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Research Application Summary

Evaluation of physiological and morphological traits conferring drought tolerance in cowpea

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Abstract

A field study was carried at Gwebi VTC to determine relationships among the morpho-physiological traits associated with drought tolerance in cowpea. Fifteen genotypes were planted in RCBD with three replications under two moisture environments, unstressed (US) and water stressed (WS). Thus, plants with reduced stomatal conductance and high chlorophyll absorbance should be selected in order to develop cowpea varieties tolerant to drought. Direct selection for number of pods per plant, harvest index and 100 seed weight would be effective under water stressed conditions since the positive correlationship was mainly due to direct effects.

Key words: Drought tolerance, grain yield, morpho-physiological traits, *Vigna unguiculata*, Zambia

Résumé

Une étude sur terrain a été réalisée à Gwebi VTC pour déterminer les relations entre les traits morpho-physiologiques associés à la tolérance à la sécheresse sur la variété de haricot noir. Quinze génotypes ont été plantés en blocs RCBD avec trois répétitions sous deux environnements d'humidité, en non-stress(US) et en stress hydrique (WS). Ainsi, les plantes à la conductance stomatique réduite et à haute densité de chlorophylle devraient être sélectionnées en vue de développer ces variétés de haricot tolérant la sécheresse. La sélection directe pour le nombre de gousses par plante, indice de récolte et poids de 100 graines serait efficace sous des conditions stressées de l'eau depuis que la correlation positive est principalement due à des effets directs.

Mots clés: Tolérance à la sécheresse, le rendement en grain, les traits morpho-physiologiques, *Vigna unguiculata*, Zambie

Background

Cowpea is one of the most important food legumes grown in the regions where drought is a major production constraint (Singh *et al*., 1997). It is cultivated on at least 14 million ha, with production of 3,722 thousand metric tons world-wide in 2003 (FAO, 2004). A substantial part of this production comes from

the drier areas where drought is prevalent among the several yield reducing factors (Watanabe *et al.*, 1997). The frequency and severity of drought may increase in the future as global warming intensifies. The study was therefore designed to furnish information on the nature of associations of several physiological and morphological characters contributing to grain yield in cowpeas and thereby proposing appropriate selection criteria under drought conditions.

Literature Summary

Morphological and physiological traits that might enhance drought tolerance have been proposed, but only a few of these mechanisms have been demonstrated in the expression of tolerance under field conditions (Ludlow and Muchow, 1990). Better adapted and higher yielding genotypes could be bred more efficiently and effectively if attributes that confer drought resistance could be identified and used as a selection criteria.

Study Description

A field study was carried out at Gwebi VTC during the dry period of August to October 2009. Fifteen advanced cowpea genotypes were planted in RCBD with three replications, under two trials water stressed (WS) and understressed (US) conditions. Two seeds were planted per station at 0.15m x 0.45 m. Water (40 mm) was supplied once every 10 days, and stopped at flowering under the WS conditions to simulate the mid seasonal drought. Soil moisture content was monitored throughout the crop cycle using a watermark. Electrodes were installed at depth of 0-5cm, 5-10cm, 10-20cm, 30-40cm and 50-60cm.Data on phenological traits, yield and yield components, plant height; NBPP, CA and SC were taken. Analysis of variance was done using GenStat Discovery version. Phenotypic correlations (r) among all traits under water stressed conditions were determined and a path coefficient analysis was done to untangle the direct and indirect contribution of the various factors to grain yield using the method of Wright (1921) and Dewey and Lu (1959).

Research Application

Drought stress determined by Drought Intensity Index (DII) (Fischer and Maurer, 1978) was severe (0.782) and this probably caused all the genotypes under the study to be of moderate susceptibility to drought. This high DII was mainly due to declining soil moisture content. The Drought Susceptibility Index (DSI) of the genotypes used ranged from 0.561 to 1.102, with genotype C/68/4/5 being the least susceptible of the fifteen genotypes. The index, Geometric Mean (GM) ranged from 35.95

Table 1. Phenotypic correlation, direct and indirect effects of different traits on grain yield of cowpea under water stressed conditions.

	Phen	Direct effects	100S WHT	DFLW	DMAT	NBPP	NPPP	S.C 1 WEEK	S.C 3 WEEK	C.A 1 WEEK	C.A 3 WEEK	H.I
100S WHT	0.84**	0.24		-0.124	0.094	0.011	0.282	4.7E-0.5	0.036	0.01	0.012	0.273
DFLW	-0.51**	0.179	-0.168		-0.08	-0.014	-0.175	-0.0013	-0.038	-0.0021	-0.0071	-0.196
DMAT	-0.707	-0.17	-0.132	0.091		0.006	-0.182	0.0002	-0.025	0.0032	-0.011	-0.27
NBPP	0.21	0.09	0.029	-0.029	0.012		0.084	-0.0005	0.0006	0.0153	0.0003	-0.0021
NPPP	0.88**	0.35	0.195	-0.089	0.089	0.021		-0.0008	0.027	0.018	0.01	0.258
S.C 1	0.076	-0.007	-0.0001	0.029	0.005	0.0059	0.039		-0.024	0.0077	0.0071	0.014
S.C 3	-0.46**	-0.076	-0.115	-0.089	-0.058	-0.0008	-0.127	0.0024		-0.0198	-0.0013	-0.154
C.A 1	0.215	0.0092	0.028	-0.004	-0.006	0.015	0.068	-0.0006	0.0163		0.0005	0.0045
C.A 3	0.49*	0.023	0.123	-0.049	0.077	0.0018	0.138	-0.0022	0.0038	0.002		0.169
H.I	0.88**	0.346	0.191	-0.101	0.134	-0.005	0.261	-0.003	0.034	0.0012	0.0125	

*($p<0.05$) ** ($p<0.001$).

to 1266.87. GM was found to be positively correlated to grain yield under water stressed conditions.

Significant GxE interactions were observed in grain yield, SC, CA and NPPP. A significant ($p<0.05$) relationship was found between NPPP, 100 seed weight and harvest index (HI) and grain yield under WS conditions. This was mainly caused by positive direct effects of these yield components. The negative relationship between days to 95% maturity and grain yield was mainly due to negative indirect effects of HI, N.P.P.P and 100 seed weight. Direct selection through NPPP, H.I and 100 seed weight would be effective under WS. SC at three weeks after water stressing was significant and negatively correlated to grain yield, NPPP and H.I. A positive and significant correlation was observed between C.A at three weeks after water stressing and grain yield, NPPP and H.I. Traits such as SC, CA, and yield components such as H.I, 100 seed weight and NPPP can be used in selecting drought tolerant cowpea lines.

Recommendation

Plants with reduced stomatal conductance and those with high chlorophyll absorbance should be selected for in order to develop varieties tolerant to drought. Number of pods per plant, harvest index and 100 seed weight should be used in selection criteria for drought tolerance under water stressed conditions.

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References

Dewey, D.R and Lu, K.H. 1959. A correlation and path co-efficient analysis of components of crested wheat grass and seed production. *Agronomy Journal* 51:515-518

FAO, 2004. Statistical databases. Available from http:// faostat.faoorg/faostat/default.jsp.

Fischer, R.A. and Maurer, R. 1978. Drought resistance in spring wheat cultivars I. Grain yield responses. *Aust. J. Agric. Res.* 29:897-912.

Ludlow, M.M. and Muchow, R.C. 1990. A critical evaluation of traits for improving crop yield in water limited environment. *Advances in Agronomy* 43:107- 153.

Singh, B.B., Chambliss, O.L. and Sharma, B. 1997. Recent advances in cowpea breeding. In: Singh, B.B., Mohan Raj D.R., Dashiell, K.E. and Jackai, L.E.N. (Eds.). Advances in cowpea research, Co-publication of International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria and Japan

International Research Centre for Agricultural Sciences (JIRCAS), Sayce Publishing, Devon. pp. 114–128.

Watanabe, I., Hakoyama, S., Terao, T. and Singh, B.B. 1997. Evaluation methods for drought tolerance of cowpea. In: Advances in cowpea research.