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Towards Identifying the Physiological and Molecular Basis of Drought Tolerance in Cassava (*Manihot esculenta* Crantz)

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Towards Identifying the Physiological and Molecular Basis of Drought Tolerance in Cassava (*Manihot esculenta* Crantz)

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Dedication:

To
My husband Murori,
and children Makena and Muthomi

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Acronyms and Abbreviations

Abbreviation	Description
ABA	Abscisic acid
ABI	Applied Biosystems
AGB	above-ground fresh-biomass
ANOVA	Analysis of variance
BecA	Biosciences for eastern and central Africa
BMZ	German Federal Ministry for Economic Cooperation and Development
bp	base pair
CBSD	cassava brown streak disease
CE	capillary electrophoresis
CEC	Cation Exchange Capacity
CIAT	International Center for Tropical Agriculture
cM	centiMorgan
CMD	cassava mosaic disease
COSCA	Collaborative Study of Cassava in Africa
CP	cross pollinated
DAP	days after planting
DDPSC	Donald Danforth Plant Science Center
DM	dry matter content
DNA	Deoxyribonucleic Acid
dNTPs	Deoxynucleotide Triphosphates
EDTA	Ethylene Diamine Tetra-acetic Acid
Embrapa	Brazilian Agricultural Research Corporation
ESSR	Expressed Simple Sequence Repeat
ETH	Swiss Federal Institute of Technology Zurich
GAUG	Georg-August University Goettingen
GCP	Generation Challenge Program
GDP	Gross Domestic Product
HI	harvest index
HLS	height of leafless stem

Abbreviation	Description
HPS	height of primary stem
HSS	height of secondary stem
IITA	International Institute of Tropical Agriculture
IPGRI	International Plant Genetic Resources Institute
KARI	Kenya Agricultural Research Institute
LG	linkage group
LL	length of expanded leaf
LOD	logarithm of odds
LR	leaf retention
LW	width of expanded leaf
MAB	marker-assisted breeding
NARS	National Research Systems
NBL	number of branching levels
NPK	nitrogen phosphorous potassium
NPS	number of primary stems
NSR	number of storage roots
PCR	Polymerase Chain Reaction
QTL	quantitative trait loci
REC	recombination frequency
rfu	relative fluorescent units
SD	stem diameter
SRFW	storage root fresh weight
SSA	Sub-saharan Africa
SSR	Simple Sequence Repeat
TBE	Tris Borate EDTA
TE	Tris EDTA
Wa	weight in air
Ww	weight in water
ZIL	Swiss Center for International Agriculture

1. General Introduction

1.1. Background

In the 21st century, the world population is increasing at a high rate. The population is faced with a crisis that defines human development and links today and tomorrow. This crisis is climate change. Sub-Saharan African (SSA) countries, which are more prominent in increasing human population, are more vulnerable to climate change. This is because, they are located in the hot tropical regions, and they highly depend on climate-sensitive sectors such as agriculture, forestry and tourism. In addition, SSA countries not only have high poverty rates, but also limited financial, institutional and human capacity to adapt to climate change (Thomas and Twyman, 2005).

Agriculture is the backbone of most countries in Africa. More than eighty percent of agriculture in SSA is rain-fed. The sector contributes about 30 percent of the Gross Domestic Product (GDP) and 30 percent of the total export value. Ninety five percent of the population depends on agriculture for its livelihood (Kaushik, 2008). In the past years, many African countries have experienced erratic droughts and declines in water supply. These have aggravated food shortages on the continent. Some countries like Kenya have declared food shortage a national disaster. Recent prediction estimates that, by the year 2050, at least one in every 4 people is likely to live in a water-deficient area (UNFPA, 1999; FAO, 2004).

Water-stress occurs ubiquitously during the growing season of many plants, and has intense negative impacts on agricultural productivity. For example, in maize a mild drought of 4 days at the flowering and silking phase of development can result in up to a 50% decrease in grain yield (Wang et al., 2005). In order to take the right turn towards a more sustainable food security situation in Africa, dramatic yield increases in the large regions susceptible to drought need to be ensured (Figure 1.1). Genetic enhancement of crops for drought tolerance appears to represent the best and most cost-effective route for ensuring sustainable and increased crop yields in the harsh SSA climate, where timing and amount of rain is often unreliable. Such genetic enhancement can be achieved by applying plant breeding techniques together with biotechnology methods. To utilize such techniques fully, there is a need to understand the molecular and physiological basis of drought tolerance and susceptibility.

In order to improve the understanding of drought tolerance mechanisms in cassava (*Manihot esculenta* Crantz), one of the most important drought-tolerant crops, a multi-disciplinary project, funded by the Generation Challenge Program (GCP) and the German Federal Ministry for Economic Cooperation and Development (BMZ), ‘‘Identifying the physiological and genetic traits that make cassava one of the most drought tolerant crops’’ was initiated. The project was implemented by several research institutions in collaboration with universities (Figure 1.2). The research presented here has been undertaken within this project.

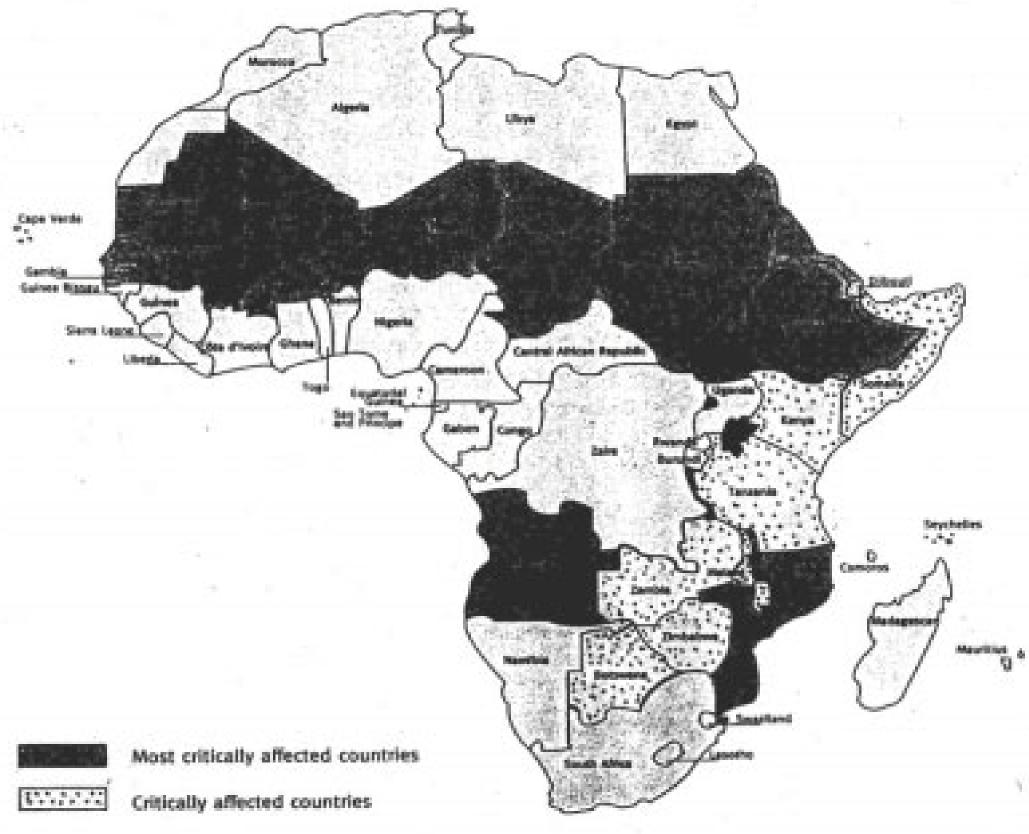

Figure 1.1. Countries affected by drought in Africa.
Source: Moustafa et al. (2002)