POLLINATION AND SEED GERMINATION SUCCESS IN 'MATOOKE' BREEDING

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WP1

Introduction

East African highland bananas (EAHB) were originally regarded as sterile. However, screening using 'Calcutta 4' revealed some fertile EAHB. This breakthrough led to EAHB crossbreeding at the International Institute of Tropical Agriculture (IITA) and National Agricultural Research Organization (NARO) in Uganda. This study aimed at assessing the progress and efficiency of the EAHB breeding programme in the first 20 years, using the data collected at IITA-Uganda from 1995 to 2015.

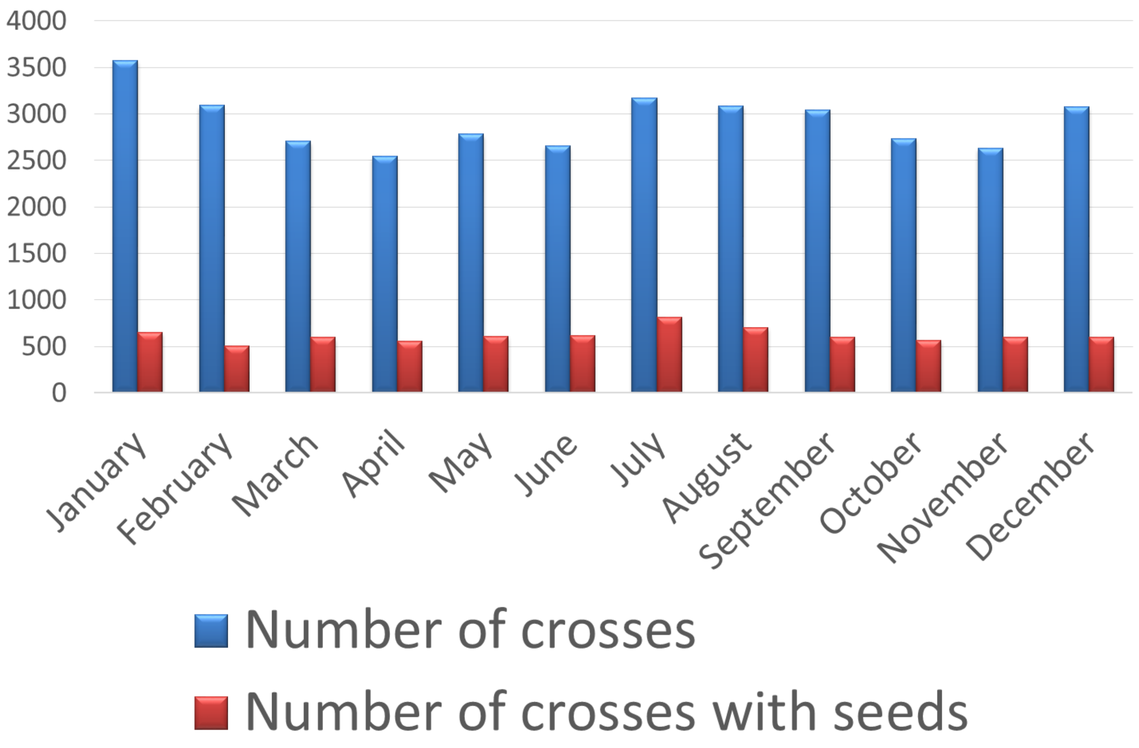

Fig.1. Total number of crosses and crosses with seed per month from 1995 to 2015

Materials and Methods

Pollination and germination data collected from 1995 to 2015 were analysed using R-software version 3.4.1. Type 1 analysis of variance was performed to assess the effect of month of a year on pollination success.

Pollination success was calculated as:

$$\frac{\text{Number of pollinated bunches with seed} \times 100}{\text{Total number of pollinated bunches}}$$

Seed germination success was calculated as:

$$\frac{\text{Number of germinated embryos} \times 100}{\text{Total number of extracted embryos}}$$

Results and Discussion

Month of the year had no significant effect (P=0.5) at 95% level of confidence, on pollination success (Fig. 1). Tetraploids were more female-fertile than triploids. Also, *Musa acuminata* subsp. *malaccensis* accession 250 had the highest pollination success when used as a male, followed by cultivar 'Rose' (Fig. 2). These two accessions outperformed 'Calcutta 4' which was regarded as the best male-fertile parent. Seed germination percentage was highest in $2x \times 4x$ (36%), followed by $2x \times 2x$ (23%). $3x \times 2x$ germination (11%) was higher than $4x \times 2x$ (7%) (Fig. 3).

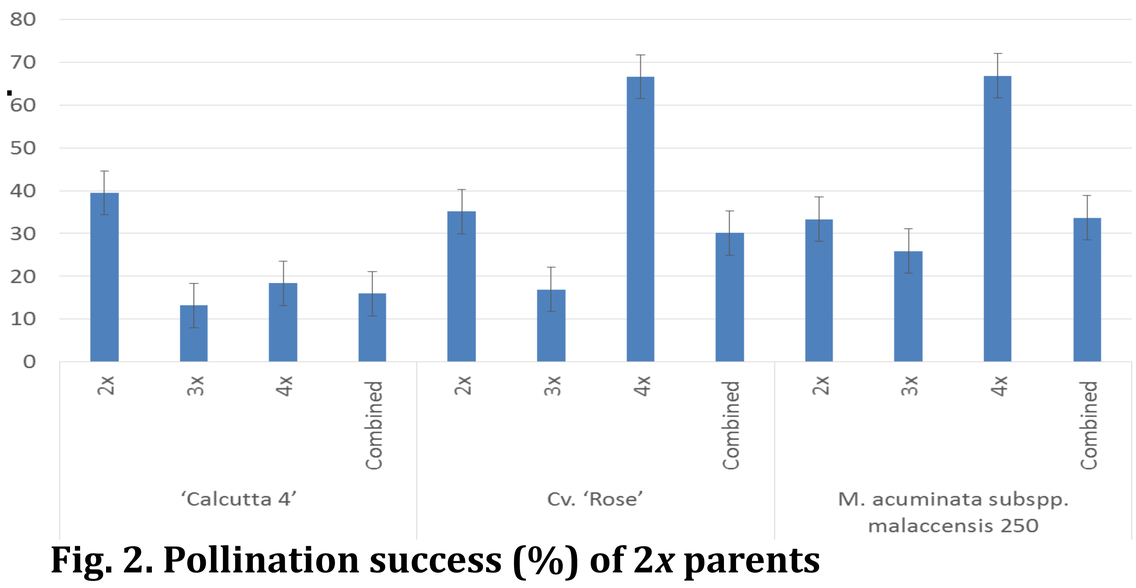

Fig. 2. Pollination success (%) of 2*x* parents

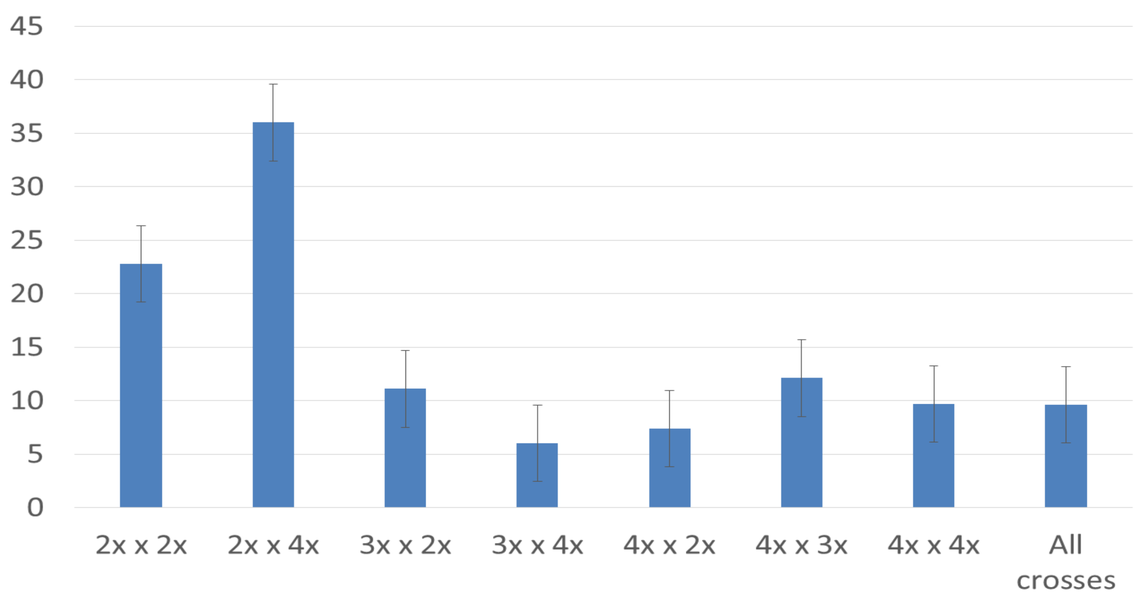

Fig. 3. Seed germination success (%)

Conclusion

Banana pollination should be done throughout the year. *Musa acuminata* subsp. *malaccensis* accession 250 and cultivar 'Rose' should be used as male parents to screen banana accessions for female fertility. Pollination should be optimized to boost seed set and embryo culture protocol should be improved to increase embryo germination rate.

Nutritional and sensory evaluation of fifteen local cooking banana (*Mchare*) cultivars

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Abstract

Banana (Musa sp.) is an important fruit worldwide. In East Africa, cooking bananas are an important staple nutritional food and play a key role in addressing the issues of food security in the region. Considerable research is focused on the improvement of banana varieties with regards to good agronomic characteristics (e.g. disease resistance) but limited work has focused on sensory qualities. Nutritional value of the local bananas (particularly *Mchare*) have not been addressed. Additionally, consumer preferences differ greatly in many varieties of banana produced. Evidently, the need to evaluate the nutritional and sensory attributes of local banana varieties cannot be overemphasized. This study expects to identify the local banana cultivars with desirable characteristics with respect to nutritional value and sensory quality. This information is vital to banana breeders for developing improved banana cultivars that will be readily adopted by local farmers.

Keywords: Local banana, nutritional value, sensory attributes, consumer preferences

Introduction

- Banana is a popular and nutritious fruit crop widely grown in tropical and sub-tropical regions. Globally, the 2nd leading fruit, in terms of production next to citrus.
- Tanzania is a 2nd leading producer in East Africa after Uganda, annual production 3.7 million metric tons.
- Nutritional and economic importance of cooking bananas (other than *Mchare*):
  - ✓ Energy: 90-320 calorie per 100 g of unripe banana (Carbohydrates).
  - ✓ Minerals: K 259–733 mg/100g; Ca 10–132 mg/100g; Fe 0.26–12.18 mg/100g and Zn 0.74–2.75 mg/100g.
  - ✓ Vitamins: ascorbic acid 1.4 – 33.5 mg/100g
  - ✓ Fibrous carbohydrate: dietary fibre 6.00 – 7.53 g/100g

Main Objective: To conduct nutritional and sensory evaluation of fifteen (15) local banana (*mchare*) cultivars in Northern Tanzania.

Specific objectives:

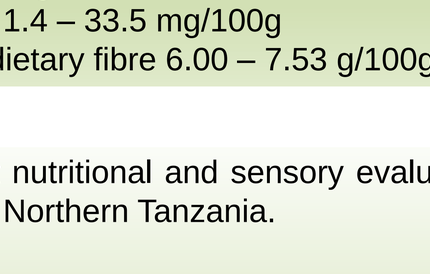
i. To determine proximate compositions [carbohydrate, crude protein, crude fat, moisture, ash, dietary fiber and energy value] and micronutrients [K, Ca, Zn and Fe] contents of bananas.
ii. To determine the physicochemical characteristics that influence banana quality [pH, firmness, the total soluble solids (TSS), titratable acidity (TA)].
iii. To evaluate sensory attributes of cooking bananas that influence consumer preferences [taste, aroma, colour and preferences].

Methodology

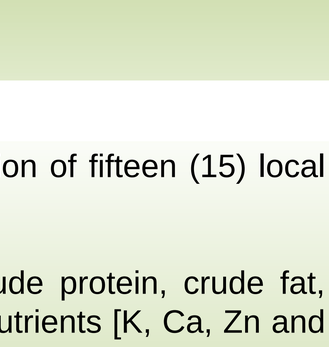
Samples of fifteen local cooking banana cultivars (*Huti* white, *Huti* green, *Mchare laini*, *Mchare mlelembo*, *Makyughu* I, *Makyughu* II, *Akondro mainty*, *Ijihu Inkundu*, *Kahuti*, TT2, *Muraru* (*Mchare*), *Muraru* red, *Muraru* white, *Maji Maji* and Njuru) will be taken for analysis.

Activity 1. Proximate analysis: Moisture content, Ash content, Crude fat, Crude protein, carbohydrate and dietary fibre all will be determined by using standard method[5].

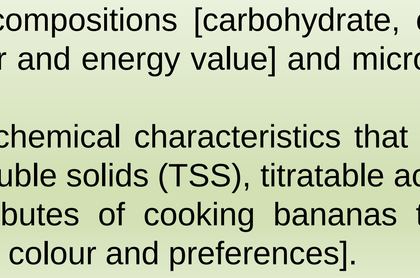
Activity 2. Elemental analysis:
Quantification of iron, zinc, potassium and calcium will be performed by Inductive Coupled Plasma Mass Spectrometry (ICP-MS) standards procedures[5].



Soxhlet system



Kjeldahl system



ICP-MS system

Fig. 1: Some analytical equipment to be used in the study

Activity 3. Physicochemical properties analysis: pH determined by pH meter, firmness by fruit penetrome**ter,** TSS by refractometer and TA by titration.

Activity 4. Sensory evaluation: A 5-point Hedonic scale will be used to rate sensory attributes i.e. taste, aroma, texture, colour and overall preference[4,7].

Expected results

i. Data on nutritional values and desirable sensory parameters of local bananas will be obtained. This information is vital to banana breeders for developing improved banana cultivars that will be readily adopted by local farmers.
ii. Mitigation of food insecurity in Tanzania and the region and enhance commercial production of bananas. Farmers will therefore be able to produce bananas that meet both industrial and consumer demands.
iii. Finding from this study will also stimulate researchers to pay attention on the underprivileged banana varieties as affordable and sustainable food source, if identified to have potential value.

FBNS Capacity

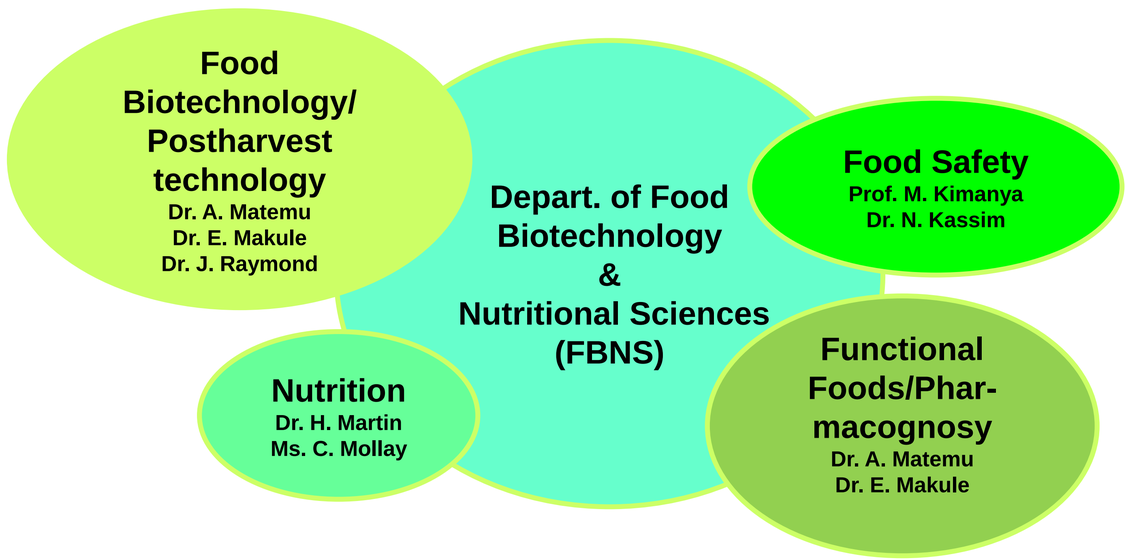


Fig. 2: NM-AIST Capacity in Food Biotechnology and Nutritional Sciences

Fig. 3: Banana recipes commonly used in local cooking bananas

Conclusion

Development of improved banana cultivars with good agronomic features that also meet nutritional needs and sensory preferences of consumers increases their value to farmers and increases the likelihood of adoption by the same group.

Acknowledgements

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Pollen Viability and Seasonal Variation in Selected Wild Musa (AA) Diploids and Mchare Cultivars

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WP1

Abstract

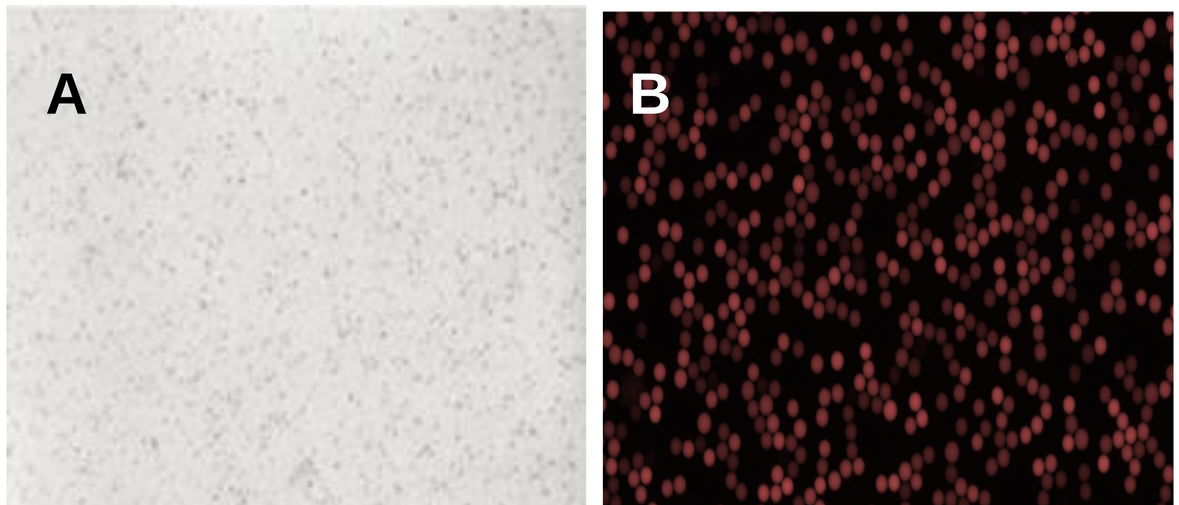
East African diploid cooking bananas include Mchare (Mshare, Muraru or Mlali) is a staple crop for millions of subsistence farmers in Tanzania and other parts of East Africa. Several endemic pathogens are severe constraints to Mchare production. Sources of resistance to these pathogens have been identified but successful introgression of resistance is impeded by sterility issues. The objective of this study was to assess quantity and viability of pollen among Mchare to identify the most fertile cultivars to be utilized in breeding schemes to provide farmers in East Africa with improved varieties. Pollen was collected once a month from fourteen genotypes, (seven wild varieties and seven Mchare varieties) over a 12 month period. Quantification of pollen grains (3 replications per genotype) was accomplished with image analysis software (ImageJ). Pollen viability was tested using TTC staining procedures. Wild (or unimproved) varieties such as 'Calcutta 4' and 'Borneo' produced the highest pollen counts and greatest percentage of viable pollen. Significant differences were observed among wild types, between wild and Mchare bananas, and among Mchare. Among Mchare varieties, three distinct groups could be observed with the most fertile cultivars (Huti White, Huti Green, and Mchare laini) performing significantly better than the other Mchare.

Introduction

The quantity and quality of pollen produced are important attributes to be considered in the selection of male parents for breeding purposes. (Ssebuliba and Tenkouano, 2007).The efforts toward improving Mchare varieties have been complicated by poor seed set caused by high rates of sterility. An assessment of pollen fertility is indispensable for any genetic improvement of plants (Fortescue and Turner, 2004). Most of the wild material assayed in this study (Calcutta 4 and others), have been used successfully as male parents by other breeding programs (Pillay et al, 2012). Mchare varieties have never been assayed as pollen sources and therefore are used exclusively as females in breeding schemes. Hybrid Mchare, however, could be utilized in breeding approaches that might involve further recombination with Mchare or as a bridge to the improvement of other cooking or dessert bananas. This study was conducted to assess the quantity and viability of pollen in Mchare cultivars, and wild diploids used at Arusha, Tanzania with the aim of identifying the most fertile varieties for further genetic studies and plant improvement.

Materials and Methods

- Pollen was collected at 8am from three anthers of 15 genotypes (7 wild varieties and 8 Mchare varieties) for 12 months in Arusha, Tanzania.
- Pollen (with a dilute detergent solution) was spread on a glass slide and digitally photographed with a stereomicroscope.
- Digital images processed to remove noise and sharpen individual pollen grains using ImageJ NIH software (Abramof et al, 2004)
- Estimates of pollen viability were obtained with a drop of Triphenyl tetrazolium chloride (TTC) stain.
- After incubation at room temperature for 2 hours, viable pollen grains took up the stain, while unviable pollen remained transparent.
- Statistics generated using GenStat 64-bit, 17th edition.



A:Parlicle analysis to obtain pollen counts*; B: *TTC -Stained pollen grains

Results and Discussion

1. Significant differences were observed in pollen production among wild varieties, between wild and Mchare types and among Mchare varieties. Mchare varieties produced less than 20% of total pollen produced by wild varieties. The highest pollen numbers per anther were observed in "Calcutta 4" and "Borneo" (Both wild varieties) throughout the year, while the lowest counts were observed in "Ijihu Inkundu" and "Makhyugu I".

2. Within Mchare, 3 genotypes, "Huti white ", 'Huti Green' and "Mchare laini" formed a group of relatively high pollen producers, while 'Ijihu inkundu' and Makhyugu I' formed a group that produced only trace amounts of pollen. The remaining genotypes formed an intermediate group.

3. Pollen viability (%) also varied significantly between the genotypes and while this was in many cases correlated with total pollen, there were exceptions: Pisang lilin produced on average over 27,000 pollen grains per anther on average but only 40% were viable.

Table 1: Pollen counts per banana anther and viability of 15 genotypes observed for months in Arusha Tanzania

Genotypes	ITC Codes	Sub species/subgroup	Type	Pollen counts per anther	Pollen Viability %
Calcutta 4	ITC.0249	ssp. microcarpa	Wild	31796 h	74 h
Borneo	ITC.0253	ssp. burmanica	Wild	31582 h	65 g
CV rose	ITC.0712	ssp.malaccensis	Wild	29229 g	55 f
P.Lilin	ITC.1121	ssp.malaccensis	Wild	27131 fg	40 cd
P.Pahang	ITC.0609	ssp. malaccensis	Wild	25853 f	57.1f
Truncata	ITC.0393	Truncata	Wild	23045 e	52.5ef
Zebrina GF	ITC.0966	ssp. zebrina	Wild	13591 d	36 c
Huti white	None	Mchare	Mchare	7942 c	58 fg
Huti green	ITC.1559	Mchare	Mchare	7270 c	47 de
Mchare laini	None	Mchare	Mchare	6547 c	51 ef
Makyugu II	ITC.1446	Mchare	Mchare	4397 b	39 c
Mchare mlelembo	ITC.1455	Mchare	Mchare	4252 b	39 c
Akondro mainty	ITC.0218	Mlali/mchare	Mchare	3363 b	27 b
Makyugu I	ITC.1454	Mchare	Mchare	328 a	16 a
Ijihu Inkundu	ITC.1460	Mchare	Mchare	224 a	13 a

Conclusion

1. **"Wild" varieties more male fertile than Mchare (5X)**
2. **Among Mchare varieties, 3 separate groupings observed in respect to fertlity**
3. **"Huti white " and "Mchare laini" are the most fertile Mchare and can be used as male parents in breeding schemes**

Acknowledgements

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Measuring banana Canopy Cover:
towards modelling banana growth with the AquaCrop model

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KU Leuven[1], International Institution For Tropical Agriculture[2] and
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WP 1

Context

Problem statement

- Banana = staple food in East African Highlands
- Smallholders ➔ low-input and rain-fed systems
- Banana needs a lot of water (about 1110 – 2690 mm annually) (van Asten, Fermont and Taulya, 2011; Carr, 2009).
  - Shallow roots
  - Evergreen canopy

  ➔ **Does not show outward signs of moisture stress**

Irrigation

- Mostly based on physiological indicators

➔ **Canopy cover (CC) = most sensitive indicator**

Crop modelling: AquaCrop (AC) growth model (FAO)

- Critical tool for understanding constraints and impacts of future climates
- Over 40 annual crops ➔ no banana and/or ratoon crops

Goal = *AquaCrop* for Banana

Incorporate banana plantation structure in AC

- First homogenous cycle
- Second ratoon cycle

AC modelling scheme:

soil moisture ➔ CC ➔ Tr ➔ B ➔ Y

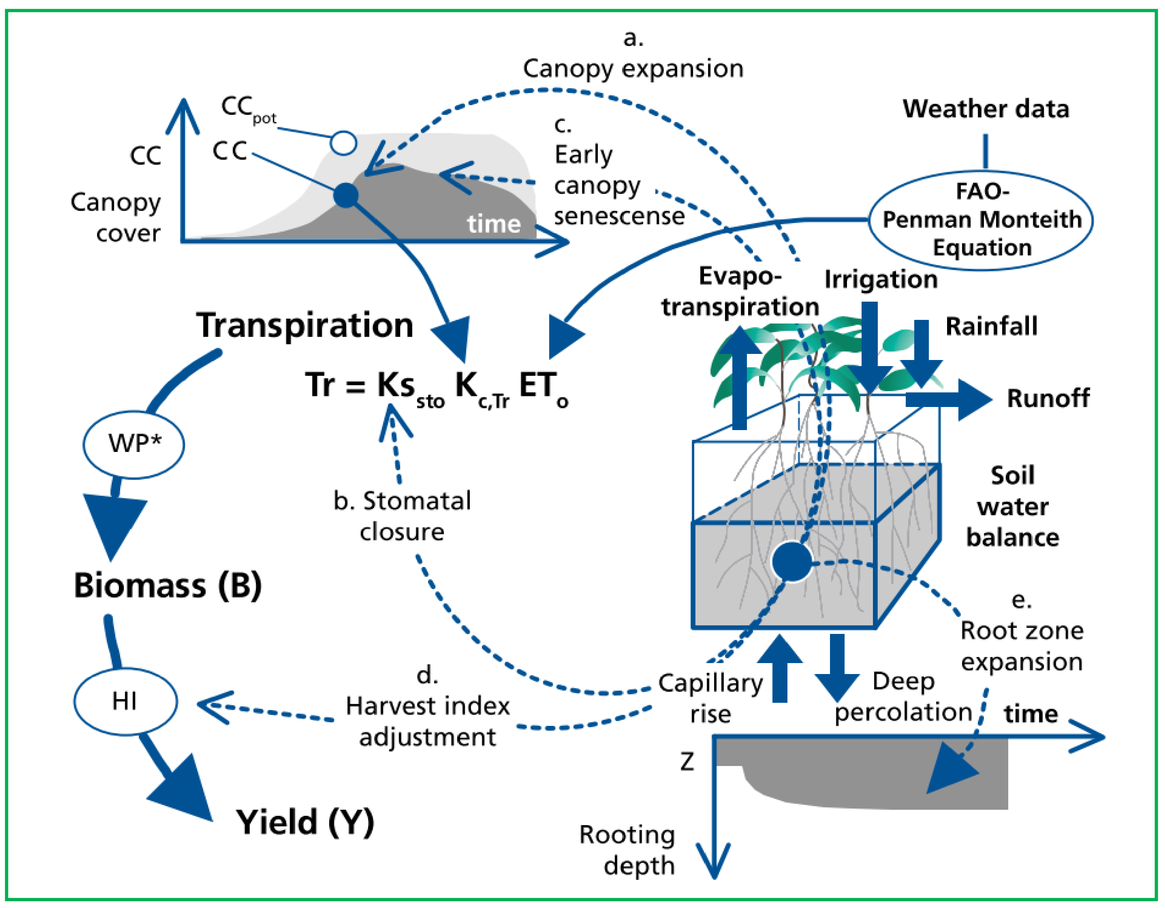

Figure 1: AC modelling scheme (Steduto et al., 2012)

Materials and Methods

Field trials = database to calibrate the AC banana model

Setup:

- 2 cultivars: Cavendish-Grand Naine and Mchare-Huti Green
- 2 irrigation treatments: Full Irrigated (FI, based on soil moisture) and Deficit Irrigated (DI, shut off irrigation after 4 months after planting)
- 2 growth cycles: 1st = tissue culture and 2nd = ratoon

Measurements:

- Climate: temperature, rainfall, wind speed and solar radiation (weather station)
- Soil: physical parameters and moisture with TDR sensors
- Crop: growth parameters, sucker emergence, canopy cover (CC) (drone), biomass (destructive), flowering, yield
- Field management: irrigation timing and amounts, fertilizing, wet bulb

Outcome:

CC evolution of banana ➔ good indicator for drought stress?
Database for AC modelling ➔ irrigation scheduling software

Results

First growth cycle Mchare

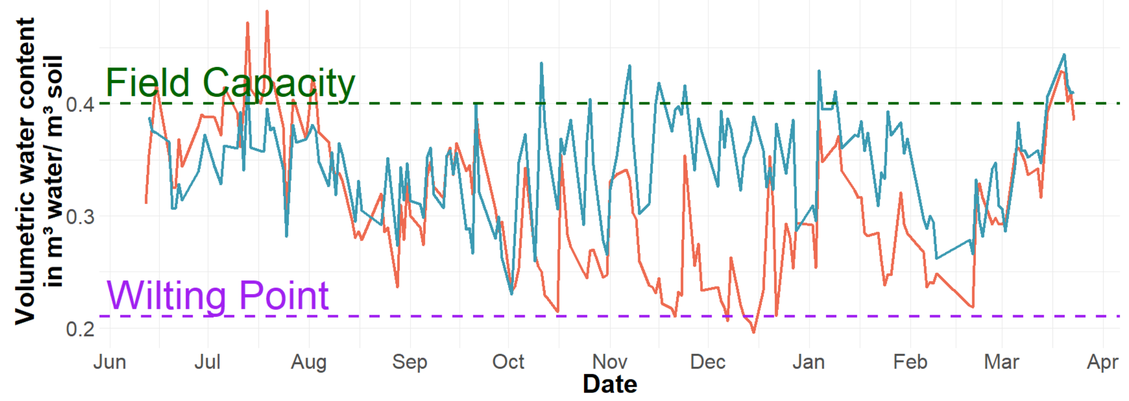

Figure 2: Soil moisture (0-30 cm depth). Blue = FI, orange= DI

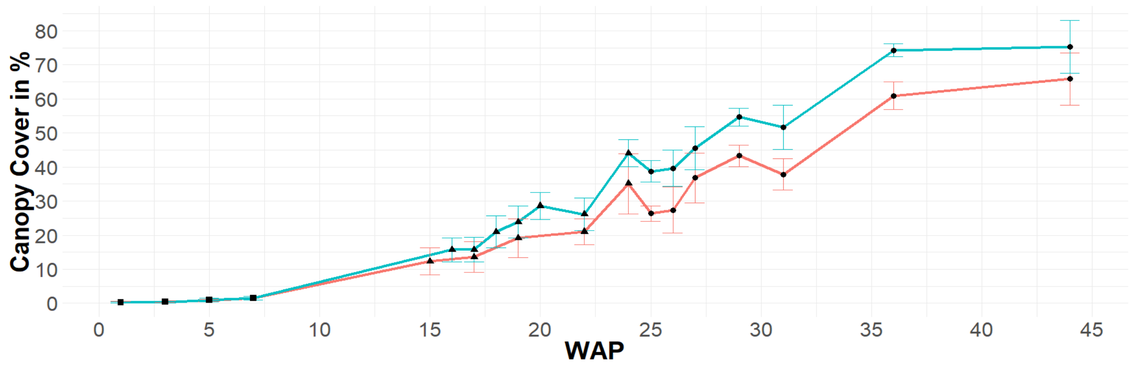

Figure 3: Canopy cover of banana plots. WAP = week after planting.

CC: imageJ script and diurnal variation

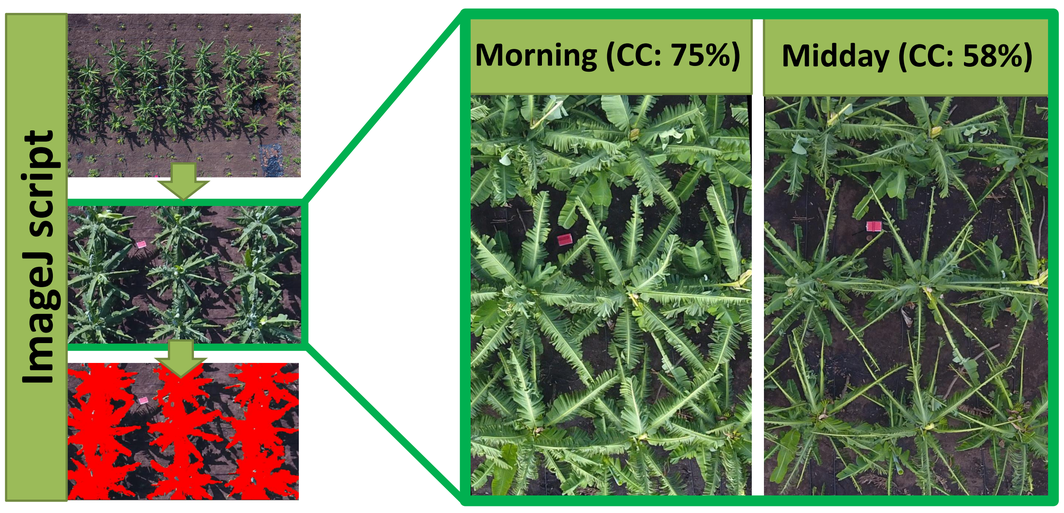

Figure 4: (Left) ImageJ script; (Right) diurnal CC variation

Conclusion

Banana growth (general)

- FI vs. DI: significant difference in growth even though plants did not show outward signs of drought stress. ➔ **need for a computer model!**
- First cycle = ready in summer 2018 ➔ start modelling

Canopy cover

- Diurnal variation of CC ➔ leaves fold in response to incoming radiation (Thomas and Turner, 2001).
  - Highest CC values are in the morning, and lowest around noon.

  ➔ **Timing of CC pictures is important**

Preliminary irrigation advice

- Heavy clay soil ➔ a lot of water held and unavailable for the banana
- In the dry season ➔ irrigation every day to always supply enough extractable water to the banana roots.

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Identification and characterization of Mchare diploids

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Work Package 1

Abstract

Characterization of Mchare bananas (AA) done with 32 minimum descriptors with the aim of determining phenotypic variability and distinctiveness among Mchare cultivars. Results displayed considerable phenotypic variation exists among Mchare in respect to external colour of the pseudostem, colour of male bud, number of hands per bunch, bract imbrication, bract rolling before falling, bract persistence and other traits. Preliminary data suggest that the phenotypic descriptors are adequate to distinguish among cultivars. Additional Mchare and Muraru cultivars will be described and a key developed for cultivar identification.

Introduction

Cooking banana important to food security in Tanzania and provides employment in rural areas. Mchare is the most important cooking banana in Arusha and Kilimanjaro, but to date they have not been well characterized. In different regions and districts of Tanzania, the same cultivar can have different names and to date molecular marker analysis has not adequately distinguished among them. Improving these bananas requires a detailed understanding of the variability that is available to breeders and documentation of phenotypic variation is needed to aide in cultivar identification.

Materials and Methods

1. Colour charts used for description of plant structures.
2. 32 minimum descriptors from *TAG (2015*)
3. Quantitative descriptors: fruit length (fruit of the third hand), number of hands per bunch and number of fruits mid hand of the bunch.
4. Qualitative descriptors: edge of petiole margin, colour of cigar leaf dorsal surface, bract behaviour before falling, pseudostem height, predominant underlying colour of pseudostem, blotches at the petiole base, petiole canal leaf III, petiole margins, petiole margins colour, bunch position, bunch shape, rachis position, rachis appearance, male bud shape, bract apex shape, bract imbrication, colour of the bract external face, colour of bract internal face, compound tepal basic colour, anther colour, dominant colour of male flower, fruit shape, fruit apex, remains of flower relicts at fruit apex, fruit pedicel length and fusion of pedicels. Descriptors analyzed below in table 1
5. Data collected from Mchare and six Muraru cultivars from June 2017 to February 2018 at IITA banana fields at Tengeru-Arusha
6. Upon completion of study, analysis of quantitative characters will be based on the mean of 3 plants.

Results

1. Differences were observed among the 8 accessions for all descriptors except for petiole margin and fruit shape.
2. Pseudostem height (PSH) ranged from 2 to >3 m
3. Number of hands per bunch ranged from 6 to 11
4. Number of fruits per hand (middle hand) ranged from 10 to 24

Discussion

The variation observed suggests phenotypic variation can be used to distinguish among Mchare cultivars and that the variation for traits such as number of fruits per hand and hands per bunch can and should be utilized in plant improvement

Descriptor	Mlelembo	Huti white	Huti green	Kahuti	Ijihu nkundu	Mchare laini	Akondro mainty	Makyughu II
PSC	Dark green	Light green	Green	Green	Red purple	Green	Watery green	Pink-purple
PMC	Not clasping	Not clasping	Not clasping	Not clasping	Not clasping	Not clasping	Not clasping	Not clasping
PSH	≤ 2	2-2.5	2.5-3	2.7-3	≥3	2-2.5	≥3	2.8
BP	Hanging vertical	Hanging vertical	Hanging vertical	Slightly angled	Hanging vertical	Hanging vertical	Hanging at 45 angle	Hanging vertical
BS	Cylindrical	cylindrical	cylindrical	Truncated cone	spiral	cylindrical	cylindrical	cylindrical
RP	With curve	With curve	Falling vertically	Falling vertically	With curve	Falling vertically	With curve	At an angle
FS	Curved	Curved	Curved	Curved	Curved	Curved	Curved	Curved
FA	Pointed	Pointed	Rounded	Pointed	Rounded	Pointed	Rounded	Blunt
NMB	10	15-20	15-20	24	15-20	15-20	15-20	>20
BBF	revolute	revolute	revolute	revolute	revolute	revolute	revolute	revolute
MBC	Purple-brown	Cream	Red brown	Brown/rustly	Cream	Red brown	Red brown	Red brown
BI	Pointed	Moderate imbricate	Highly imbricate	Moderate imbricate	Moderate imbricate	Moderate imbricate	Moderate imbricate	Moderate imbricate
AC	White	Cream	Cream	Cream	Yellow	Cream	Yellow	Cream
BAS	Pointed	Intermediate	obtuse	Pointed	Intermediate	Intermediate	Intermediate	Intermediate
MBL	21	18	20	19	20	20.5	18	19
NHB	6	9	8	7	9	7	6	11

Table 1. Descriptors utilized for characterization of Mchare germplasm in Arusha Tanzania

PSC (Pseudo stem colour), PMC (Petiole margin clasping), PSH (Pseudostem height), BP (bunch position), BS (Bunch shape), RP (Rachis position), FS (Fruit shape), FA (Fruit apex), NMB (Number of fruits mid-hand bunch, BBF (Bract behavior before falling), MBC (Male bud colour), BI (Bract imbrication), AC (Anther colour), BAS (Bract apex shape), MBL (Male bud length cm), NHB (Number of hands per Bunch)

Bunch variation among Mchare cultivars

Bud variation among Mchare cultivars

Finger and psuedostem variation among Mchare cultivars

References

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Occurrence and distribution of *Pseudocercospora fijiensis* mating types in Uganda and Tanzania

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WP2

Introduction

Black Sigatoka is a disease of banana caused by the hemibiotrophic fungus *P. fijiensis,* which produces both asexual and sexual spores. Sexual development and mating compatibility in fungi is controlled by mating type (Mat) genes. Mating types Mat 1-1 and Mat1-2 are determined by unrelated sequences occurring at the same chromosome region in all isolates of a given species (Turgeon and Yoder, 2000). *P. fijiensis* is a heterothallic fungus requiring the presence of both mating types in close proximity for sexual reproduction to occur. Occurrence of a 1:1 distribution of mating type alleles within a population indicates the importance of sexual reproduction in epidemiology and evolution of the pathogen. Populations that undergo random and frequent mating allow creation of new genotypes which may aid in habitat adaptation and pose a challenge in pathogen control strategies.

Materials and Methods

Infected leaves bearing stage 6 symptoms were collected from different agroecological zones in Uganda (Kawanda, Sendusu, Luwero, Mbarara) and Tanzania (Mbeya, Arusha, Bukoba). Single ascospore isolates were obtained through the ascospore discharge method (Twizeyimana et al., 2007). Species identification was done using species specific primers MF137/R635 (Johanson and Jeger, 1993). Mat1-1 and Mat1-2 specific primers (Arzanlou et al., 2010) were used to analyse the frequency of mating type idiomorphs within the populations. Chi-square tests were conducted to determine if the mating type ratios for each population departed significantly from the null hypothesis of 1:1. A 0.05 Type I error rate was applied to accept or reject the null hypothesis of a statistically equal mating type ratio of 1:1.

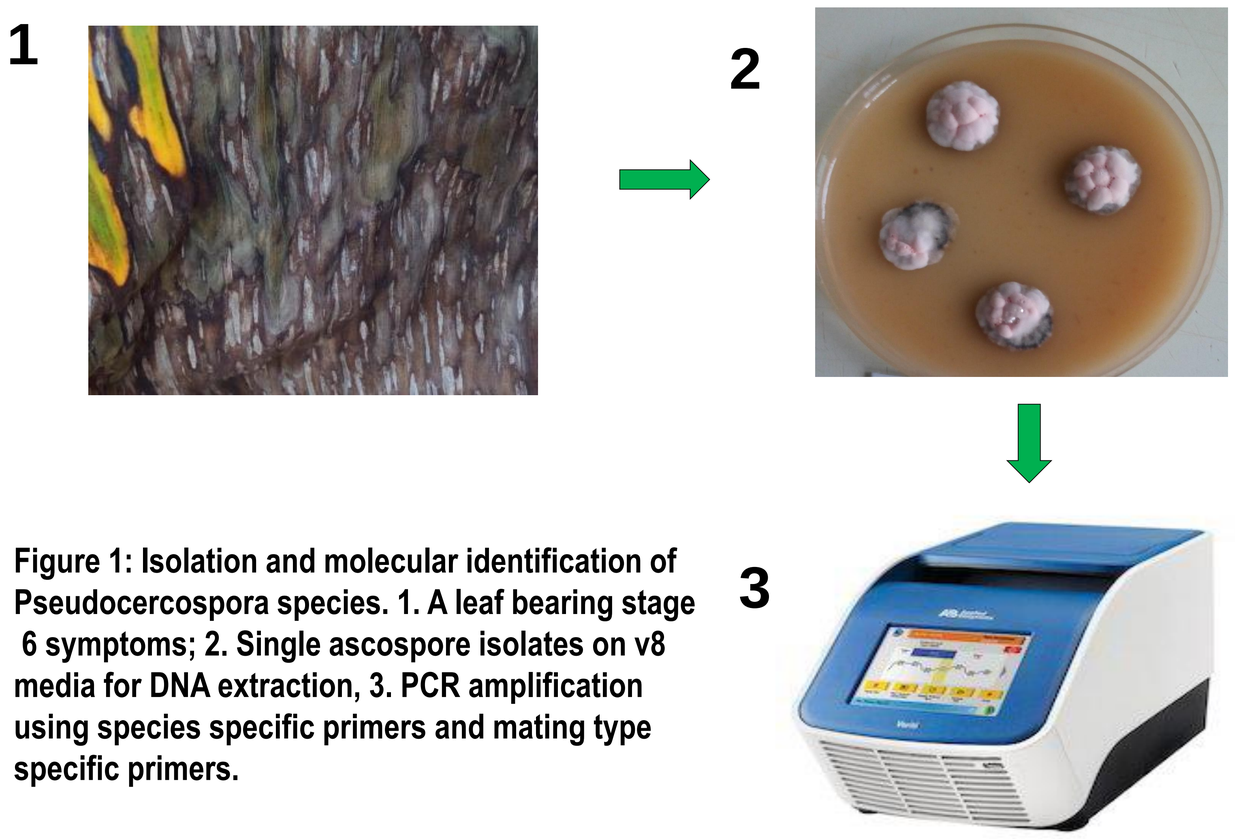

Figure 1: Isolation and molecular identification of Pseudocercospora species. 1. A leaf bearing stage 6 symptoms; 2. Single ascospore isolates on v8 media for DNA extraction, 3. PCR amplification using species specific primers and mating type specific primers.

Results and Discussion

A total of 318 pure isolates were recovered from all the sites under study and confirmed to be *P. fijiensis* using PCR (**Figure 2**). Both mating types were found in all regions, farms, plants and leaves sampled except Mbeya where Mat1-2 was absent. Of the isolates, 59% were Mat1 while 41% were Mat2 and followed the expected 1:1 in some regions (**Table 1**) which is an indicator of random and frequent sexual reproduction (Zhan et al., 2002). A deviation from the null hypothesis was observed in Sendusu, Arusha and Mbeya. This may have arisen from the sampling strategy or that the population originated from a single introduction event. Unequal frequencies in mating is also thought to arise from differences in virulence between the mating types thus the more virulent type produced more infective spores(Conde-Ferraez et., 2010; Zhan et al., 2007).

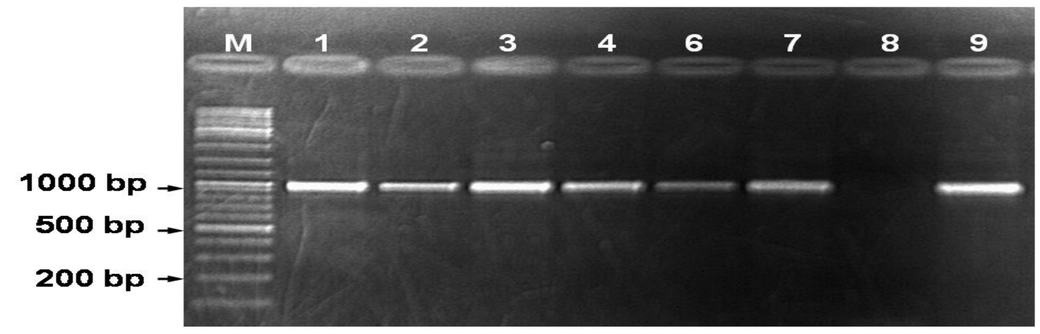

Figure 2: Detection of *P. fijiensis* using the species specific primer pair MF137/R635. Lanes 1-7 are selected isolates from the region, Lane 8 is a no template control and lane 9 is a CBS isolate.

A different amplification profile was observed in Mbeya and some isolates in Bukoba where Mat1-1 primer produced a smaller fragment approximately 480bp (**Figure 3**) suggesting that the populations may have undergone some evolutionary change that affected the mating type loci. Sequence analysis of the mating type region from different locations will help to explain the observation.

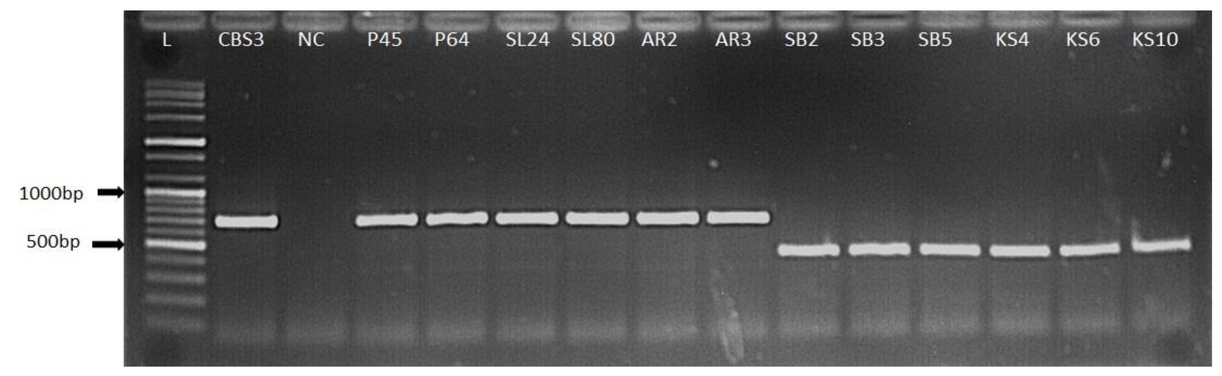

Figure 3: Amplification profile of selected isolates using *P. fijiensis* Mat1-1 specific primer (Mat1-1F/Mat1-1R). L is DNA Ladder, Lane 2 is a Mat1 isolate from CBS; Lane 3 is a no template control; lanes 4-8 are isolates from kawanda and Luwero; lanes 9-14 are isolates from Mbeya and Bukoba.

Table1: Mating type frequencies among sampled regions

Region	No. farms sampled	Mat1	Mat2	Chi-square value	P value
Kawanda(Research farm)	1	34	29	0.396	0.53
Sendusu(Research farm)	1	35	16	7.078	0.008
Luwero	14	34	43	1.0519	0.3
Mbarara	11	30	36	0.54	0.46
Mbeya	8	32	0	32	1.54×10^{-8}
Bukoba	3	5	6	0.09	0.76
Arusha	4	14	4	5.55	0.02

Conclusion

- Sexual reproduction is prevalent within the *P. fijiensis* populations except in Mbeya.
- A high genetic and pathogenic variability is expected within the region which is likely to affect durability of introduced resistance.
- Evolutionary forces are likely to have altered the mating type region.
- Sequence analysis for the mating type region will help explain the variability observed in Mbeya and Bukoba.

Acknowledgements

The authors thank IITA training unit for scholarship.

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Infestation assessment of banana weevil (*Cosmopolites sordidus* Germar) in different banana-based farming systems in Arusha and Kilimanjaro regions, Tanzania

WP2

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Abstract

The present study was conducted to determine population size, infestation level and farmer's understanding of banana weevils in different banana-based farming systems (BFS) namely banana monoculture, banana-beans, banana-coffee and banana-maize in Nkoaranga, Mbuguni and Ngurdoto villages (Meru District) and Uduru, Uraa and Mbosho villages (Hai District) from June-September, 2017 in Northern Tanzania. The data collected were analyzed by using GENSTAT 11th edition and SPSS Version 21. There were significant differences (P<0.05) in the number of banana weevils in different BFS but not to coefficient of infestation. 68.8% of banana farmers ranked that banana weevil to be the first insect pest of banana and a problem. This study calls for more studies on identifying factors for the highest population in a banana-maize system and how banana weevils can be managed in Tanzania.

Key words: banana weevil, *Cosmopolites sordidus*, population, infestation, Tanzania

Introduction

Banana weevil (*Cosmopolites sordidus* Germar) is an insect pest of banana plants (*Musa spp*.). Its larvae are principal destructive stage through feeding creating numerous galleries to banana corms. The damage causes interference with root initiation and development, uptake of plant nutrients and water transport. Its high infestation rate can lead to crop failure, farm abandonment and yield loss up to 100%. In Tanzania, 30% of yield loss and banana farm abandonment has been reported at Muleba district, Kagera region. Other regions reported to be highly infested with weevils include Arusha, Kilimanjaro, Mbeya and Morogoro. Despite of its agricultural importance, there is limited information on their population variations, damage levels and farmer's understanding in different banana-based farming systems in Tanzania**.**

Materials and Methods

The study sites were villages of Nkoaranga , Mbuguni and Ngurdoto (Meru District, Arusha region) with altitude of 1343, 941 and 1304 m.a.s.l respectively and Uduru, Uraa and Mbosho (Hai District, Kilimanjaro region) with altitude of 1277, 1384 and 1287 m.a.s.l respectively. It was conducted in Split-split-split experimental design. Materials used were GPS, camera, desuckering tool, machete, Square grid, thermometer, questionnaire sheets and colour banana weevil image plate.

Presence of banana weevils was assessed by using 3 pseudostem traps (representing 3 replications) set in each randomly selected banana-based systems per village (Fig 1) according to per Swennen (1990). Weevil adults captured (Fig 2) were counted (Fig 3) followed by recording of banana cultivars, environ temperature and GPS coordinates.

Fig 1: Pseudostem trap

Fig 2: Adult weevils on trap

Fig 3: Adult weevil counting

Weevil damage level was assessed through coefficient of infestation method as per de Oliveira *et al.* (2017) involving destructive sampling. Three randomly selected banana plants per banana farming system were uprooted and their corms were cut cross-sectionally to expose the galleries. Square grid (Fig 4) was placed over cut surfaces followed by counting and recording total number of affected cells (necrotic or dark tissue) (Fig 5) and its banana cultivar.

Fig 4: Square grid and infested corms

Fig 5: Scoring banana weevil damage

Farmer's understanding of banana weevils was done through questionnaires and standard interviewing aided by colour banana weevil image plate. 48 total randomly selected farmers gender-balanced were interviewed

Results and Discussion

There was significant different (p<0.05) between the number of banana weevils but not to the coefficient of infestation. The highest average value was recorded from banana-maize (29.17) followed by banana-beans (8.1). Highest damage level was recorded in banana-beans (31.25 %) followed by banana-coffee farming systems (24.5%). Mbuguni village had the highest weevil population per farm (124). Such highest number could be related to an observed temperature of more than 20°C, a factor that favour banana weevil growth (Gold and Messiaen, 2000). Of the locations, highest banana weevil number (153) per farm was recorded also in Mbuguni. This is supported by low crop sanitation and low attitude of 941 m.a.s.l. as explained by Wachira *et al*. (2013) and Njau *et al*. (2011). 68.8% of banana farmers ranked banana weevil the first banana insect pest and a problem. 75% of farmers said different banana farming system did not reduce the population of weevils and their infestation. This could be attributed by a low understanding of the farmers on the banana weevil problem as banana weevil reported to be nocturnal, cryptic, free and soil-dwelling insect (Shukla, 2010).

Table 1: Number of weevils per trap and coefficient of infestation on different banana-based farming systems

SN	Farming system	Average number of weevils per trap	Coefficient of infestation (%)
1	Banana monoculture	5.50b	18.75a
2	Banana-beans	8.17b	31.25a
3	Banana-coffee	5.08b	24.58a
4	Banana-maize	29.17a	15.00a
	Mean	12.00	22.4
	LSD (0.05)	17.93	20.65
	F-Statistics	*	ns
	p-value	0.027	0.420

Mean followed by the same letter within a column are not significant different based on Duncan Multiple Range Test (DMRT) at p=0.05., ns=non significant.*=significant at P≤0.05.

Conclusion

Banana weevil is indeed a problem in the study area. This study calls for more studies identifying factors responsible for highest weevil population in banana-maize farming system and how the banana weevil problem can be managed in the study area and other locations in Tanzania.

Acknowledgements

The author acknowledge Government of Tanzania, Nelson Mandela African Institution of Science and Technology (NM-AIST) for and International Institute of Tropical Agriculture (IITA) for financial support on My MSc. Programme studies.

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Role of Nematodes (*Pratylenchus goodeyi*) on Fusarium wilt disease severity on banana in Tanzania

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WP 1

Abstract

A pot culture experiment was conducted to study the role of plant parasitic nematodes (*Pratylenchus goodeyi*) on severity of Fusarium wilt disease (FWD) in banana caused by *Fusarium oxysporum* f.sp. *cubense* (Foc) using selected susceptible and resistant cultivars. Results revealed that, treatments involved nematode inoculated 14 days prior to Foc and combined inoculation showed higher FWD severity on susceptible genotypes and hastened disease occurrence with a reduction in plant growth compared to untreated control. Such results suggest that nematodes play a detrimental role in the severity of FWD on Foc susceptible banana cultivars by acting as a predisposing factor for the fungal pathogen infestation. Foc resistant genotypes remain resistant regardless of presence of nematodes.

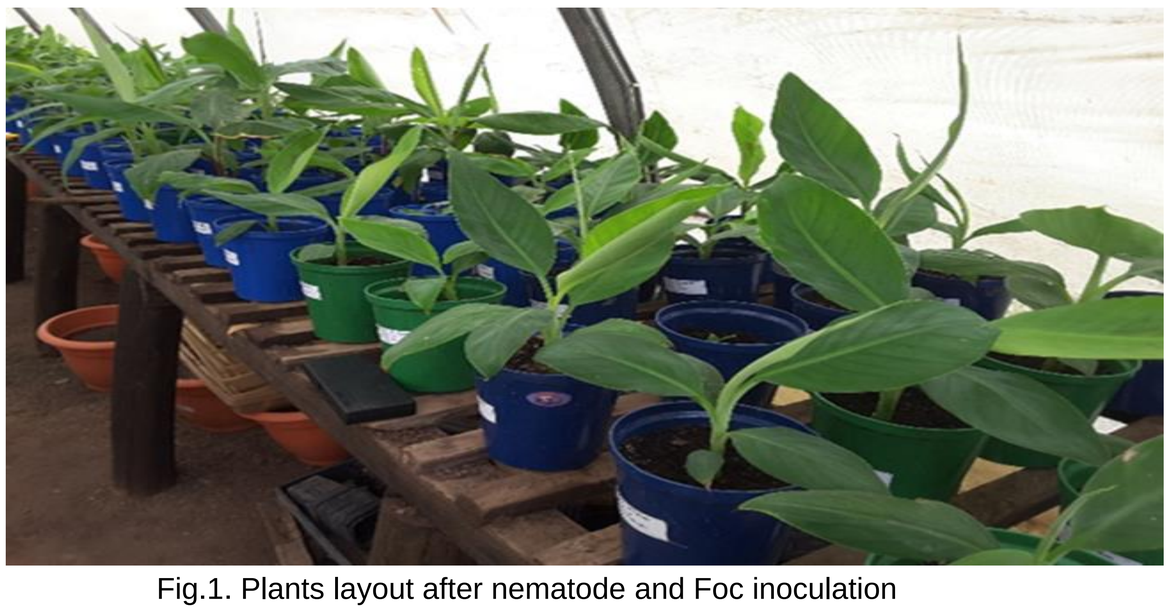

Fig.1. Plants layout after nematode and Foc inoculation

Introduction

Bananas are of major importance as a food crop in East Africa representing one third of the calorie intake and up to 80% of the household income for approximately 4.5 million smallholder families. Tanzania cultivates about 400,000 hectares of land that produces about 3.7 MT. Despite its importance, banana yield in Tanzania is declining with insect pests and diseases being the major causal factors. Of the pest problems, nematodes were the most frequently mentioned while in terms of diseases, Fusarium wilt caused by *Fusarium oxysporum* f.sp. *cubense* (Foc) is the most destructive disease of banana in the region. Interaction between parasitic nematodes and Foc is clear from studies carried outside East Africa; however, this has not been elucidated in Tanzania. Furthermore, the agro-ecologies and banana genotypes in Tanzania are different. It is therefore important to clearly understand well the status and interaction of plant parasitic nematodes and Foc in banana genotypes.

Materials and Methods

- Banana seedlings from 9 cultivars (Mchare laini, Huti green, Grand naine, JD Yangambi, cv Rose, Gros Michel, Sukari ndizi, Nakitengwa and Kazirakwe) were selected due to their susceptibility and resistibility to both Foc and nematodes
- Potted in 2 kg pots with sterilized mixture of soil, sand and farm yard manure (2: 1: 1)
- Treatments: 1. Foc, 2. Nematode, 3. Nematode + Foc, 4. Foc followed by nematode (14 days later), 5. Nematode followed by Foc (14 days later), 6. Control (no inoculation) each replicated three times in a split plot design (Fig.1)
- Nematode inoculum comprised of 60 juveniles *P. goodeyi* and Foc inoculum comprised of 50 g of pre sterilized millet seeds inoculated with Foc (Fig. 2)

Results

- *P. goodeyi* inoculated 14 days prior to Foc and combined inoculation increased the FWD severity and hastened the wilting with a maximum reduction in plant growth over untreated control
- Foc resistant genotypes remained resistant regardless of presence of nematodes

Table: Effects of different treatments on Fusarium wilt disease severity on plant girth, height, number of leaves, root damage and corm rot of banana in this study

Treatments	Effects					
	Disease severity (%)	Girth (cm)	Height (cm)	No of leaves	Com rot (1-6)	Root lesion (%)
Control	0.00a	18.86a	26.83b	8.89a	1.00a	0.00a
Nematode alone	0.00a	18.63a	25.17b	7.04a	1.00a	9.44c
Foc alone	31.07b	16.14b	22.95a	6.48a	2.93b	0.00a
Foc followed by nematode	26.89b	17.12b	23.59b	6.94a	2.48b	0.56b
Foc + Nematode	20.19c	17.07b	22.95a	6.93a	2.85b	1.53b
Nematode followed by *Foc*	36.67c	14.16b	21.35a	6.72a	1.93c	6.48c
Mean	19.1	16.99	23.99	6.82	2.03	3.00
Lsd	16.37	4.20	2.72	2.84	0.88	2.84
F-statistics	***	**	*	ns	***	***

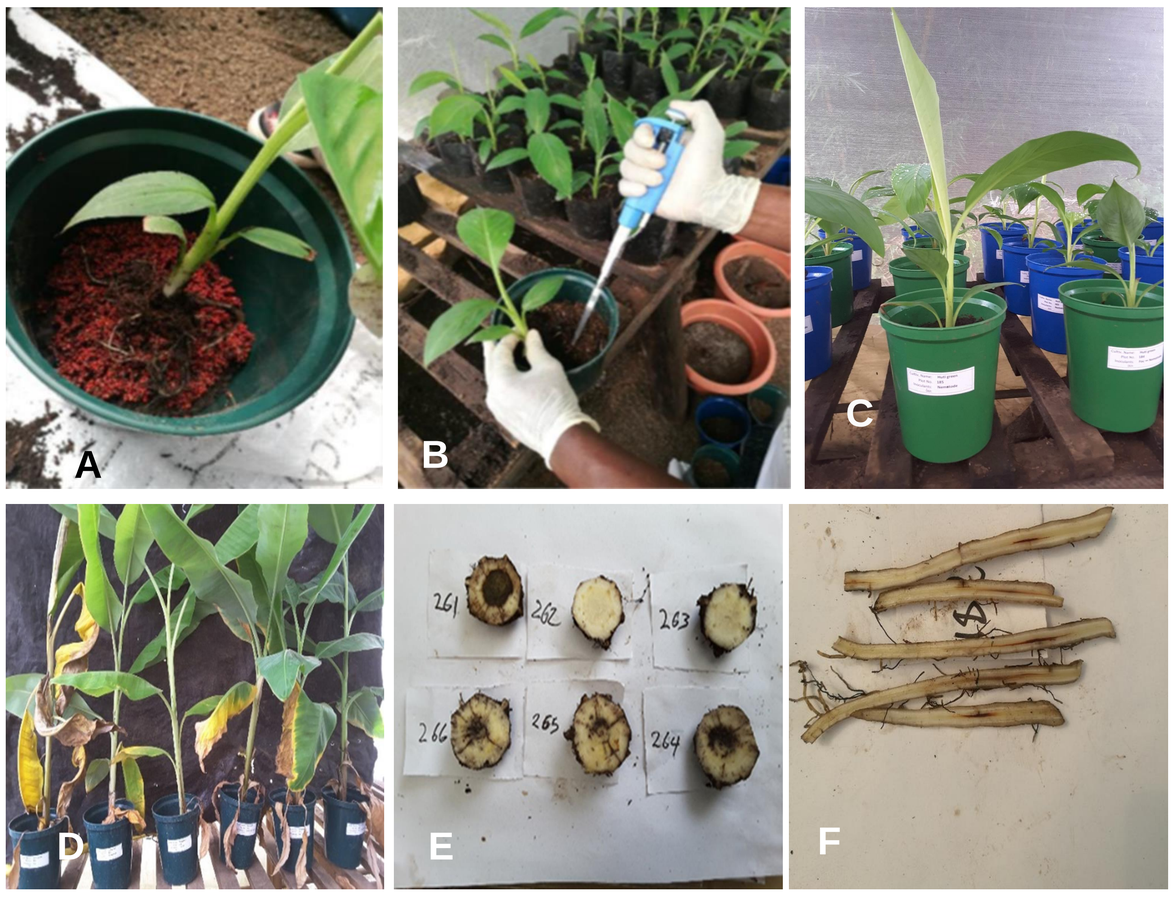

Fig.*2:* Cultivars inoculation, (A) Foc (B) nematode (C) Pants after inoculation (D) FWD external symptoms (E) FWD internal symptoms (F) Root lesions

Conclusion and Recommendation

- Nematodes act as a predisposing factor for the fungal pathogen infestation
- Any management strategy to Foc in the field must therefore also be integrated with nematode management
- Use of resistant cultivars is highly recommended in Foc affected areas

Selected references

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Acknowledgements

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PRELIMINARY QTL MAPPING FOR *FOC* R1 RESISTANCE IN BANANA

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WP3

Introduction

Fusarium wilt, a fungal disease caused by *Fusarium oxysporum* f. sp. *cubense* (Foc), is one of the most disastrous diseases of banana, causing an estimated annual yield loss of 60 to 90%. Attempts to control Foc using chemical, cultural and biological methods have not been very effective. Host plant resistance found in wild bananas is the most appropriate and cost effective intervention to control Foc. Conventional breeding in *Musa* is hampered by low number or complete absence of seeds upon pollination, size of the plants, the crop's long life cycles, the long breeding cycle (10-12 yrs) coupled with limited knowledge of the genetics of resistance to diseases such as Foc. Understanding genetics of resistance to Foc and application of molecular Marker Assisted Selection/Breeding (MAS, MAB) to map the Foc QTL will aid in shortening the banana breeding cycle and carry out effective breeding for resistance to *Foc* in *Musa*.

Materials and Methods

Results and discussion

Table 1. DSI screening results for Kokopo X Monyet F'1 population (154/170)

	Resistant	Partially resistant	Susceptible	Highly susceptible
Rhizome Discoloration	22	90	28	14
Leaf severity index	1	72	67	14
Stem Splitting	196	122	0	

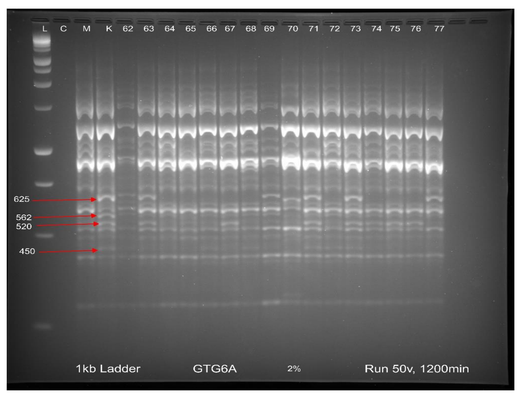

Figure 1. Gel picture showing polymorphic and heritable bands of Kokopo x Monyet ISSR- GTG6A

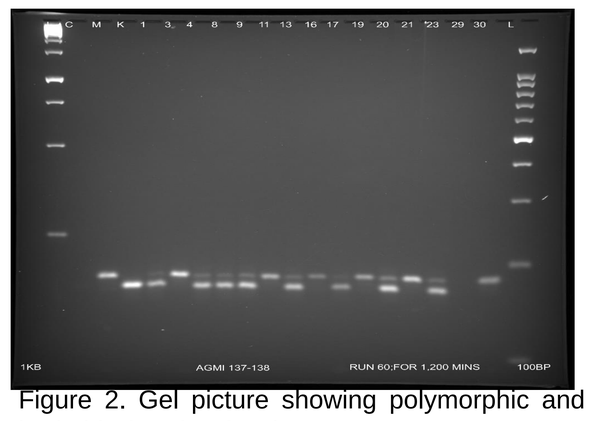

Figure 2. Gel picture showing polymorphic and heritable bands of Kokopo x Monyet SSR-AGMI 137-138

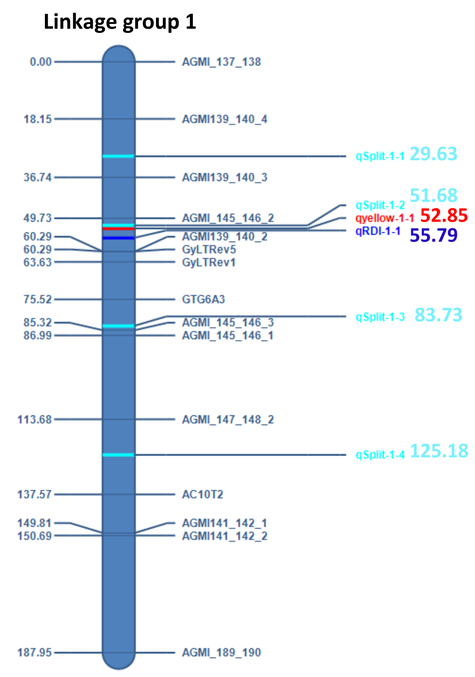

Figure 3. Foc race 1 QTL for RDI, LSI and SP for 60 F1 genotypes of Kokopo x Monyet Population.

Phenotypic screening of Kokopo x Monyet and their 154 F_1 hybrids grouped the genotypes into resistant, partially resistant, susceptible and highly susceptible by RDI, LSI and SP (Table 1). Genotypic screening of Kokopo x Monyet F_1 populations using 4 IRAP and 40 ISSR and 37 SSR markers revealed polymorphic and heritable markers. An example of representative gels showing polymorphic and heritable bands for all marker categories is shown in pictures above (Figures 1&2). These polymorphic and heritable markers were used for QTL analysis for Foc 1 resistance. A preliminary QTL analysis for the first 60 screened genotypes of Kokopo x Monyet population was performed GACD software [5]. The results mapped a tentative QTL for RDI, LSI and SP located between Markers AGMI 139-140_2 and AGMI 146-147_2 on linkage group 1(Figure 3).

Conclusion

A QTL analysis for all the 170 Kokopo x Monyet population will be performed to confirm or identify a real Foc race 1.

HETEROBELTIOSIS IN BANANA BREEDING

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WP3

Introduction

Heterosis, or hybrid vigour, is the superiority of the hybrid for a certain trait over the mean of its two parents. Heterobeltiosis is a form of heterosis where the hybrid is superior to its best parent. Banana breeding is a tedious, time-consuming process, taking up to two decades to develop a hybrid. Exploiting heterosis in banana breeding will contribute to selecting breeding material with high compatibility, thus increasing banana breeding efficiency. Here we document heterobeltiosis by using the recently bred NARITA 'Matooke' hybrids and their grandparents.

Fig. 1. Heterobeltiosis on bunch size, comparing NARITA 17 with its progenitor landrace "Entukura"

Materials and Methods

A field experiment was set up at Sendusu (Uganda) in 2015 with the NARITA hybrids, their parents (4*x* and 2*x*), grandparents (3*x* landraces and 2*x* wild species), and local 3*x* 'Matooke' cultivar checks in a rectangular lattice design with two replications. Bunch weight and other agronomic data were recorded. The NARITAs were compared with their 3*x* 'Matooke' grandmothers because their direct parents (4*x* and 2*x*) are not suitable for local tastes. Heterobeltiosis on bunch weight was calculated with the data of cycle 1 and 2 as: **Heterobeltiosis (%) = [("NARITA" mean bunch weight - "3*x* Grandmother" mean bunch weight)/"3*x* Grandmother" mean bunch weight] × 100**

Results and Discussion

All the 23 NARITAs showed heterobeltiosis for bunch weight, compared to their grandmothers (3*x* 'Matooke'), despite the heterozygosity of the parents. NARITA 17 had the highest bunch weight (29.4 Kg) and the highest heterobeltiosis of 287% (Figure 1, Table 1), followed by NARITA 23 and NARITA 9 (186% and 166%, respectively). NARITA 19 had the lowest heterobeltiosis: 7%. NARITA 7, the only released NARITA hybrid cultivar in Uganda so far, had a heterobeltiosis of 58%.

The factors behind heterobeltiosis in banana are yet to be defined. Nonetheless, heterobeltiosis shows the potential to produce high yielding banana hybrids in relatively few crossbreeding cycles. The heterobeltiotic effect is easily fixed in the hybrids by vegetative propagation of bananas.

Table 1: Heterobeltiosis in the NARITA banana hybrids, comparing bunch weight of the hybrids and the grandmothers

NARITA hybrid	Grandmother	Bunch weight NARITA (kg)	Bunch weight grandmother (kg)	Grandparent heterobeltiosis (%)
NARITA 17	Entukura	29.4	7.6	287
NARITA 23	Kazirakwe	24.9	8.7	186
NARITA 9	Enzirabahima	21.0	7.9	166
NARITA 22	Enzirabahima	19.9	7.9	152
NARITA 8	Enzirabahima	19.6	7.9	148
NARITA 14	Enzirabahima	19.2	7.9	143
NARITA 2	Entukura	17.7	7.6	133
NARITA 13	Nakawere	20.0	9.1	120
NARITA 3	Enzirabahima	17.2	7.9	118
NARITA 4	Enzirabahima	16.6	7.9	110
NARITA 18	Kabucuragye	24.6	12.2	102
NARITA 10	Enzirabahima	15.2	7.9	92
NARITA 11	Nakawere	16.6	9.1	82
NARITA 12	Nakawere	16.3	9.1	79
NARITA 5	Enzirabahima	13.8	7.9	75
NARITA 15	Enzirabahima	13.3	7.9	68
NARITA 21	Nakawere	15.0	9.1	65
NARITA 16	Enzirabahima	12.6	7.9	60
NARITA 7	Nakawere	14.4	9.1	58
NARITA 1	Enzirabahima	12.2	7.9	54
NARITA 6	Nfuuka	17.4	11.6	50
NARITA 20	Entukura	9.5	7.6	25
NARITA 19	Nakawere	9.7	9.1	7

Conclusion

Heterobeltiosis in high yielding banana hybrids was achieved after a few crossing generations. Since bananas are vegetatively propagated, the effect of heterobeltiosis is easily fixed in the hybrids and will not be lost over time after release and further commercialization of these hybrids.

UNDERSTANDING THE GENETICS OF RESISTANCE TO *FUSARIUM OXYSPORUM* F.SP. *CUBENSE* RACE 1 IN BANANA

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WP3

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Abstract

Effective breeding requires a thorough understanding of genetics of the trait. However, genetics of resistance to Foc race 1 in banana is still unclear. In this study, we used F1 population (106 progenies) derived from a 'Paliama X Borneo' cross, to assess the genetics of resistance to Foc race 1. Parents, F1 progenies and control plants were inoculated with Foc race 1 using a millet seed technique. Results revealed that Paliama and Borneo were statistically different in disease reaction ($P<0.05$) showing susceptibility and resistance respectively and their F1 progenies segregated ($P<0.05$) for both leaf and corm symptoms. The continuous distribution observed suggests that a single-gene model previously described probably does not exist in this population. QTL analysis is underway to clearly understand the genetic nature of this resistance.

Keywords: Genetics, F_1 population, millet seed technique, single-gene model

Introduction

- ✓ *Fusarium* wilt is a serious disease of banana, but resistance exist in Musa
- ✓ Vakili (1965) and Ssali et al. (2013) brought conflicting results on genetics of Foc race 1. Prompt the necessity to analyse other populations for the trait
- ✓ We present the results to assess the genetics of resistance to Foc race 1 based on F_1 diploid population

Materials and Methods

- ✓ Foc race 1 (isolate VCG 0125) and millet seeds were prepared as described by Viljoen et al. (2017). A millet seed inoculation technique were used
- ✓ Parents, F_1 progenies, and controls plants were inoculated with Foc race 1
- ✓ Plants were evaluated in the screen-house for 60 days after inoculation (dpi)
- ✓ Data for discolorations on leaves (1-5 scale) and inner corms (1-6 scale) were collected.
- ✓ ANOVA and mean separation generated with Genstat 18th version (VSN)

Results and Discussion

- ✓ Paliama and Borneo differ significantly ($P<0.05$) (Fig. 1 & Table 1)
- ✓ The symptoms on F_1 progenies indicate differences in response to Foc race 1 at 60dpi (Fig. 2 and 3)
- ✓ Mean for disease severity of F_1 progenies showed variation ($P<0.05$) in response to Foc race 1(Table 2)
- ✓ The continuous distribution observed (Fig.4) suggests that a single-gene model previously described probably does not exist in this population

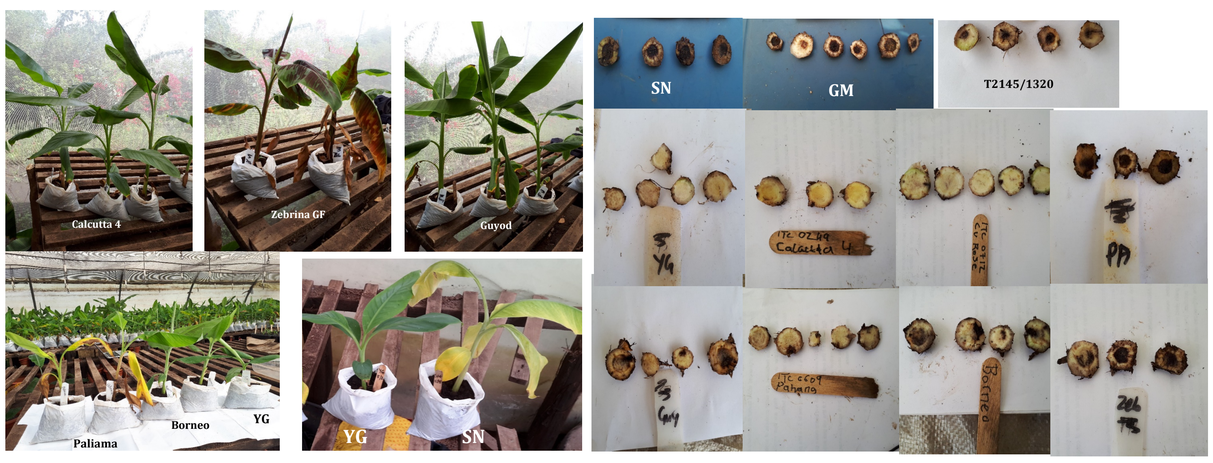

Figure 1: Foc race 1 symptoms on Leaf (38 dpi) and inner corms (60dpi) of parents and controls.SN = Sukari ndizi, GM = Gros Michel, PA = Paliama, YG = Yangambi, Zeb= Zebrina GF, GUY= Guyod

Table 1: Means separation for parents and controls based on disease severity on inner corms at 60dpi caused by Foc race 1

Cultivar	Disease severity	Cultivar	Disease severity
Yangambi	1.00a	Borneo	2.53bc
Calcutta 4	1.17a	2145/1320	2.82c
Cv-Rose	1.25a	Paliama	4.82de
Pahang	1.27a	Zebrina GF	4.17de
Guyod	1.68ab	Gros Michel	4.67de
Long Tavoy	2.50bc	Sukari ndizi	5.03e

Means followed by the same letter do not differ significantly at P=0.05) by the Fisher's protected test. L.S.D = 0.89, C.V% = 6.9

Figure 2: Foc race 1 symptoms on leaves (60dpi) of F_1 progenies and controls

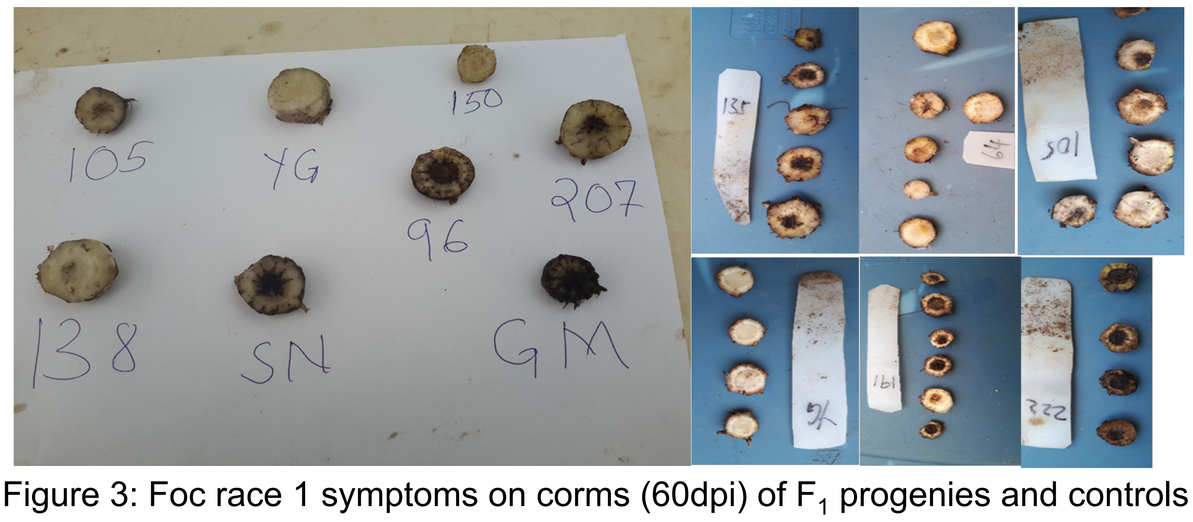

Figure 3: Foc race 1 symptoms on corms (60dpi) of F_1 progenies and controls

Table 2: ANOVA for mean disease severity of 106 F_1 progenies and controls based on inner corm discolorations at 60 dpi

Source of variation	Degree of freedom	Sum of square	Mean sum of square	Variance ratio	F. probab.
Rep stratum	2	0.638	0.319	0.29	
Genotypes	109	324.966	2.981	2.73	<.001
Residual	218	238.479	1.094		
Total	329	564.083			

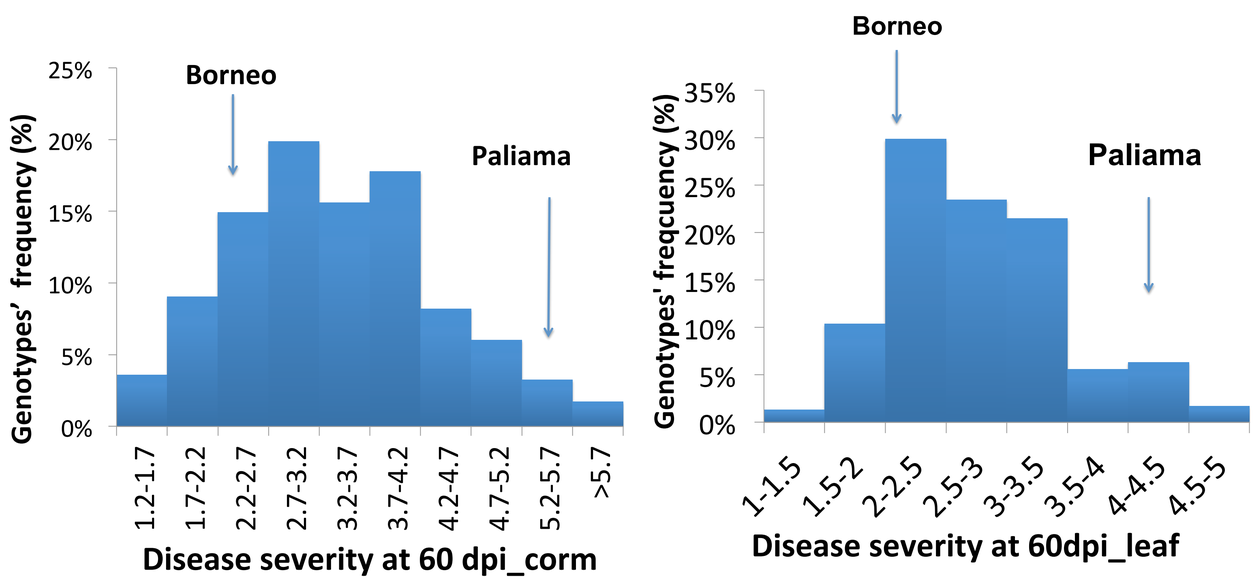

Figure 4: The distribution of 106 F_1 progenies based on disease severity on leaf and corm at 60dpi . The arrows show the score of the parents.

Conclusion

- ✓ Paliama is susceptible to Foc race 1
- ✓ A single-gene model probably does not exist in this population
- ✓ QTL analysis is required to understand the genetic nature of this resistance.

Acknowledgements

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- ✓ TC lab personnel for assist on proliferations and experimental activities

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Post-harvest use of banana in Uganda and Tanzania: Banana food and beverage products, product characteristics and cultivar preferences by farmers

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WP4

Abstract

A preliminary overview of banana food and beverage product profiles, farmers' trait preferences for the products and cultivars used to make those products from six regions where the baseline data was collected in Uganda and Tanzania is presented. Understanding the characteristics of the various fresh foods or processed products, ingredients used, processing methods and end users' trait preferences of cultivars that are popularly used to produce the products can help breeding programs in priority setting and developing a selection strategy for example when prioritising which consumption traits to maintain or improve, and/or to provide context regarding why or why not certain cultivars are adopted or rejected. New cultivars must have traits that end users desire for fresh fruits or for producing their traditional/local products, and lack of these desired traits potentially affects adoption rates.

Keywords: banana, product, preference, Uganda, Tanzania

Introduction

Banana (Musa spp) is a major staple crop and can be processed into different food and beverage products or eaten as a fresh fruit. The fruits are highly nutritious with large amounts of carbohydrates, phosphorus, calcium, potassium, Vitamin A (some cultivars) and Vitamin C (Aïtchédji et al. 2010; Ubi et al. 2016). On average, bananas contribute between 16 to 31% of the total calorie intake in East Africa (Abele et al. 2007). Banana cultivars in this region are categorised into 4 main usage types: cooking, roasting, beer/beverage/brewing and dessert (Karamura et al., 2012; Swennen and Vuylsteke, 1991). A range of factors influence the preferences regarding the products made from the different banana types and cultivars preferred to make these products. Sociocultural, demographic, environmental and economic factors influence food traditions, food choices and cuisines in different societies

Materials and Methods

Purposive sampling of 6 banana producing districts located in different agro-ecological zones in Tanzania and Uganda

- 2 districts in Uganda (Luwero in Central Region and Mbarara in Western) and 4 districts in Tanzania (Meru in Arusha, Moshi in Kilimanjaro, Bukoba in Kagera and Rungwe in Mbeya)
- Random sampling at the subcounty/division and village level

- Total FGDs conducted – 23 (11 consisted of women only, 9 men only and 3 included both men and women
- Number of villages – 14
- Average no. of participants in each FGD - 9

Results

Table 1: Products from different banana types

	Uganda		Tanzania			
Banana usage type	**Luwero**	**Mbarara**	**Bukoba**	**Meru**	**Moshi**	**Rungwe**
Cooking	matooke	matooke ensaano wine	matoke/ ebitoke omusongo supu	machalari mtori kideri loshoro kitawa mangolo	machalari mtori kiburu shiro ng'ande kitawa mchemsho makashi memba	mbalaga (machalari) ugali (unyangwa) mtori supu ugali wandizi
Roasting	gonja	gonja, etekyere	gonja, chipusi, omwokya, kukaranga	kitafunwa, ndizi yakuchoma/roast, crisps, chips, biskuti	ndizi roast, crisps	choma mafuta, choma majiva, ndizi za kukaanga, ndizi kuchoma, choma mkaa, unga
Dessert	tugalya/ menvu, kabalagala	eminekye yokurya, kabaragara	mbivu/ ebihise, balagala	matunda/sukari, naasha	matunda	kula mbivu, vitumbua (vibama), juisi, wine
Beer	mubisi , waragi, tonto	Tonto, eshande, waragi, wine	rubisi, konyagi/gong o, togwa	mbege/pombe, juisi, ndizi kuchoma	mbege/ pombe, juisi, ndizi kuchoma, nalu (togwa)	vitumbua (vibama), mbege/pombe

Table 3: Traits of a good product for main products from cooking banana

Product	Traits/characteristics of a good product			
	Colour	Texture	Aroma/Flavor/Taste	Other
Matooke	yellow after peeling and cooking	soft , pliable like chewing gum when cooked, feeling in the hand (soft like sponge), slippery on fingers, smooth on tongue and throat like sweet banana, smooth as you swallow, "takes itself down" to stomach	good aroma (can be brought by leaves), good smell taste (no feeling of sap)	keeps together when mashed
Matoke/ ebitoke	yellow in colour,	moderate soft, smooth and soft	good aroma, good flavour good taste	elastic cooked for min time (30 min) should satisfy people when taken, has enough starch has small amount of water
Machalari	yellowish white/cream/milk, brown when mixed w/ other ingredients	turns soft when cooked, slightly soft texture	good smell -- depends on ingredients taste - not too sweet, good taste, not sour	
Mbalaga	slightly yellow due to mixture of many ingredients; orange colour but faint	texture- has a bit of viscosity texture in hands -soft and slide in hand	'natural smell' of mbalaga slight sugar taste, 'natural taste' of mbalaga, not sour	

Table 2: Cultivar preferences for select main products from cooking banana

	Product	Select cultivars that make good product	Traits/characteristics of cultivars that make good product/ traits before preparation
Luwero	Matooke	Kibalawo, Kibuzi, Kisansa Mbwazirume	smooth peeling skin straight big fingers which are easy to peel plant height - not so tall and not so short at harvest drought resistant e.g. Nakitembe compact bunches making it hard to remove fingers (-ve), some have weak resistance to weather conditions (-ve)
Mbarara	Matooke	Butobe, Enjagata, Enyeru Kibuzi, Mbazilume	yellowish when peeled straight and big fingers hence easy to peel, mature fast easy to cook makes good matooke even if not ripened (Embururu, Butobe and Enjagata can make nice matooke even when not fully mature unlike Kibuzi that can only make nice matooke when fully grown)
Meru and Moshi	Machalari	Meru Bogoya, Mshare, Uganda Moshi Bukoba, Kimalindi, Mshare Mnyenyele	not too hard, soft, medium soft not small fingers, big fingers straight fingers smell good e.g. Mnyenyele and Bukoba
Rungwe	Mbalaga (machalari)	Bogoya, FHIA, Malindi, Mshare, Ndiali Plantain (Mzuzu), Uganda/Bukoba	when cooked should not turn out like porridge should not have ulcers, cultivar not produced using industrial fertilizers should not be too soft , when cooked should not turn like porridge

Conclusion

- A range of products (Table 1) made using different processing methods (steaming in banana leaves, boiling, mashing, frying, roasting) and various ingredients were identified
- Some product and cultivar traits are very generalized and not detailed enough to be used in breeding e.g. 'tastes nice', 'long shelf life'. Some consumption traits are however difficult to quantify (Table 2)
- Farmers mention a range of cultivars they use to make different products indicating diversity in the different regions (Table 3)
- Farmers have tacit knowledge which might not be easy to explain hence researchers need to probe further and use a range of methods to extract this knowledge
- Results indicate the complexity of breeding for end-users given the large number of factors (products, traits before and after processing, location, varieties) – need biochemical quantification
- Results emphasize the need for breeding programs to test hybrids for consumption in different agro-ecologies.

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Preliminary insights from sensory evaluations of NARITAs at the Kawanda field site, Uganda

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WP4

Abstract

Sensory evaluations were conducted to assess consumer acceptability of NARITA hybrids at the Kawanda field site. The panelists who are staff at the institute, were provided with coded samples of four NARITAs plus one local check (Mbwazirume) and asked to rate each sample on a 5-point hedonic scale for the following attributes: color, texture, taste, aroma, flavour, and overall acceptability for a common local staple, *matooke*. Matooke is prepared by steaming peeled bananas in banana leaves and then mashing. The local check, Mbwazirume was highly preferred compared to all the NARITAs. The results indicate that NARITA 7, NARITA 18 and NARITA 24 are the most preferred among the NARITAs and have the potential to be taken for on farm trials.

Keywords: sensory, NARITA, matooke, acceptability

Introduction

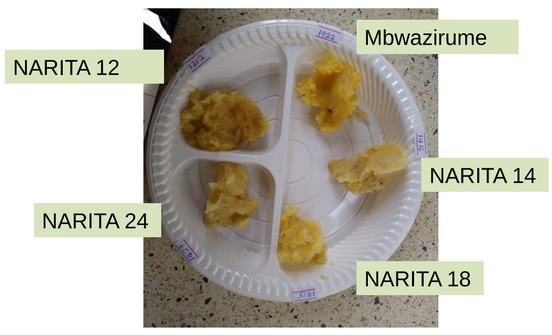
A comparative evaluation of NARITAs and a local check was done. Sensory attributes assessed included appearance in terms of color, texture (softness or hardness), taste, aroma, flavour, and overall acceptability. Organoleptic tests of new cultivars are an essential part of banana breeding to ensure they meet target consumer preferences. Cultivars that are not organoleptically accepted by the target population can hinder adoption (Ekesa 2017).

Materials and Methods

- **Harvesting:** Samples were harvested early in the morning and postharvest characteristics measured. For each round, five samples - 4 NARITAs and one local check were harvested
- postharvest parameters recorded included–bunch weight, no. of hands on the bunch, finger length, circumference etc.
- **Sample preparation:** Done a day after harvest since in practice, bananas are harvested, transported and sold to consumers after a day or two.
- Preparation method: The five samples were each peeled and wrapped in banana leaves and steamed for about 2 hours, mashed and recooked for another hour before serving. Each sample was tied with a unique colored string for differentiation
- To ensure uniform preparation conditions, samples were steamed in one saucepan for about 2 hours,
- **Serving:** Five coded samples were put on one plate and presented to panelists with a questionnaire and a glass of water.
- **Tools used:** Hedonic scale (1 to 5)
- 1= dislike very much, 2 = dislike slightly 3 = neither like nor dislike, 4 = like lightly, 5 = like very much
- 1= very bad, 2= bad, 3= fair, 4= good, 5 = very good

Sample preparation

Serving



Panelist assessments

Results and Discussion

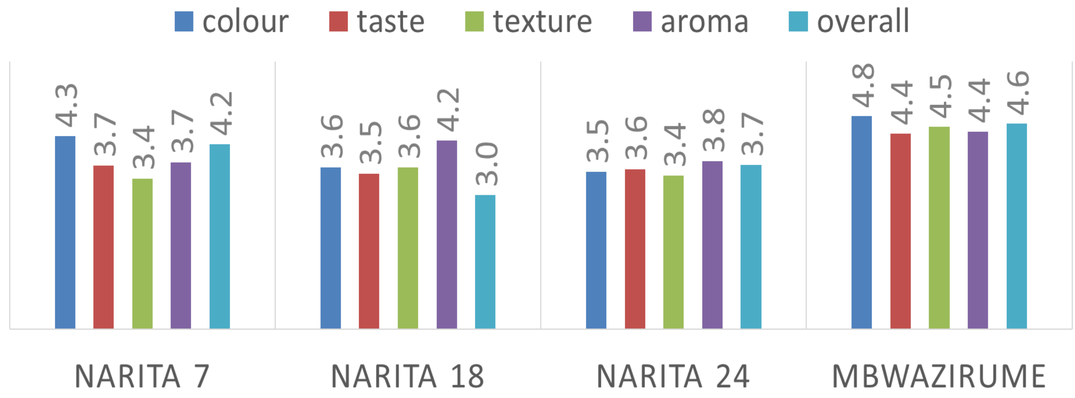
Mbwazirume, the local check was the most acceptable genotype with the highest mean scores for all attributes. In terms of overall acceptability, NARITA 7 had the second highest score (Table 1). NARITA cultivars with mean scores greater than 3 for all attributes were 7, 18 and 24 (Fig 1). These have the potential to be accepted by target populations if taken on farm. Other NARITAs with mean overall acceptability > 2.5 are 2, 4, 12, 15 and 23.

Table 1: Means of evaluated sensory attributes for select NARITAs

	colour	taste	texture	aroma	overall acceptability	N
NARITA 2	2.6	2.8	2.3	2.4	2.7	30
NARITA 4	3.2	2.8	2.8	-	2.6	29
NARITA 7	**4.3[a]**	**3.7[a]**	**3.4**	**3.7[a]**	**4.2[a]**	36
NARITA 10[J]	1.7	2.0	1.9	2.2	1.8	36
NARITA 12	2.9	2.8	2.7	3.0	2.7	22
NARITA 15	3.2	2.9	2.8	-	2.9	26
NARITA 16[J]	1.4	2.5	1.9	2.6	2.2	20
NARITA 18	**3.6**	**3.5**	**3.6**	**4.2[a]**	**3.0**	16
NARITA 22[J]	1.4	2.0	2.4	2.3	1.6	33
NARITA 23	2.4	2.8	2.6	3.4	2.6	27
NARITA 24	**3.5**	**3.6**	**3.4**	**3.8**	**3.7**	34
Mbwazirume	**4.8**	**4.4**	**4.5**	**4.4**	**4.6**	88

[a]means not significantly different from those of Mbwazirume (the local check) at the 5% level by Tukey's test
[J]NARITAs 10, 16 and 21 have been classified as best for juice by the field data collectors and maintenance staff at the Kawanda and Mbarara trial sites

Fig 1: NARITAs with mean scores >=3 for all attributes



Conclusion

The local check, Mbwazirume was highly preferred compared to all the NARITAs. Results indicate that NARITA 7, NARITA 18 and NARITA 24 are the most preferred among the NARITAs and have the potential to be taken for on farm trials. Reasons provided by participants for preferring the above mentioned NARITAs include resemblance to 'usual matooke', appealing yellow colour, soft food and god taste. Evaluations also need to be conducted with farmers in the target populations and other actors in the banana value chain.

Acknowledgements

We would like to sincerely thank the data collectors in the field site in Kawanda, the participants and the research assistants at the NARL laboratory for their commitment.

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Banana Breeding Tracking Tool: BTracT

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WP5, WP1

Abstract

The Banana breeding Tracking Tool (BTracT) is a system that has been developed to enhance the data management, monitoring and reporting of activities within the Banana breeding programs. It utilizes technological frameworks which allow for data capture on handheld devices. The system also synchronizes data from various locations and allows for querying and analytics on a central dashboard.

The system was built on workflows that were mapped with extensive input from the breeding program on the critical steps and activities in both the field and the laboratory. BTracT is fully integrated to the global banana breeding database (Musabase) and the data flow is seamless.
BTracT has been implemented in Arusha and will be rolled out in Sendusu and Ibadan.

Introduction

Banana breeding programs face a number of technical challenges such as ploidy and sterility of banana cultivars, slow propagation, space requirements and the time required for breeding. To overcome some of the logistical and management constraints in this long-winded process, we have developed a data management system, BTracT, that is complementary and fully integrated with Musabase[2].

The system allows accurate, timely and efficient data collection, data management, analysis and interpretation of results that are crucial at all stages of the crop improvement cycle in Banana. Such information is not only important in monitoring progress but also identifying bottlenecks, providing biological insight and in providing alerts for situations where immediate intervention is required.

Materials and Methods

Initially the development process involved gathering of user requirements and mapping the data flow within the breeding program. This involved mapping the entire process and flow with the domain expertise from the scientists (Fig 1).

BtracT is developed using the Open Data Kit (ODK) framework[3] and provides a handheld application on Android devices for remote data capture and access. A dashboard was also developed for data integration and visualization using the versatile, R-Shiny framework[1].

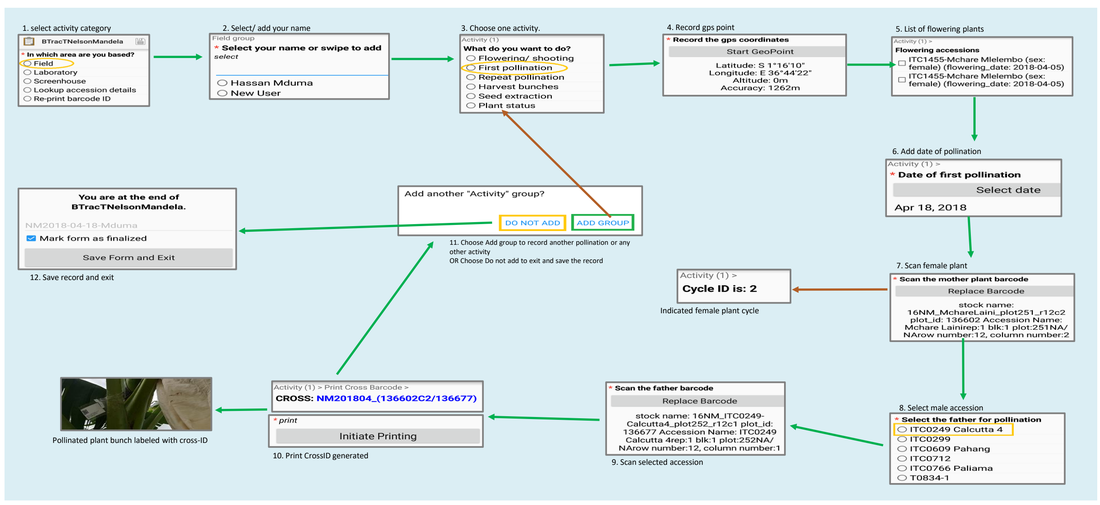

Fig 1: Screenshots of first-pollination activity on BTracT App

To utilise fully the functionality of BTracT, the steps outlined below would be required:

- Designate plants in the pollination blocks with barcode labels generated through Musabase
- Generate the field trial Cross-wishlist through Musabase for use in BTracT handheld application.
- Perform field activities and collect relevant data eg: pollination, harvest, tissue culture
- Visualize aggregated data through the dashboard.

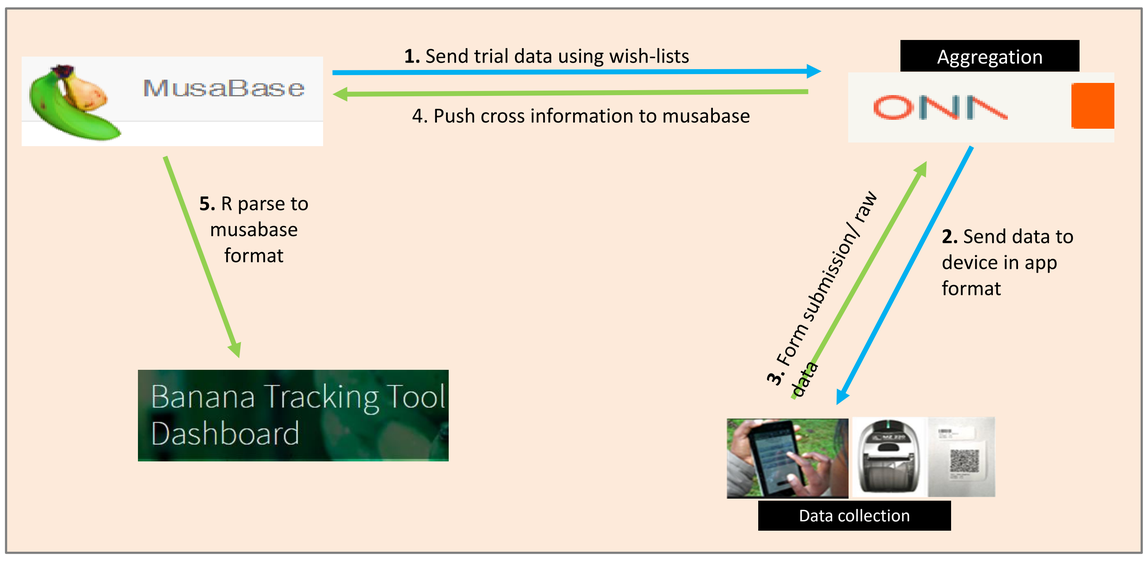

Fig 2: BTracT data system pipeline

Results and Discussion

BTracT is now fully implemented and functional for banana crossing data collection in Arusha.

Upcoming trainings and development would lead to a standard BTracT tool that will be used across locations for Banana breeding and could be easily adapted for other root and tuber crops.

In future additional features such as alerts, 'travelling salesman' algorithm for efficient pollinations in the field and improved a customized reports for users will be made available.

Fig 3: Screenshots of BTracT dashboard for data visualization

Acknowledgements

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