DROUGHT TOLERANCES COWPEA GENOTYPES IN THE SAVANNAH ECOLOGY OF GHANA

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ABSTRACT

Cowpea is the second most important legume crop grown in Ghana and a major crop for food security. It has higher content of protein, vitamins, mineral and flavonoids than other foods and can be used in the prevention of malnutrition for the majority of the country's people, but especially rural farmers. In Ghana, the crop has recorded low grain yield due to drought / water deficit during the last several growing periods and is aggravated due to continuous global climate variability and the erratic rainfall pattern that has engulfed the northern part of the country. Our research was conducted to identify cowpea lines that are tolerant to drought from among existing breeding lines and farmers varieties in Northern Ghana. Genotypes were collected from the Savannah Agriculture Research Institute (SARI) and United State of Department Agriculture (USDA) and were evaluated on non-drought and drought stress conditions in an open field environment. The genotypes were planted in augmented designs Kpachi, Gnaring and Waribogu in the Northern Region of Ghana. Drought resistance and susceptibility, drought intensity, mean productivity, geometric mean productivity, yield stability and yield reduction were the indices used to determine the drought tolerance of the genotypes. Days to flowering and maturity, seed yield per plant and seed yield per hectare showed significant differences in the tested genotypes. Drought intensity index (0.61) was high which showed the high drought stress severity effect on cowpea grain yield on genotypes tested. Seven (7) genotypes were drought tolerant based on their values of drought susceptibility index, yield stability index and yield reduction rate. Drought tolerance combined with yield stability are highly desirable characters for genotypes and for selecting good genetic source for further improvement to drought resistance.

INTRODUCTION

Cowpea (*Vigna unguiculata* (L) Walp) is one of the most important food crop grown in Africa with good soil fertility enhancement ability (Yirzagla et al., 2016). Cowpea is rich in amino acids like lysine and tryptophan which provide 16% to 32% of needs to the human diet (Davis et al., 1991; Adekola and Oluleye, 2007).

The crop forms important part of diets and rank second after groundnut in Ghana and most parts of Africa it contributes to food security and in the prevention of malnutrition (Monyo and Laxmipathi,2014). Cowpea fixes atmospheric nitrogen into the soil through the association with rhizobia (Dakora et al, 1987) and the residues incorporated into the soil for the subsequent nutrition of the next crop in the same field.

Despite the importance of Cowpea to rural household and global food security, the average yield on farmers' fields is low (400 – 600 kg/ha) compared to values recorded on research fields (1600 – 2500 kg/ha) (MOFA, 2010; Yirzagla et al., 2016). In Ghana and most parts of Africa, drought among other biotic and abiotic factors, plays a major role in reducing crop yields through its effect on photosynthate allocation and biomass accumulation (Thung and Rao, 1999 and Rao, 2001).

The possible effects of drought on yield and global food security is further compounded by the uncertainties of climate change in the future. As a result, crop genotypes are required that can grow and produce appreciable yield under drought conditions. Given the importance of Cowpea to food and nutritional security, there is the need to develop and/or select available varieties and /or landraces for improved water relations. The present study is aimed at selecting for water use efficiency among Cowpea landraces and USDA genotypes using physiological traits related to drought tolerance.

MATERIALS AND METHODS

A total 240 genotypes from USDA and SARI Augmented design was used with 2 replications with 15 incomplete blocks. Each genotype was planted in 3m long row and 75 cm between the incomplete blocks.

Planting distance of 75 cm x 30 cm or a seeding rate of 44444 seeds per hectare. Seeds were hand sowed and two seed per hole. Seeds were planted in early July and late August, 2016. Treatments were Non- moisture stress (July planting) and drought stress (August plating) and harvested in late September and mid November 2016 respectively.

The quantitative traits evaluated were 50% days to flowering (DF), Days to pod maturity (DM), Seed per pod and Grain yield/seed yield.
Statistical analysis was carried out using SAS general linear model

Secondary variables

Drought intensity Index (DII)= $1- \frac{\hat{Y}_{ds}}{\hat{Y}_{ns}}$ (Fischer, and Maurer, 1978)

Drought Susceptibility Index (DSI) = $\left(\frac{1-\left(\frac{Yds}{Yns}\right)}{DII}\right)$ (Fischer &Maurer, 1978)

Drought tolerance index (DTI)= $\frac{Yds*Yns}{\hat{Y}ns*\hat{Y}ns}$ (Fernandez, 1992)

Mean Productivity (MP)= $\left(\frac{Yds+Yns}{2}\right)$ (Rosielle and Hamblin, 1981)

Geometric Mean Productivity (GMP) =$\sqrt{Yds \times Yns}$ (Fernandez, 1992)

Yield Reduction Rate (YRR)= $\left(\frac{Yns-Yds}{Yns}\right)x100$ (Rosielle & Hamblin, 1981)

Yield stability index = $\frac{Yds}{Yns}$ (Bouslama and Schapaugh, 1984)

Figure 1: Cowpea Plants in The Field

Figure 2: Cowpea Fresh Pods

Figure 3:Cowpea Seeds

RESULTS

Table1. means of four traits of 240 cowpea genotypes grown under drought stressed and well watered treatments

	Trait	Location	Genotype	Genotype*Location
NS	DF	0.43ns	2.09***	0.55ns
	DM	8.89***	1.35***	0.69ns
	NSP	149.70***	1.84***	1.29***
	GY	151.63***	1.89***	1.38***
DS	DF	0.12ns	1.59***	0.40ns
	DM	4.05**	0.96ns	0.67ns
	NSP	125.11***	1.71***	1.13ns
	GY	79.94***	24.21***	1.05ns

DS – Drought stress, NS – Non- Drought stress, DF – Days to flowering, DM – Days to maturity, NSP – Number of seeds per pod, GY – Grain Yield

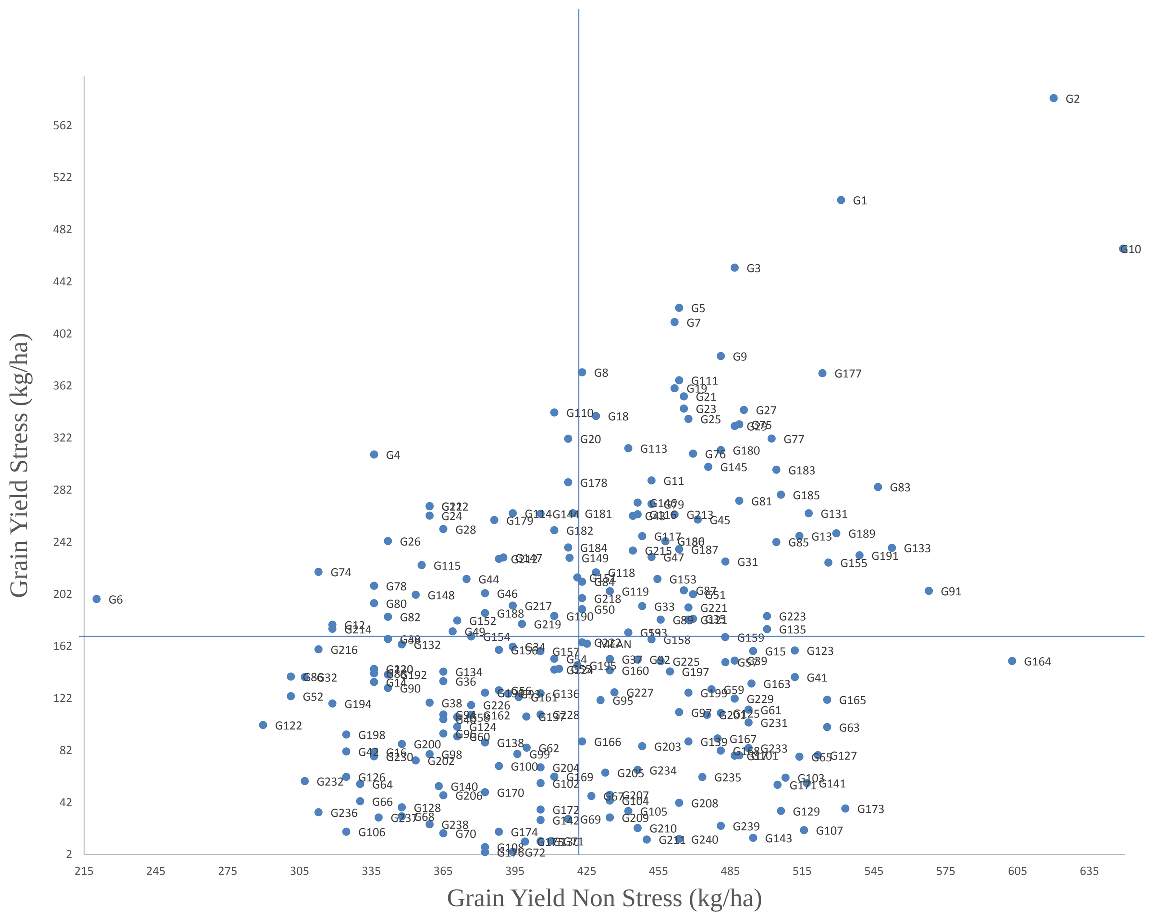

Figure 4: Scatter gram showing the identification and categorization of genotypes based on their seed yield in a comparison of Drought Stress and Non-Stress treatments . Horizontal and vertical lines indicate mean values

Table 2 – Drought tolerance indices of 64 cowpea genotypes performed well under NS and DS conditions at Tamale, Northern Region of Ghana in July to November 2016.

Geno	NS	DS	DSI	DTI	MP	GMP	PRR	YSI
Geno1	531.22	504.66	0.08	0.95	517.94	517.77	0.05	0.95
Geno2	620.08	582.88	0.10	0.94	601.48	601.19	0.06	0.94
Geno3	486.79	452.72	0.11	0.93	469.75	469.44	0.07	0.93
Geno5	463.61	421.89	0.15	0.91	442.75	442.26	0.09	0.91
Geno7	461.68	410.89	0.18	0.89	436.29	435.55	0.11	0.89
Geno9	481.00	384.80	0.33	0.80	432.90	430.22	0.20	0.80
Geno18	428.84	338.78	0.34	0.79	383.81	381.16	0.21	0.79
Geno111	463.61	366.25	0.34	0.79	414.93	412.07	0.21	0.79
Geno19	461.68	360.11	0.36	0.78	410.89	407.74	0.22	0.78
Geno21	465.54	353.81	0.39	0.76	409.68	405.85	0.24	0.76
Geno23	465.54	344.50	0.43	0.74	405.02	400.48	0.26	0.74
Geno10	649.06	467.32	0.46	0.72	558.19	550.74	0.28	0.72
Geno25	467.47	336.58	0.46	0.72	402.03	396.67	0.28	0.72
Geno113	442.36	314.08	0.48	0.71	378.22	372.74	0.29	0.71
Geno177	523.49	371.68	0.48	0.71	447.59	441.10	0.29	0.71
Geno27	490.66	343.46	0.49	0.70	417.06	410.51	0.30	0.70

DS – Drought stress, NS – Non- Drought stress, DSI - Drought Susceptibility Index, DTI - Drought tolerance index, MP - Mean Productivity, GMP - Geometric Mean Productivity, YRR - Yield Reduction Rate and YSI - Yield Stability index.

DISCUSSIONS

•Drought intensity index was high at 0.61 which showed drought stress severity on grain yield. Drought tolerant genotypes were selected based on drought susceptibility index, yield reduction rate and yield stability index.

• 64 genotypes gave higher yield than the mean values in both treatments called category A. They were showed significantly (P ≤ 0.05) superior yield performance relative to the population means under both drought Stress and non-Stress treatments. Seven (7) were drought tolerant based on small values of drought susceptibility index and yield reduction rate and high values of drought tolerance index and yield stability index.

•55 genotypes were susceptible to drought stress found below the population mean of the stress but produced well under NS condition called category B.

• 77 genotypes gave lower yield than the population means in both treatments called category C. They were showed significantly (P ≤ 0.05) poorer yield performance relative to the means under both drought stress and non- stress treatments

• 44 genotypes were susceptible to drought stress found below the population mean of the non-stress but produced well under stress condition called category D.

CONCLUSIONS

In conclusion, the present study reports variations in the number of days to maturity resulting from differences in days to flowering, possibly in response to climatic and environmental factors across planting locations. Variable grain yield was also recorded for the study genotypes in response to both stress and planting locations.

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