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Phenotypic Variability for Tolerance to Drought Stress of Bambara Groundnut (Vigna Subterranea (L) Verda)

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Abstract:
Three varieties of bambara groundnut: Purple eyed (V_1), white eyed (V_2) and freckled (V3) were evaluated for phenotypic parameters in the Teaching and Research Farm, Ambrose Alli University, Ekpoma. The potted plant experiment was in 3x4 Factorial fitted in to Complete Randomized Design (CRD) with four replicates and watery regimes. Differences based on drought tolerance for phenotypic parameters were estimated under different watery regimes (R_1- 1 day (control), R_2-4 days, R_3-7 days and R_4-10 days). There were significant differences between all the water regimes applied. The watering regime (R_3) at seven days interval showed the highest mean values for the characters examined, while prolonged drought of 10days watering intervals recorded the least. Significant potentials exist for the improvement of the crop productivity by selecting plants that are better equipped especially to cope with drought. Phenotypic coefficients of variation (PCV) for pod length (17.0cm), 100 seed weight (338.41g) and yield/plant (96.6) were higher compared to other parameters studied. The white eyed variety (V2) is the most adapted for drought prone areas.

Keywords: *Phenotypic, variabilty, genotypic, heritability, genetic gain*

1. Introduction

Bambara groundnut (vigna subterranea (L.) verdc) is an indigenous crop that has been cultivated in Africa for centuries. It is a well-known crop in the whole of sub-Saharan Africa (Goli, 1997). Its cultivation seems to have preceded the introduction of the common groundnut (Arachis hypogaea). Bambara groundnut belongs to the family fabaceae, subfamily papilionoideae, although further refinement of its taxonomy has been undertaken in recent years (Goli, 1997).Cultivation of bambara groundnut is reported to have been carried out as far as India, Sri Lanka, Indonesia, the Philippines, Malaysia, New California and South America, particularly Brazil, but it seems that the present level of cultivation outside Africa is negligible.

The area under bambara groundnut cultivation in the Sahel and Sudan Savanna Zones of Nigeria has declined over the past two decades. Farmers in these areas estimated that present area under cultivation is about 5-20% of that of 20 years ago. According to Evans (1996) and Brink (1990), they attributed this declined to drought. The alternating wet and dry season (they later characterized by intense heat) causing a rapid decomposition of soil organic matter in the Savanna, which is the major bambara groundnut production area. Prolonged dry spells during the wet season, and the abrupt cessation of the rains prior to full crop maturity are perennial problems in the savanna ecological zones. Owonubi and Yayock (1997), reported that under these conditions, either the crop fails or growth is retarded, resulting in low yields.

Bambara nuts are adapted to both the poor and fertile soil of the whole continent. The plant produces seeds that are high in protein (14-24%) and carbohydrate (60%) content. The plant exhibits considerable tolerance and grows in soil with varied nutrient fertility including low and high nitrate levels. It produces yields in poor soil where no other crops can survive (Linnemman 1994).

Drought has become a very interesting topic since it is the most prevalent stress among environmental stress that tends to significantly affect crop yield. Drought as an environmental stress causes water deficit. Our local varieties of bambara groundnut in the hands of the indigenous farmers are underdeveloped in terms of agronomic yield and adaption to drought. It adversely affected crops but the magnitude of effects will vary with the timing of stress. Drought stress affects seed formation more than total dry matter yield, the harvest index declines as the drought stress increases (Earl, 2002).Thus, the aim of most research on the crop is to select varieties or phenotypes with higher levels of drought tolerance. The current research is therefore aimed at selecting the drought resistance variety the most the most fascinating phenotypic characters, which would be recommended to local farmers in drought prone areas.

2. Materials and Method

The experiment was carried out at the Teaching and Research farm, Ambrose All University Ekpoma (Lat 6^0 42'N. Long6^0 68'E). Three varieties of bambara groundnut (purple eyed, white eyed and freckled) obtained from Department of Crop Science, Kogi State University, Ayangba were evaluated using 3x4 factorial fitted in to a Complete Randomized Design and replicated four times. The bambara groundnut were sowed in polyethylene bags as potted plants arranged 30cm by 30cm between and within in a land divided into 36 plots. Each plot contains 6 potted plants leading to a total of 216 plants. One seed was planted in each polyethylene bag. The bambara groundnut was planted as a late crop (5^{th} October to December 2015). The planted crops were watered at intervals of one day, four days, seven days and ten days respectively. The sets of plants which were watered serve as check for comparison.

Hand weeding was carried out three times at two weeks, six weeks and twelve weeks after planting. To enhance high yield, 3.04kg of N.P.K (20:10:10) soaked in 10 liters of water for three days, corresponding to 400kg/ hectare was applied. Insecticide (Karate EC) was applied at the rate of 30ml per liter of water at 6 weeks and 12 weeks to control insects.

3. Data Collection

3.1. Plant Height

At 36 days after planting, a measuring tape was used to measure the height of the plants from the soil surfaces to the apex of the plant. The values were recorded in centimeters.

3.2. Number of Leaves per Plant

Leaves per plant per pot were counted and recorded.

3.3. Leaf Area

This was determined by using a graph tracing method. Fully mature leaves randomly selected from each variety and the different water regimes were placed on graph papers traced and then the number of squares of traced area was recorded as the leaf area in cm^2.

3.4. Number of Pods per Plant

Five plants were randomly selected and uprooted, the number of pods on each plant harvested counted and the mean value recorded.

3.5. Pod Length

Five fully matured pods harvested from each treatment were measured and the mean value of pod length recorded in cm.

3.6. Number of Seeds per Pod

Five pods were randomly selected from each variety and the pods openedthe number of seeds per pod counted and the mean value record.

3.7. Seed Length

Ten seeds were randomly selected from each variety, measured in centimeters and the average length recorded.

3.8. Weight of Pod

Ten pods from each variety were randomly selected, weighed and the average value recorded in regime.

3.9. Weight of 100 Seeds

100 seeds were obtained from each variety and then weighed with sensitive scale, the values were then recorded.

3.10. Grain Yield/Plants

The grain yield/plant was calculated as the product of the number of seeds/plant and the mean weight of seed for each treatment.

3.11. Data Analysis

Data collected were analysed using analysis of variance (ANOVA) at 5% level of probability and the means separated using Least Significant Differences (LSD).

3.12. Coefficient of Variation (CV)

The coefficient of variation for treatment means were calculated using the formula by Steele and Torrie, (1980).

4. Results and Discussion

There were significant differences between all the water regimes applied in terms of plant height. High soil moisture enhanced the growth of bambara groundnut although it is observed that watering regimes of every seven days interval showed the highest mean values for plant height. Significant differences between freckled, white eyed and purple

eyed were observed in plant height. There were no significant differences between R_4 and R_1 and R_2 for number of leaves/plant. R_3 was highly significance different from other watering regimes for leaves/plant.

Number of leaves/plants of purple eyed and freckled were similar, but significantly different from white eyed. Leaf area showed no significant differences between R_4 and R_3 and also between R_3 and R_2. However, extended drought 10 days resulted in reduced values of leaves/plant. A similar observation was earlier reported by Ndubisi (1982) and Okeleye et al (1999) that heavy rainfall favour vegetative growth in Southern Nigeria. Thus, soil moisture content affects the yield of bambara. However, in the present study, high vegetative growth is associated with low seed yield. Plant height, leaves/plant and leaf area/plant depended on water regimes as well as the variety under study. Variety (V_2) white eyed recorded the highest mean value of 15.83cm for plant height, 19.19 for number of leaves/plant and least mean value of 323cm²forleafarea/plant.

Watering Regime		Plant height (cm)	Leaf area /plant cm²	Pods /plant	Pod length (cm)	Seed Length (cm)	Weight pod(g)	100 seeds weight(g)	Yield plant (g)
R_1	1 day	15.68^b	18.75^b	342^b	111.08^a	1.40^a	1.81^a	90.81^b	10.06^a
R_2	4 day	15.47^c	18.67^b	360^b	10.83^b	1.51^b	1.44^a	1.81^a	90.75^b
R_3	7 days	15.75^b	19.08^a	345^c	10.83^b	1.49^b	1.26^c	1.82^a	90.95^b
R_4	10 days	15.83^a	18.75^b	306^c	10.75^b	1.50^b	1.34^b	1.81^a	90.84^b

Table 1: Evaluation of Agronomic Characters of Bambara Groundnut Using Different Watering Regimes
Figures within a Column with the Same Alphabet Are Not Significantly Different (P⩾0.05) from Each Other

Varieties		Plant Height (cm)	No of leaves /plant	Leaf area/ plant (cm)	No of pods/ plant	Pod length (cm)	Seed length (cm)	Weight pod (g)	100 seeds weight.(g)	Yield/plant (g)
V_1	Purple eyed	15.75^a	18.56^b	361^a	10.81^a	1.48^a	1.37^a	1.72^a	91.12^a	20.40^a
V_2	White eyed	15.83^a	19.19^a	323^b	11.13^a	1.57^a	1.41^a	2.22^a	101.48^a	25.07^a
V_3	Freckled	15.49^a	18.69^b	342^b	10.69^a	1.48^a	1.30^b	1.51^b	79.92^b	12.90^b

Table 2: Evaluation of Agronomic Characters of Bambara Groundnut in Three Different Varieties
Figures within a Column with the Same Alphabet Are Not Significantly Different (P⩾0.05) From Each Other

	Plant height (36days)	No of leaves/plant at onset of flowering	Leaf area (cm)	No of pods per plant	Pod length (cm)	Seed length (cm)	Weight of pod/plant (g)	Weight of 100 seeds (g)
Plant height	1							
Leaves/plant	0.238	1						
Leaf area	0.062	0.021	1					
Pods/plant	0.013	0.046	0.138	1				
Pod length	0.016	0.203	0.048	0.005	1			
Seed length	0.028	0.109	0.167	0.153	0.444**	1		
Weight of pod	0.18	0.155	0.113	0.118	0.368*	0.257	1	
100 seed weight	0.203	0.102	0.006	0.107	0.339*	0.297	0.962*	1
Yield/plant (g)	0.049*	0.073	0.009	0.926*	**0.707	0.597*	0.814	0.348*

Table 3: Correlation (R) Matrix for the Different Phenotypic Characters of Bambara Groundnuts.
*** Correlation Is Significant at the 0.01 Level (2-Tailed)*
** Correlation Is Significant at the 0.05 Level (2-Tail)*

There were variations in the number of pods/plants among the different watering regimes and varieties. Water regime R_1 had the highest number of pods/plant when compared with other watering regime. Different watering regimes affected the number of pods/plants. The number of pods/plants was not influenced by number of days to flowering and this contradicts the earlier report by Okeleye et al (1999) who reported that number of days to flowering had significant effect on pods/plant.

Generally, late maturing varieties accumulate more vegetative matter and hence less seeds. Pod length varied insignificantly among the varieties. However, white eyed has the highest mean value of 1.41cm for pod length. The length of seeds did not depend on pod length. Weight of pod/plant was significantly different among the varieties studied. Weight of pod depended on the varieties not water regime applied. Seasonal variation had no effect on pod weight. 100

seed weight was significant for the different soil moisture occasioned by the different water regimes. Freckled seed differed significantly different from other seed varieties for 100 seed weight. The significant differences recorded by freckled eyed may be due to the weight of pod as the weight of pod determines the weight of seed for bambara groundnut.

Correlation coefficient showed that seed length was positively correlated with pod length and weight of pod($P<0.01$); 100 seeds weight positively correlated with pod length, seed length ($P<0.05$) and weight of pod ($P<0.01$). Thus, improving seed weight can also lead to improving pod length, seed length and weight of pod and vice versa. It has been reported that tiny and malformed seeds contributed to a reduction in pod and seed weights (Okeleye et al 1999). Similar observation has also been reported that weight of pod is positively correlated to weight of seeds. (Backiyarani et al 2002). Goli et al., (1997) reported that number of leaves, pods per plant and 100 seed weight most strongly correlated with grain yield. This study agreed with those earlier reports.

Exploration of variability in response to drought would permit not only to identify some tolerant varieties, but also to determine useful criteria for phenotypic improvement. Drought tolerance in bambara groundnut is expressed in developmentally specific pattern, such as early vegetative stage, flowering and pollination stage, and post – flowering stage. This study revealed the level of tolerance to drought for the three varieties to be $V_2 > V_1 > V_3$.

5. Conclusions

The effects of drought stress on the growth and yield of bambara groundnut depend on the degree of stress. Generally, bambara groundnut tolerates a high degree of low soil moisture content, however, extended drought during the growth stage eventually leads to low yield. Drought stress reduces the number of seeds and pods formation due to increased flower abortion resulting from extreme water stress. The characters, which could be selected for improvement in bambara groundnut under stress are leaf area, pod length, seed length, yield per plant and weight of 100 seeds.

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