLP and PCR Analysis from a Single Dry Seed. Plant Molecular Biology Reporter, March 1998, Vol. 16, no. 1, p. 90.

xxvii. KANG, Hee Wan; CHO, Yong Gu; YOON, Ung Han and EUN, Moo Young. (1998). A Rapid DNA Extraction Method for RFLP and PCR Analysis from a Single Dry Seed. Plant Molecular Biology Reporter, March 1998, Vol. 16, no. 1, p. 90.

xxviii. Kumar, M. A and Venkatachari, A. (1971). Studies on the Effect of Intra-Row Spacing and Fertility Levels on the Yield and Quality of Two Varieties of Groundnut (Arachis hypogaea L.). Indian Journal of Agricultural Research,5:67 – 69.

xxix. Marrewijk, W. K and Louwaars, A. K. (1992). Seed Supply System in Developing Countries. CTA, Netherlands, pp. 1.

xxx. Mozingo, R. W and Steele, J. L. (1989). Intra-row Seed Spacing Effects on Morphological Characteristics, Yield, Grade and Net Value of Five Peanut Cultivars. Peanut science,16:95 – 99.

xxxi. Naab, J. B., Boote, K. J. Prasad, P. V. V, Seini, S. S and Jones, J. W. (2009). Influence of Fungicide and Sowing Density on the Growth and Yield of Two Groundnut Cultivars. Journal of Agric Sci. 147: 179 – 191.

xxxii. Olorunju, P. E., Kuhn, C. W., Demski, J. W., Misari, S. M and Ansa, O. A. (1992). Inheritance of Resistance in Peanut to Mixed infections of Groundnut Rosette Virus (GRV) and Groundnut Rosette Assistor Virus and a Single Infection of GRV. Plant Disease. 76:95-100.

xxxiii. Olurunju, P. E., Kuhn, C. W., Demski, J. W., Misari, S. M and Ansa, A. O. (1991). Disease Reactions and Yield Performance of Peanut Genotypes Grown Under Groundnut Rosette and Rosette Free Environments. Plant Dis.75:1269 – 1273.

xxxiv. Oppong-Sekyere, D., R. Akromah, M.M. Akpalu, A.D. Ninfaa, E.Y. Nyamah, M.M. Braimah and A-R. S. Salifu (2015). Participatory Rural Appraisal of Constraints to Groundnut (Arachis hypogaea L.) Production in Northern Ghana Int.J.Curr.Res.Aca.Rev.2015; 3(10): 54-76.

xxxv. Padi, F. K., Adams, F and Kombiok, J. M. (2006). Registration of Foliar Disease Resistant and High Yielding Groundnut Varieties ICGV 92099 and ICGV 90084. International Arachis Newsletter, No. 26, pp. 22 – 23.

xxxvi. Padi, F.K. (2008). Genotype × Environment Interaction for Yield and Reaction to Leaf Spot Infections in Groundnut in Semi-arid West Africa: Genotype × Environment Interaction and Leaf Spot Resistance in Groundnut. Euphytica, 164, 143-161.

xxxvii. Reddy, T.Y., Reddy V.R and Anbumozhi, V. (2003a). Physiological Responses of Groundnut (Arachis hypogea L.) to Drought Stress and its Amelioration: A Critical Review. PlantGrowth Regulation, 41: 75-88.

xxxviii. Reddy, T.Y., Reddy V.R and Anbumozhi, V. (2003b). Physiological Responses of groundnut (Arachis hypogaea L.) to Drought Stress and its Amelioration: A Review. Acta Agronomica Hungarica, 51: 205-227.

xxxix. Singh, R. P., Kumar, R., Singh, M and Karwara, S. P. S. (1988). Symposium: Peanut Use in Efficient Cropping Systems Semi-Arid Zones of India. Jan 7-10. Abstract, p.5.

xl. Sugri, I., Abdulai, M.S., Larbi, A. (2015). Participatory Variety Selection of Okra (Abelmoschus esculentus L.) Genotypes for Adaptation to the Semi-arid Agro-ecology of Northern Ghana. Afr. J. Plant Sci. 9: 466–475. hdl.handle. net/10568/72658.

xli. Tanka, T., Tanaka H., Machida C., Watanabe M and Machida Y. (2004). A New Method for Rapid Visualization of Defects in Leaf Cuticle Reveals Five Intrinsic Patterns of Surface Defects in Arabidopsis. The Plant Journal, 37, 139-146.

xlii. Varshney, R.K., Hoisington, D.A and Tyagi, A.K. (2006). Advances in Cereal Genomics and Applications in Crop Breeding. Trends Biotechnol. 2006; 24:490 - 499.

xliii. Virender, S and Kandhola, S.S. (2007). Productivity of Semi-Spreading and bunch-type varieties of groundnut as influenced by sowing dates. Journal of SAT Agricultural Research, 5 (1): 1 – 3.

xliv. Virk, A.S., Kaul, J.N., Bhangoo, B.S and Singh, A. (2005). Influence of Planting Techniques and Plant Population on Biology and Pod productivity of Summer Groundnut varieties. Research on crops, 6(1): 173 – 174.

xlv. Vorasoot, N., Akkasaeng C., Songsri P., Jogloy S and Patanothai A. (2004). Effect of Available Soil Water on Leaf Development and Dry Matter Partitioning in 4 Cultivars of Peanut (Arachis hypogaea L.). Journal of Science and Technology, 26, 787-794.

xlvi. Vorasoot, N., Songsri, P., Akkasaeng, C., Jogloy, S., and Patanothai, A. (2003). Effect of Water Stress on Yield and Agronomic Characters of Peanut. Journal of Science and Technology, 25, 283-288.

xlvii. Williams, E.J and Drexler J.S. (1981). A Non-Destructive Method for Determining Peanut Pod Maturity, Pericarp, Mesocarp, Color, Morphology and Classification. Peanut Science, 8, 134-141.

xlviii. Wright, D. L., Tillman, B., Jowers, E., Marios, J., Ferell, J. A., Katsvairo, T and Whitty, E. B. (2009). Management and Cultural Practices for Peanuts. Publication # SS – AGR – 74 (www.edis.ifas.ufl.edu (23/4/2010).

xlix. Wuma, H., Jogloy S., Toomsan, B and Sanitchon. J. (2009). Response to Early Drought for Traits Related to Nitrogen Fixation and their Correlation to Yield and Drought Tolerance in Peanut (Arachis hypogaea L.). Asian Journal of Plant Sciences, 8, 138-145.

Appendix

Month & Year	Temperature (°C) Min.	Max.	Relative Humidity (%)	Rainfall (mm)	Sunshine Hours
May, 2015	22.8	33.0	82	185.8	5.3
June, 2015	22.5	31.4	85	279.8	4.6
July, 2015	22.3	29.8	88	145.0	3.3
August, 2015	20.8	29.5	88	164.5	3.4
September, 2015	21.3	30.0	87	148.9	3.3
October, 2015	21.6	31.3	85	95.8	5.7
November, 2015	22.2	32.7	84.20	30.7	4.8

Table 8: Mean Monthly Climatic Data of Experimental Location during Period of Study, SARI, Nyankpala, Tamale, N/R

Month	2016						2017			2018	
	Rainfall (mm)	Temp (°C)		R. Humidity (%)		Sunshine duration (hrs.)	Rainfall (mm)	Temp (°C)		R. Humidity (%)	Sunshine duration (hrs)
		Max	Min	High	Low			Max	Min	High	Low H Max Min H L Sun.
January		34.0	19.9	25	11			35.9	20.6	23	13 8.2 35 19.1 25 11 7.5
February		37.9	22.1	29	09			38.3	24.0	21	11 38 23.7 3720 7.4
March		39.3	25.7	54	28			41.3	26.2	50	24 8.5 39.7 26.7 59 29 7.3
April		39.6	27.4	73	37	7.7		40.7	27.5	63	32 8.3 39.5 27.4 65 337.4
May		37.1	26.3	79	46			36.4	25.7	79	47 8.0
June		33.5	24.6	83	57			32.9	24.3	87	59
July		31.4	23.5	91	65	6.3		31.6	23.7	91	66
August		31.1	23.6	90	68	5.6		30.9	23.3	91	69 5.8
September		31.5	22.7	93	67	6.6		31.5	23.2	93	67 6.2
October		34.0	22.9	86	51	8.1		35.3	21.7	79	44 8.2
November		38.0	22.1	65	32	7.9		35.9	20.9	53	22 8.1
December		37.0	21.2	29	15	7.9		35.5	20.6	29	17 7.4
Total		424.4	282	797	486			426.2	281.7	759	471

Table 9: Mean Monthly Climatic Data of Experimental Location during Period of Study, Department of Ecological Agric Bolgatanga Polytechnic, Bolgatanga, U/E

Lab. No.	Sample Id	Ph H_20 (1:2.5)	% Oc	% Om	% N	Mg/Kg P	Mg/Kg K	Mg/Kg Ca	Mg/Kg Mg	Texture			
										% SAND	% SILT	% CLAY	% LOAM
1	UDS FIELD	5.60	0.485	0.836	0.0464	6.04	72.97	185.84	47.59	68.32	30	1.68	

Table 10: Chemical Composition of Soil at the Experimental Field (Nyankpala-UDS Fields)

Lab. No.	Sample ID	pH H_20 (1:2.5)	% OC	% OM	% N	mg/Kg P	mg/Kg K	mg/Kg Ca	mg/Kg Mg	Mg/Kg Na	TEXTURE			
											% Sand	% Coarse Silt	% CLAY	% LOAM
1	Dep't of Eco. Agric Fields	6.1	0.36	0.62	0.03	2.3	0.1	3.2	1.34	0.04	77.0	4.0	12.0	5%

Table 11: Chemical Composition of Soil at the Experimental Field (Dep't of Ecological Agriculture, Bolga Poly)