Application of molecular marker assisted selection in developing common bean varieties with improved multiple resistances to the major diseases in Kenya

Kenya Agricultural & Livestock Research Organization (KALRO), Kakamega, Kenya

Dr Reuben Otsyula, KALRO, Kenya

Project team members

Mr Yona Masheti

Mr Shadrack Odikara

Mr Shamir Misango

Mr Allan Shivachi

Project locations

KALRO's bean breeding team inspecting multiple disease resistant bean varieties being tested in a farmer's field, 2021.

PROJECT OVERVIEW

Background

Beans provide 45-60% of the Kenyan population's dietary protein intake and 25% of their calories. The crop's major biotic constraints include *Pythium* root rot, anthracnose (ANT, causative pathogen *Colletotrichum lindemuthianum*), common bacterial blight (CBB; *Xanthomonas axonopodis*), bean common mosaic virus (BCMV); bean common mosaic necrotic virus (BCMNV) and scab (*Elsinöe phaseolus*).

Advanced yield trials, KALRO, Kakamega, 2021.

Objectives

1. To improve the capacity of popular local bean land races and cultivars to resist infection by the pathogens responsible for key diseases.
2. To determine the economic impact of scab on bean productivity.
3. To Identify and characterize sources of genetic resistance to scab.

Progress to date

1. Advanced yield trials have been conducted at both KALRO Kakamega and Bungoma, based on 45 backcross derivatives bred from crosses between the recipient variety CAL 194 (a *Pythium* resistant variety with market-class qualities), and the donor varieties MCM 2001 (BCMV/BCMNV), G2333 (anthracnose) and VAX3 (CBB). The performance of these lines is contrasted with that of a panel of check cultivars (CAL 194, KK Red 16, GLP2 and KK 8). Read more.
2. BC3 Backcross breeding populations to confer multiple disease resistance to selected Kenyan landraces (Sugar 1, Sugar 2, Sugar 3) developed using the parent donors (CAL 194 for *Pythium* and G233 for anthracnose). Read more.
3. A number of entries (RWR 2245, CAL 70, CAL 232A, KK 8, CAL 110 and GLP2) expressing resistances to CBB, anthracnose, and scab were tested and have been submitted to the 2020 National Performance Trials, an

important step towards authorized release in Kenya. Note that KK 8, CAL194, and Red 16 are all varieties bred by Dr. Otsyula prior to the initiation of this KT-funded project. Read more.

4. Breeding materials have been developed to transfer the scab resistance carried by CAL 06 and CAL 110 into the farmer-preferred varieties Red 16, Rosecoco 194 and KK 8.

Kenyan bean varieties targeted for improvement by the KALRO project: KKRIL05/Red16 (i); KK Yellow (ii); Red 40 (iii); Sugar 1 (iv); Sugar 2 (v); Sugar 3 (vi); and Sugar 4 (vii).

PROJECT TEAM MEMBERS

Dr Reuben Otsyula

Principal Research Officer, KALRO Kakamega, Kenya.

Dr Otsyula has led the KT-funded bean improvement programme in KALRO, Kenya, since its inception in 2015.

Mr Patrick Oucho
Technical assistant

Mr Yona Masheti
PhD student

Mr Shamir Mishango
MSc student, pathologist

Mr Shadrack Odikara
MSc student/ molecular breeder

Mr Faida Kelele
Pathology Technician

Mr Allan Shivachi
PhD student, past team member

STUDENT PROJECTS

Prevalence, epidemiology and management of bean scab (*Elsinoë phaseoli*) of common beans (*Phaseolus vulgaris*) in Kenya

Mr Yona Masheti


Mr Yona Masheti

PhD, Crop Protection, University of Nairobi, Kenya, 2019- 2022.
Supervisors: Professor James W. Muthomi (University of Nairobi, Kenya), Dr Reuben Otsyula (KALRO), Professor Paul Gepts (University of California, Davis), Dr Esther Arunga (University of Embu, Kenya).

Bean scab threatens to become a major biotic constraint for Kenyan bean producers. Although reputed to have caused major losses in yield, the disease (causative fungus *Elsinoë phaseoli*) is as yet poorly understood.

Project objectives

1. To determine the prevalence and variants of *Elsinoë phaseoli* in Kenya.
2. To establish the environmental conditions that affect the incidence of bean scab.
3. To identify appropriate management options for bean scab.

Progress to date

1. The occurrence of scab was assessed in farmers' fields in major bean growing zones. Sampling has been completed in 14 of the 22 target counties.
2. Disease management options used in the control on bean scab farmers in Kenya have been assessed. Rodazim, a fungicide of the group of benzimidazoles, contains carbendazim, an active ingredient effective against scab.

Map with the locations of field sampling for bean scab (i); bean scab damage on the upper side of infected leaves (ii); lower side of infected leaves (iii); pods (iv); bean scab isolates grown in culture (v).

Prevalence, epidemiology and management of bean scab (*Elsinoë phaseoli*) of common beans (*Phaseolus vulgaris*) in Kenya

Mr Yona Masheti


Mr Yona Masheti

MSc in Crop Protection, University of Nairobi, Kenya, 2017-2019.
Supervisor: Dr Reuben Otsyula.

Project overview

This study was carried out by Yona Masheti as part of the requirements for his award, made in 2019, of a University of Nairobi MSc degree in Crop Protection. Its objectives were to document the influence of environment on disease incidence and severity, while also determining the effect of varying the crop's planting time on disease incidence and severity. Diseased tissue was sampled over two growing seasons from 18 bean varieties planted in smallholder farms located across Western Kenya.The incidence, distribution and severity of eight diseases were monitored, namely angular leaf spot, anthracnose, bacterial spot, BCMNV, BCMV,

CBB, halo blight and scab. The agronomic performance of the varieties was recorded.

The ranking of the varieties proved to be environment-dependent. Those showing the most promise in terms of multiple disease resistance, high yield and yield stability were Red 16, Red 13 and CAL 194. The advice given to farmers across the whole area is to plant early and to choose varieties well adapted to the local environment.

A set of the bean diseases identified in farmers fields: angular leaf spot (ALS; i); scab (ii); common bacterial blight (CBB; iii); bacterial brown spot (iv); and bacterial common mosaic virus (BCMV; v).

Identification of novel candidate genes associated with scab resistance in common bean

Mr Shadrack Odikara


Mr Shadrack Odikara

MSc, Bioinformatics,
Supervisors: Dr Benard Kulohoma University of Nairobi (UoN), Dr Evans Nyaboga (UoN), Dr Reuben Otsyula (KALRO).

Project objectives

1. To determine the phenotypic variation among common bean accessions for scab resistance in the field.
2. To identify SNPs and putative genes associated with scab resistance using diverse set of common bean accessions by GWAS approach.
3. To develop high-throughput PCR based markers for MAS targeting scab resistance in common bean.

Progress to date

1. Two field trials are being conducted during the 2021 long rains season: one in KALRO-Kakamega and the other in Butonge. The germplasm being assessed for the incidence and severity of scab infection comprises 11 Kenyan bean varieties along with 171 entries of the Andean Diversity Panel (ADP).

Progression of scab disease. 1: small lesions; 2-1 and 2-2: scab lesions coalesce into dead tissue zones, leaves begin to curl inwards, stem twists; 3-1 and 3-2: disease progresses to over 50% of the plant, defoliation and stem twisting.

Genotypic characterisation and improvement of disease resistance in landraces and local cultivars of beans popularly grown in medium and high-altitude zones of Kenya

Mr Shamir Misango

MSc, Plant Breeding and Biotechnology, University of Nairobi.
Supervisors: Dr Esther Arunga, University of Embu, and Dr Reuben Otsyula, KALRO Kakamega.

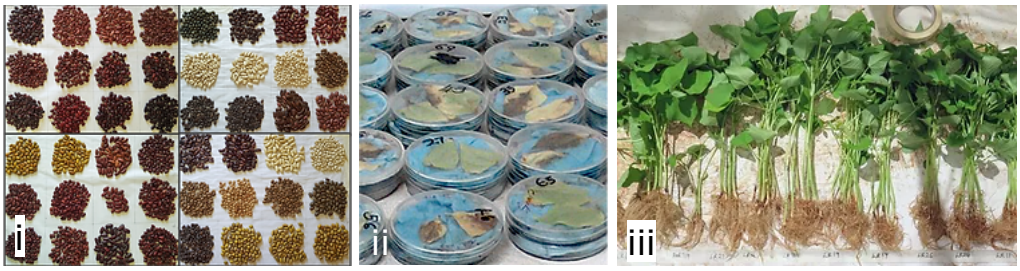

Mr Shamir Misango

Project objectives

1. To determine genetic diversity of 100 common bean landraces in medium and high-altitude zones of Kenya.
2. To characterise local bean cultivars and landraces for *Pythium* root rot and anthracnose resistance.
3. To introgress *Pythium* root rot and anthracnose resistance in common bean landraces using molecular markers.

Progress to date

1. Germplasm collection and morphological characterisation of 120 landraces.
2. Eighty-nine common bean landraces and nine local cultivars were planted in the field at KALRO-Kakamega. Data collected on morphology, growth habit, disease resistance and agronomic characteristics. Ninety landraces were planted in the screen house together with the anthracnose-resistant check (G2333) and the susceptible checks (Tasha and Chelelang). The detached leaf method was used to determine reaction to anthracnose. Molecular markers were used to assess the level of diversity.
3. The landraces Sugar 1, Sugar 2 and Sugar 3 were selected for improvement to combine *Pythium* root rot and anthracnose resistance, using the donor varieties CAL 194 (*Pythium*) and G2333 (anthracnose). BC2F1 and BC3F1 populations have been evaluated (by marker assisted selection and phenotypic characterisation) and lines with double disease resistance have been identified.



Composite of photographs showing seed diversity among collected Kenyan bean landraces (i); detached leaf method for assessing susceptibility to anthracnose (ii); scoring resistance to *Pythium* root rot in the bean landraces collected (iii).

Pyramiding resistance genes for major bean disease occurring in Western Kenya through marker assisted selection

Mr Allan Shivachi


Mr Allan Shivachi

Project objectives

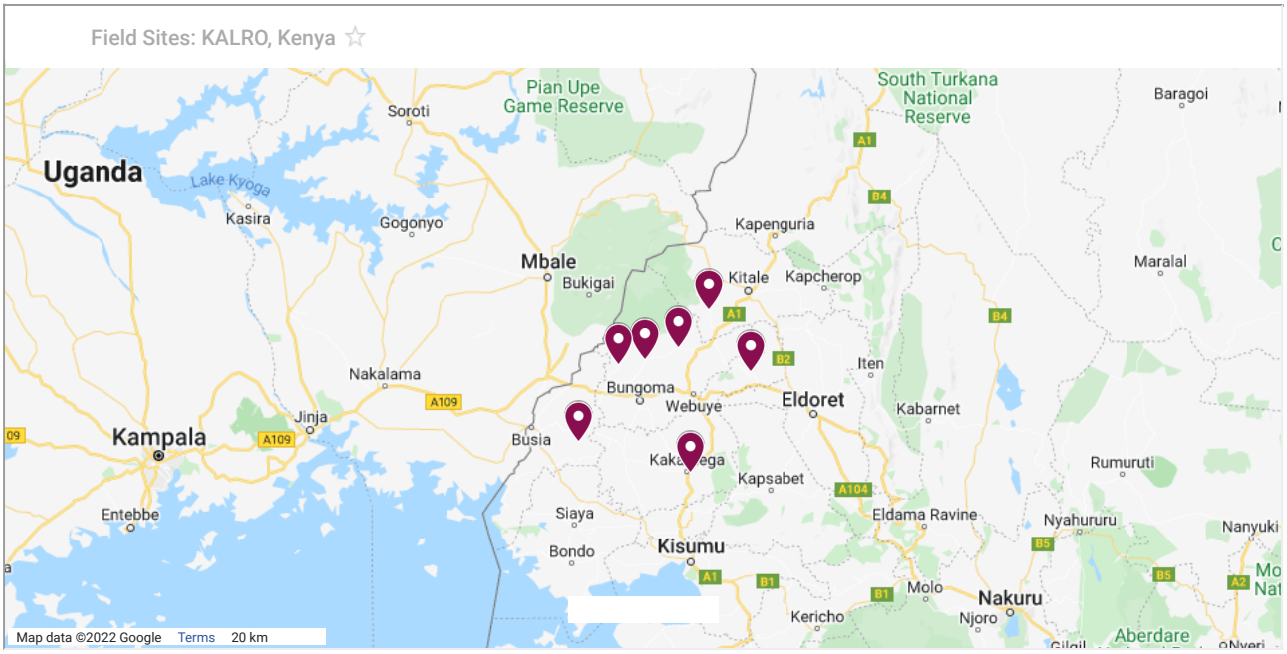
This study was carried out by Allan Shivachi as part of the in Doctor of Philosophy (PhD) degree in Genetics and Plant breeding of the University of Embu. The research was supervised by Dr Esther Arunga (University of Embu), Dr Reuben Otsyula (KALRO) and Professor Paul Njiruh Nthakanio (University of Embu). Its objectives were to phenotype and genotype a range of advanced bean breeding lines with respect to their resistance against anthracnose, CBB, BCMV and BCMNV, and to employ parallel marker-assisted backcrossing to introduce resistance against anthracnose, CBB, BCMV and BCMNV into CAL 194, a *Pythium*-resistant variety with market class qualities. The donors for these resistances were VAX 3 (CBB), G2333 (anthracnose) and MCM 2001 (BCMV and BCMNV).

Achievements

A set of 61 KALRO advanced lines (25 in the red market class and 36 in the Calima class) were characterised both phenotypically with respect to their level of resistance against anthracnose, CBB, BCMV and BCMNV, and genotypically, using markers linked to known genes for resistance to these diseases. The lines selected for further assessment were KK 8, KK 071. CAL 135, GLP 585, Red 13, TWR 2245, CAL 304A and Red 40. Three parallel backcross populations were generated based on the recipient CAL 194 and were subsequently intercrossed to develop CAL 194 derivatives showing resistance against CBB, anthracnose and BCMV/BCMNV, while retaining the recipient parent's resistance against Pythium root rot. The selection process was based on the use of both molecular markers and assessment of phenotype in response to artificial inoculation. Twelve (12) BC3F2-derived selections carrying resistances to at least one of the target diseases in addition to *Pythium* root rot resistance are currently being tested as potential releases in advanced yield trials.

Advanced bean breeding lines in greenhouse for artificial disease inoculation (i); symptoms of susceptible plants inoculated with CBB (ii) and BCMV (iii); crosses for BCM/NV (F1; iv).

PROJECT LOCATIONS



Location of the KALRO Kakamega research institute's field trial sites.