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Research Application Summary

Post flowering drought tolerance in cowpea genotypes in Uganda

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Abstract

Drought stress remains a challenge in the drought prone areas of eastern and north eastern regions of Uganda where cowpea is predominantly grown. Yield losses of up to 50% have been reported on cowpea due to drought. This study was undertaken to identify cowpea genotypes tolerant to drought. Germplasm tested included Ugandan landraces and released varieties, Brazil lines, Makerere University breeding lines, and elite IITA germplasm. The experiment was laid out in a randomized complete block design in a split plot arrangement with three replications. Watering regime was the main plot treatment and the 30 test genotypes subplot treatments. Data were collected on yield and its components and was subjected to analysis of variance, principal component and correlation. Based on these indices the following genotypes showed considerable levels of drought tolerance: WC8, Secow 5T, Secow 3B, Secow 2W, NE5, NE44, MU15, MU24C, IT84 and MU17, implying that they can be utilized as sources of drought tolerance in breeding for drought tolerant cowpea lines as well as promoted for cultivation.

Key words: Hybridization, quantitative indices, split plot

Résumé

Le stress hydrique demeure un problème dans les zones sujettes à la sécheresse des régions de l'est et du nord-est de l'Ouganda où le niébé est la principale culture. Des pertes de rendement jusqu'à 50% ont été reportées sur le niébé en raison de la sécheresse. La présente étude a été conduite pour identifier les génotypes de niébé tolérants à la sécheresse. Les germoplasmes testés etaient des variétés locales et publiées de l'Ouganda, les lignées du Brésil, les lignées sélectionnées de l'Université Makerere et le germoplasme élite de l'IITA. L'expérimentation a été conduite dans un dispositif de blocs aléatoires complets dans un arrangement de split plot avec trois répétitions. Le traitement principal des parcelles était le régime d'arrosage en plus de 30 autres traitements de sous-parcelles de génotypes. Les données ont été collectées sur le rendement et ses composantes et soumises aux analyses de la variance, en composantes principales et de corrélation. Sur la base de ces indices, les génotypes suivants ont montré des niveaux considérables de tolérance à la sécheresse:

WC8, Secow 5T, Secow 3B, Secow 2W, NE5, NE44, MU15, MU24C, IT84 et MU17, indiquant qu'ils peuvent être utilisés comme souches de tolérance à la sécheresse dans la sélection des lignées de niébé tolérant à la sécheresse, et promus pour leur culture.

Mots clés: Hybridation, indices quantitatifs, split plot

Background

Cowpea (*Vigna unguiculata* L. Walp) is grown worldwide with an estimated cultivation area of about 14.5 million hectares annually and an annual worldwide production of over 4.5 million metric tonnes (Singh *et al*., 2002). Cowpea is a crop of major importance to the nutrition of poor rural households in the drier regions of Eastern Africa (Bisikwa, 2010). It is a source of protein for resource poor farmers as well as an essential component of cropping systems. In Uganda, cowpea occupies an economically important place among grain legumes especially in the eastern and northern regions where it is an important source of protein and household income (Bisikwa, 2010). Despite its widespread cultivation in Uganda, the yields in farmers' fields are still very low averaging 300-500 kg/ha against a yield potential of 1500 to 3000 kg/ha (Bisikwa, 2010). The low yields have been attributed to a number of biotic and abiotic stresses, low yielding local varieties, seed scarcity and poor soils (Bisikwa, 2011). Yield losses of 40 to 50% have been reported in cowpea in Uganda due to drought (NaSARRI, 2011). Breeding for drought tolerance in cultivated cowpea genotypes is a best way of reducing these losses. Currently, however, there is limited information on the levels of drought tolerance in the cultivated germplasm in Uganda for use as sources of drought tolerance. The study therefore sought to identify cultivars with appreciable degree of tolerance to drought stress.

Literature summary

Drought is currently the most important abiotic stress limiting cowpea production worldwide (Singh *et al*., 1999a; Hall, 2004). In Uganda, over trillion Shillings (Uganda currency) in damages and losses in the agriculture sector due to drought have been reported (Bigirimana, 2012). Similarly, 40 to 50% losses in cowpea due to drought have been reported (NaSARRI, 2011). However, no research has been done to assess the levels of drought tolerance in the cultivated cowpea genotypes. The absence of a genetic improvement program targeting drought tolerance in Uganda contributes to the low cowpea yields of 500 kg/ha against a potential of 1500 to 3000 kg/ha . Elsewhere, drought tolerant varieties have been identified and released for use by farmers and researchers (Belko *et al*., 2013). Hence, a crop improvement program geared at developing drought tolerant cultivars needs to be established to assist in the identification of suitable parents for hybridization. The development of cowpea cultivars with enhanced levels of drought tolerance will ensure high and stable yields even in dry environments, contribute to food security and consequently, economic growth (Agbicodo *et al*., 2009).

Study description

The study was conducted between May and December 2015 in a water proof screen house at Makerere University Agriculture Research Institute, Kabanyolo (MUARIK). The germplasm collection consisted of Ugandan landraces and released varieties, Brazil lines, Makerere University breeding lines, and elite IITA germplasm. The experiment was laid out in a randomized complete block design in a split plot arrangement with three replications, three watering regimes as main plots; treatment 1 (T1) as unstressed; T2, severe water stress, T3, intermediate water stress and the 30 test genotypes were the subplots. Water stress treatment was imposed after the emergence of flower buds (R1) (Akyeampong, 1985; Chiulele, 2010). Data were collected on yield and its components and was subjected to appropriate statistical analyses (analysis of variance, principal component and correlation) using GenStat discovery edition 12.

Research application

The genotypes showed considerable variability in tolerance to drought. Genotype effect was significant ($P < 0.001$)for yield, number of pods per plant, number of seeds per pod and hundred seed weight (Table 1).

Stress tolerance index (STI) had a strong significant positive correlation (Table 2) with mean yield under no stress ($r = 0.79$, $P < 0.001$), mean yield of a genotype under stress ($r = 0.90$, $P < 0.001$), mean productivity and geometric mean productivity indicating that selection based on this index would improve yield under stress and no stress. Similarly, the first principal component which accounted for 63.6% of the variation between the genotypes (Table 3) had a strong positive correlation with Yp (r = 0.60***), Ys (r = 0.98***), MP (r = 0.95***), GMP (r = 0.97***) and STI (r = 0.95***) (Table 3) suggesting that selection for high

Table 1. Summary of analysis of variance table for yield and its components of 30 cowpea genotypes grown under drought stress and non- stress conditions at Kabanyolo, Uganda

Source	DF	Mean square				
		Days to flowering	Pods per plant	Seeds per pod	100 seed weight	Grain yield
Reps	2	176.8	0.92	6.69	2.67	1.35
Water stress levels	2	6685.9**	805.72***	5154.77***	387.63***	540.03***
Main plot error	4	268.1	0.68	6.39	2.09	0.81
Cultivar	29	724.8***	9.15***	15.07***	1.31***	3.02***
Cultivar* Water Levels	58	162.8*	3.44***	12.84***	0.98***	1.65***
Sub plot error	174	114.5	1.59	5.06	0.39	0.57
Total	269					

* Significant at $P < 0.05$, ** at $P < 0.01$, *** at $P < 0.001$

Table 2. Correlation analysis among yield under no stress and stress, drought tolerance indices and principal components

	YP	YS	GMP	MP	STI	SSI	SI	TOL	PRINC_1	PRINC_2
YP	1.00									
YS	0.47**	1.00								
GMP	0.76***	0.92***	1.00							
MP	0.81***	0.90***	0.99***	1.00						
STI	0.79***	0.90***	0.99***	0.99***	1.00					
SSI	-0.04	-0.44*	-0.36*	-0.32	-0.32	1.00				
SI	0.21	-0.76***	-0.47**	-0.41*	-0.42*	0.40*	1.00			
TOL	0.29	-0.71***	-0.39*	-0.33	-0.35	0.40*	1.00***	1.00		
PRINC 1	0.60***	0.98***	0.97***	0.95***	0.95***	-0.46*	-0.59***	-0.59***	1.00	
PRINC 2	0.80***	-0.14	0.23	0.30	0.29	0.35	0.79***	0.79***	0.00	1.00

* Significant at $P < 0.05$, ** Significant at $P < 0.01$, *** Significant at $P < 0.001$

Yp: Mean yield of a genotype under no stress; Ys: Mean yield of a genotype under no stress; MP: mean productivity; GMP: geometric mean productivity; STI: stress tolerance index; TOL: tolerance index; and SSI: stress susceptibility index; PRINC1: first component; PRINC2: second component

Table 3. Principal components loadings for the measured traits of cowpea genotypes

Indices	Principal components	
Traits	Princ 1	Princ 2
YP	0.26	0.54
YS	0.44	-0.09
GMP	0.43	0.16
MP	0.42	0.20
STI	0.42	0.19
SSI	-0.22	0.25
SI	-0.29	0.50
TOL	-0.26	0.53
Variation	63.61	27.32
Total variation	63.61	90.93

Yp: Mean yield of a genotype under no stress; Ys: Mean yield of a genotype under no stress; MP: mean productivity; GMP: geometric mean productivity; STI: stress tolerance index; TOL: tolerance index; and SSI: stress susceptibility index; PRINC1: first component; PRINC2: second component

yielding genotypes is possible on the basis of indices under the first principal component. Hence, STI and Geometric Mean Productivity quantitative indices were used to quantify the levels of drought tolerance of the 30 cowpea genotypes. Based on these indices the following genotypes showed considerable levels of drought tolerance: WC8, Secow 5T, Secow 3B, Secow 2W, NE5, NE44, MU15, MU24C, IT84 and MU17, implying that they can be utilized as sources of drought tolerance in breeding for drought tolerant cowpea lines as well as promoted for cultivation.

Recommendation

It is recommended that the identified drought tolerant lines be used for the development of drought tolerant cowpea lines since most of them are locally adapted.

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