EXPLORING THE GENETIC POTENTIAL OF LOCALLY ADAPTED GERMPLASM FOR DROUGHT TOLERANCE: A CASE FOR COWPEA (*VIGNA UNGUICULATA (L.)* Walp) FROM MALAWI

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Abstract

The shortage of improved cowpea (Vigna unguiculata (L.) Walp) varieties and increased frequency of droughts in Malawi have created a need to identify drought tolerant genotypes with desirable agronomic and utility characteristics. This research evaluated local germplasm maintained by the Malawi Plant Genetic Resources Centre (MPGRC), as an initial step towards the identification of genotypes with drought tolerance. Eco-geographic characterisation revealed diverse ecologies among the different germplasm collected. These genotypes were subsequently assessed for drought tolerance in a glasshouse study. All genotypes which tolerated low moisture conditions in the glasshouse originated from areas with high rainfall and low temperatures suggesting that extreme environmental conditions and/or human mediated actions interfered with adaptation processes. Furthermore, the eco-geographic characterisation identified germplasm gaps which need to be filled by either collection or repatriation of germplasm from international genebanks. The establishment of on-farm conservation in areas with low rainfall and high temperature such as Chikwawa and Nsanje districts may enhance adaptation of cowpea to drought conditions. Genotypes 479, 601, 645, 2226 and 3254 fully recovered from moisture stress, while 2232 started wilting within one week of drought stress initiation in the first glasshouse experiment. The genotypes which recovered from moisture stress showed low scores for wilting scales, low leaf wilting index (LWI), high relative water content, high scores for stem greenness and high levels for re-growth. In addition, the first glasshouse experiment resulted in the development of a leaf wilting index, which has been identified as an easily used method for scoring wilting, compared to common wilting scales. In a subsequent glasshouse experiment, all the genotypes which fully recovered from moisture stress showed high relative water content during the period of stress, but showed differences in other physiological traits. For example, genotypes 479, 601, 645 and 2226 had reduced stomatal conductance, transpiration rate and net photosynthesis, while 3254 maintained high scores for the three traits from the initial stage of moisture stress. Although 2232 showed a high transpiration rate and stomatal conductance, its net photosynthesis was significantly reduced, compared to all the other genotypes, after the third week of stress. The differences in physiological traits among genotypes indicated that 3254 has drought tolerance; 479, 601, 645 and 2226 avoid drought while 2232 is drought susceptible. The field performance of these six genotypes and two released varieties (Sudan 1 and IT82E16) was assessed in field trials in Malawi at Baka, Bvumbwe, Chitala, Chitedze and Kasinthula. Results from field trials revealed significant *variation for reproductive, yield and seed characteristics. Sudan 1, IT82E16, 409 and 601 matured in less than 65 days after planting; 3254 took 70 days and 645, 2226 and 2232 took more than 85 days. Genotype 3254 consistently gave high yields at sites with low rainfall and high temperatures compared to 2232 which yielded poorly at the same sites. The eight genotypes showed variation in seed size with genotype 2226 producing large seeds (>20g/100 seeds) at all sites. The seed size of 2232 was significantly lower than 2226 at sites with low rainfall and high temperatures. The field performance of these genotypes reflects the physiological responses observed in the glasshouse, confirming the drought response categories of the genotypes. The agreement between glasshouse experiments and the field trial suggests there is intrinsic value in the locally adapted germplasm maintained by the Malawi Plant Genetic Resources Centre. Among the genotypes tested in the field, farmers selected 479 for early maturity; 2226 and 2232 for high leaf biomass; 3254 for high pod load; 2226 and 2232 for large seeds; Sudan 1 for small seeds; and 601, IT82E16 and Sudan 1 for smooth seed texture. Genotype 3254 was ranked poorly at all the sites due to rough seed texture. Genotypes for potential use in improving production of cowpea in drought prone areas were identified. In the absence of released drought tolerant varieties, it is recommended that genotypes with drought avoidance characteristics be promoted in areas with mild droughts, while 3254 with its typical drought tolerance may be suitable for areas with intense droughts. However, the rough seed texture of 3254 may limit its usefulness due to its poor ranking by farmers at all sites. Priorities for future cowpea in Malawi include investigating inheritance of drought tolerance in cowpea.*

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Dedication

I dedicate this work to my wife, son, dad and mum, for being instrumental throughout my academic journey.

I also dedicate this work to the children of Malawi who do not complete their education, often because their parents do not appreciate its value. It is my prayer that such parents begin to realise the importance of education in changing the world. I also dedicate this work to all the people and organisations that selflessly support the education of children in Malawi. May you gain more blessings for this noble cause.

To the parents: *"If you think education is expensive, try ignorance"* by Derek Bok.

To the goodwill ambassadors: "*Education is the most powerful weapon which you can use to change the world*" by Nelson Mandela.

Candidate's declaration

This is to certify that the research carried out for my Doctoral thesis entitled "*Exploring the genetic potential of locally adapted germplasm for drought tolerance: A case for cowpea* (*Vigna unguiculata* (L.) Walp) *from Malawi"* at the Institute of Agriculture and Environment, Massey University, New Zealand is my own work and that the thesis material has not been used in part or whole for any other qualification.

CANDIDATE'S NAME LAWRENT L.M. PUNGULANI

SIGNATURE

DATE 23/10/2014

Supervisor's declaration

Chief Supervisor's Name ....James Millner........

Signature ....JPMillner........

Date ....24/10/14........

Co-Supervisor's Name ....Warren Williams........

Signature ....JPMillner on behalf........

Date ....24/10/14........

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Acronyms

ABA	Abscisic Acid
ANOVA	Analysis of Variance
asl	Above Sea Level
ASWAp	Agriculture Sector Wide Approach
CBD	Convention on Biological Diversity
CIAT	International Centre for Tropical Agriculture
DAES	Department of Agricultural Extension Services
DARS	Department of Agricultural Research Services
DLS	Delayed Leaf Senescence
E	Net Transpiration
EPA	Extension Planning Area
FAO	Food and Agriculture Organisation of the United Nations
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GIS	Geographic Information System
GLM	General Linear Model
Gs	Stomatal conductance
IBPGR	International Board for Plant Genetic Resources
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
IITA	International Institute of Tropical Agriculture
IAE	Institute of Agriculture and Environment
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
LSD	Least Significant Difference
LWI	Leaf Wilting Index

MC	Moisture Content
MGDS II	Malawi Growth and Development Strategy II
MLS	Multilateral System
MPGRC	Malawi Plant Genetic Resources Centre
NZAID	New Zealand Aid for International Development
PGU	Plant Growth Unit
Pn	Net photosynthesis
PRA	Participatory Rural Appraisal
PVS	Participatory Variety Selection
QTL	Quantitative Trait Loci
RCBD	Randomised Complete Block Design
RWC	Relative Water Content
SLA	Specific Leaf Area
STG	Stem Greenness
TDR	Time-Domain Reflectometer
TE	Transpiration Efficiency
UCR	University of California Riverside
WS	Water Stressed
WUE	Water Use Efficient
WW	Well Watered