DROUGHT TOLERANCE IN ANDEAN AND MESOAMERICAN GENOTYPES OF THE COMMON BEAN

Ombaka Joseph Orende

B.Sc. Agriculture (Hons) University of Nairobi

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DEPARTMENT OF PLANT SCIENCE AND CROP PROTECTION

FACULTY OF AGRICULTURE

UNIVERSITY OF NAIROBI

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Declaration

I declare that this thesis is my original work and has not been presented for a degree or award in any other University.

Signature ---------- Date: .....

Ombaka Joseph Orende

SUPERVISORS:

Signature..... Date.....

Prof. Paul M. Kimani,

Department of Plant Science and Crop Protection,

University of Nairobi

Signature…… Date……

Prof. Mary W.K Mburu,

South Eastern Kenya University (SEKU)

Signature…… Date: .....

Prof. R. D. Narla

Department of Plant Science and Crop Protection,

University of Nairobi

ABSTRACT

Dry bean (*Phaseolus vulgaris* L.) is a popular legume sensitive to water stress especially during reproductive development phase. Adaptation to drought stress is therefore an increasingly important trait in production of dry beans crop. Climate change has caused a low water resource, abandoned farming land, frequent crop failure and food insecurity, and the emerging strong market preferences in Africa drives research to adapt to changing conditions. The objective of this study was to select bean lines tolerant to drought stress through on-station evaluation, on-farm variety selection and to determine physiological traits associated with drought tolerance. Two hundred and sixty three (263) genetically diverse genotypes composed of 155 large seeded, and 108 small seeded grain types sourced from International Center for Tropical Agricultural (CIAT) core collections, regional and national breeding programs, the Gene Bank of Kenya farmer varieties and landraces were screened for drought adaptation at Kabete Field Station at University of Nairobi. The large seeded beans were further classified into red mottled with 81 genotypes, red kidney with 49 genotypes and speckled sugar beans with 25 genotypes. The small-seeded beans comprised of small red, navy beans and carioca, pinto and purple with 36 genotypes in each market class. The experimental design was split-plot with three replicates. The germplasm was screened under drought stress nursery with water stress as main treatment (irrigated and rain-fed) while season and genotypes as sub-plots. Each plot consisted of two 3m rows. Spacing was 50cm between rows and 10cm between plants. Both trial treatments were irrigated up to flowering stage to ensure uniform crop stand. Rain-fed plots depended on rain water, while irrigated plots received three supplemental sprinkler irrigations depending on visual appearance of the plants.

Data was collected on shoot traits. This included 50% time to flowering and maturity, 100-seed-mass and grain yield. Biomass data was collected by harvesting half meter (0.5m) of every plot and dried in the oven at 60^{o}C for 72 hour to constant weight. Shoot biomass, seed biomass, pod biomass at mid pod and harvest and pod wall biomass at harvest weights were recorded. Drought intensity index, drought susceptibility index, pod harvest index and pod wall biomass proportion were derived from above collected data. The data was subjected to analysis of variance to determine the significance of treatment effects. A correlation analyses for rain-fed grain yield to biomass data was done to determine traits associated with drought stress.

Results indicated that drought stress reduced the grain yield by 40% in small-seeded lines and by 60% in large-seeded. Genotypic variation existed among tested lines, and RAB 618, CIM-NAV-02-02-11-1, CIM-DWF-CLIMBOI-10-2 were outstanding among small-seeded (Mesoamerican gene pool) while CIM-RM-02-03-09, CIM-RK-03-03-12 and Sharp black were outstanding among those of large seeded (Andean gene pool) compared to commonly grown varieties. Moderate drought stress

of drought intensity index (DII=0.3) during the 2008 long rain season reduced grain yield by 40%, while more severe drought (DII=0.72) in 2010 reduced grain yield by 63%. Drought tolerant genotypes recorded drought susceptibility index ranging from 0.59 to 0.8, while ECAB 0010 was the most susceptible among test lines with DSI of 1.56.

Results indicated that fourteen small-seeded and eleven large seeded genotypes recorded 40% to 60% grain yield advantage over commonly grown varieties including KAT 69, KAT 56, KAT B9, KAT B1, GLPX92, AWASH 1, and GLP 1004. The superior genotypes tolerant to drought stress included CIM-RM-02-01-07, CIM-RM-02-04-03, ECAB 0031, CIM-RK-03-03-14, NS 15457-3 and Sharp black for large seeded and RAB 618, GBK 035102, MR 13508-7, MR 13944-32-1P (small red), CIM-NAV-02-02-11-1, VCB 81013, CIM-NAV-02-01-1-2, CIM-NAV-02-03-17-2 (carioca, pinto and purple) and GCI-ZEBRA-269-RAR-2, CIM-DWF-C-01-53-3, GCI-ZEBRA-268-RAR-2 (Navy beans).

During farmer participatory variety selection, 29 large and small seeded lines tolerant to drought stress in three drought prone regions of Central, Eastern and Rift valley were selected. Farmers' key selection criteria were tolerance to drought stress, high yield, uniformity, early maturity and preferred market quality. Drought tolerant with high yielding genotypes selected by farmers across regions recorded 35% to 43% yield advantage to KAT 69, KAT 56, KAT B9, KAT B1, GLPX92, GLP 1004. The selected genotypes included GCI-CAL-271-RAR-2, NUA 59, CIM-RM-02-01-03, CIM-RK-03-03-12, CIM-RK-03-02-09, CIM-RK-03-03-16, NS 15457-3, sharp black and sugar 131. Fifteen among the 29 selected genotypes coincided with breeder selections at Kabete Field Station indicating overlap of breeder and farmer selection criteria. Grain yield under drought stress conditions was strongly correlated to time to maturity r=0.67**, 100-seed mass r=0.57**, pod harvest index (PHI) r=0.52** and pod wall biomass proportion r=-0.63**. This confirmed that these traits affected yield of common beans. We recommend the use of these traits for selection of common beans for tolerance to drought stress.

Key words: Drought stress, market class, participatory variety selection.