Breeding of sweetpotato for improvement of root dry matter and β-carotene contents in Ethiopia

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Introduction

- Sweetpotato is among most important root crops in Ethiopia

- The second in terms of area coverage and first in terms of production among root and tuber crops

Introduction…

Table 1. Area and production for selected root crops in Ethiopia, 2013/14-2014/15

Crop	Area in hectares		Production (ton)	
	2013/14	2014/15	2013/14	2014/15
Sweetpotato	53,369.19	59,269.07	1,782,725	2,701,599
Potato	66,745.61	67,361.87	784,993	921,832
Taro	42,656.73	48,817.41	1,193,538	1,448,834
Cassava	-	-	-	-

Source: CSA (2015)

Introduction…

Key traits in sweetpotato/breeding goals

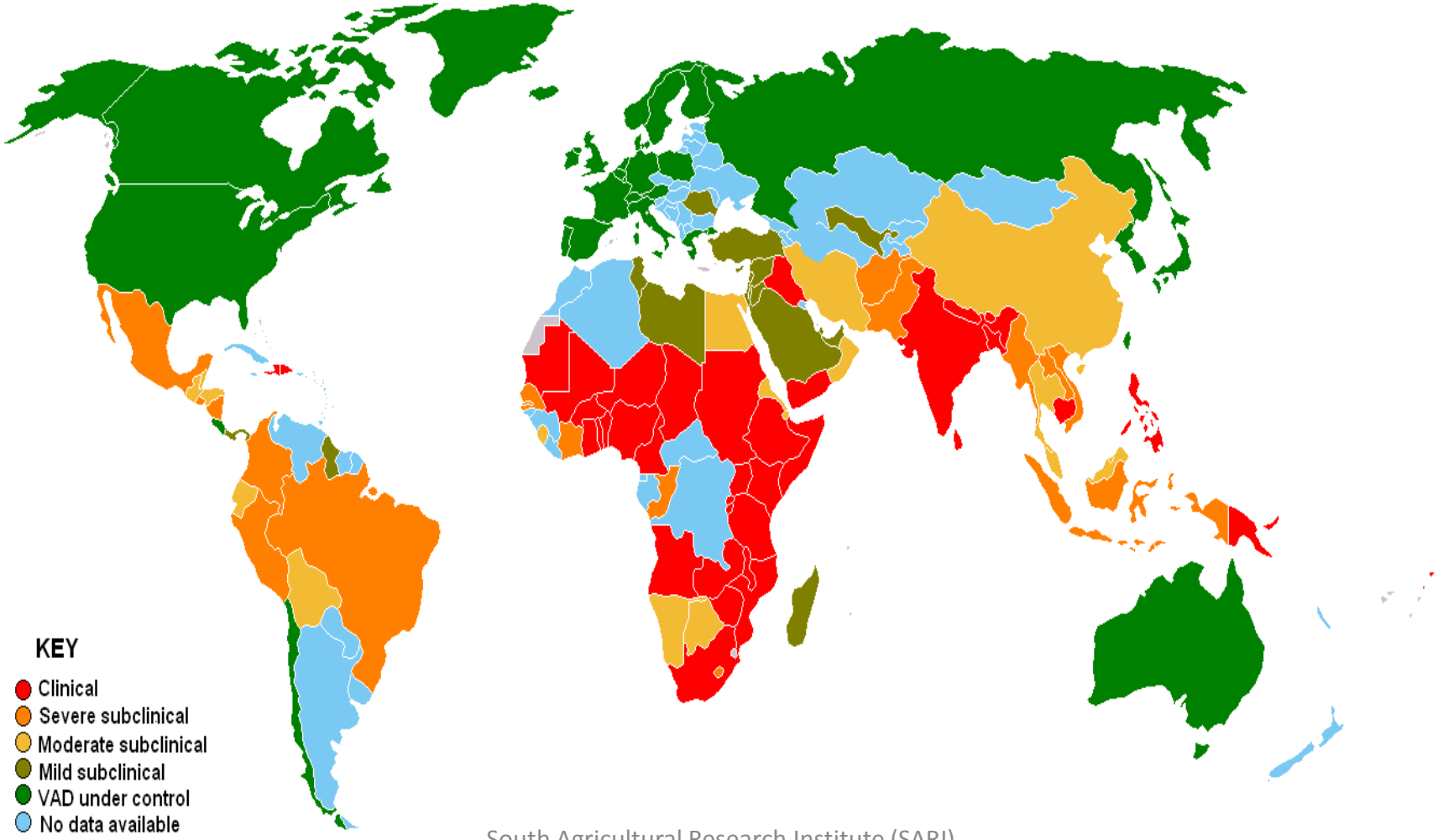
- ✓ Root yield
- ✓ β-carotene content
- ✓ Dry matter content
- ✓ Diseases (SP virus)
- ✓ Insects (SP weevil)

Why β-carotene?

- Vitamin A deficiency is a serious health problem
  - ✓ Results in blindness, stunted growth, weak resistance and death
  - ✓ Serious problem for
    - pre-school children
    - Pregnant mothers and
    - Lactating mothers

Why β-carotene?

Trends of vitamin A deficiency in children in 138 low-income and middle-income countries between 1991 and 2013: a pooled analysis of population-based surveys



Why β-carotene?...

- To combat the problem of VAD
- Orange fleshed sweetpotato (OFSP):
  - ✓ Good source of vitamin A
  - ✓ Cheapest staple food
  - ✓ Easily accessible
  - ✓ Year-round source of vitamin A
- White-fleshed are the most popular
- There is a need for cultivars with high β-carotene – i.e OFSP

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Why dry matter?

- OFSP cultivars:
  - ✓ Low acceptance by farmers/consumers
  - ✓ B/se of low root dry matter content (RDMC)
- RDMC is one of the limiting factors
- Most consumers prefer cultivars with high RDMC
  - ➢ Good eating quality, long shelf-life and processing quality
  - OFSPs in Ethiopia have low RDMC
  - ✓ Improving the RDMC – to increase acceptability of the OFSP cultivars

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Objectives

1. To determine the combining ability, type of gene action and heritability of RDMC and β-carotene content, and yield related traits of selected sweetpotato clones, for further evaluation and breeding.

2. To estimate the magnitude of G x E interactions and to select stable and high yielding candidate sweetpotato clones for RDMC, β-carotene content and fresh root yield, and to identify the most discriminating and representative test environments in Ethiopia.

Objectives…

3. To assess associations between yield and yield related traits and to identify the most efficient yield-predicting traits in sweetpotato for effective selection.

4. To determine the nutritional value of newly developed OFSP clones and to establish the associations between β-carotene content and other micro-nutrients for targeted large scale production to alleviate nutrient deficiencies.

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Genetic analysis of root dry matter and β-carotene contents, and yield related traits in sweetpotato

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Materials and Methods

Table 1. List of the seven sweetpotato parents used in a diallel crosses

No.	Genotypes	Root flesh colour	RDMC (%)	Source	Resistance to SPVD
1	Ukrewe	Pale orange	28.5	CIP	Unknown
2	Resisto	Deep orange	25.0	CIP	Susceptible
3	Ejumula	Deep orange	29.0	CIP	Susceptible
4	PIPI	Pale yellow	31.5	CIP	Resistant
5	NASPOT-1	Pale yellow	26.5	CIP	Resistant
6	Temesgen	White	33.0	Ethiopia (Released variety)	Susceptible
7	Ogansagan	White	34.5	Ethiopia (Released variety)	Unknown

Materials and Methods…

Crossing

- ✓ the first controlled crossing in Ethiopia
- ✓ 20 parents (10 WFSP and 10 OFSP)
- ✓ flowering problem
- ✓ only 7 parents produced sufficient flowers
- ✓ changed design from NC-II to half diallel
- ✓ self- and cross-incompatibility
- ✓ low seed set
- ✓ germination prob

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Materials and methods…

F_1 seeds were harvested

scarified with sul uric acid

germination test do e

planted on polystyrene t ys

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Materials and methods…

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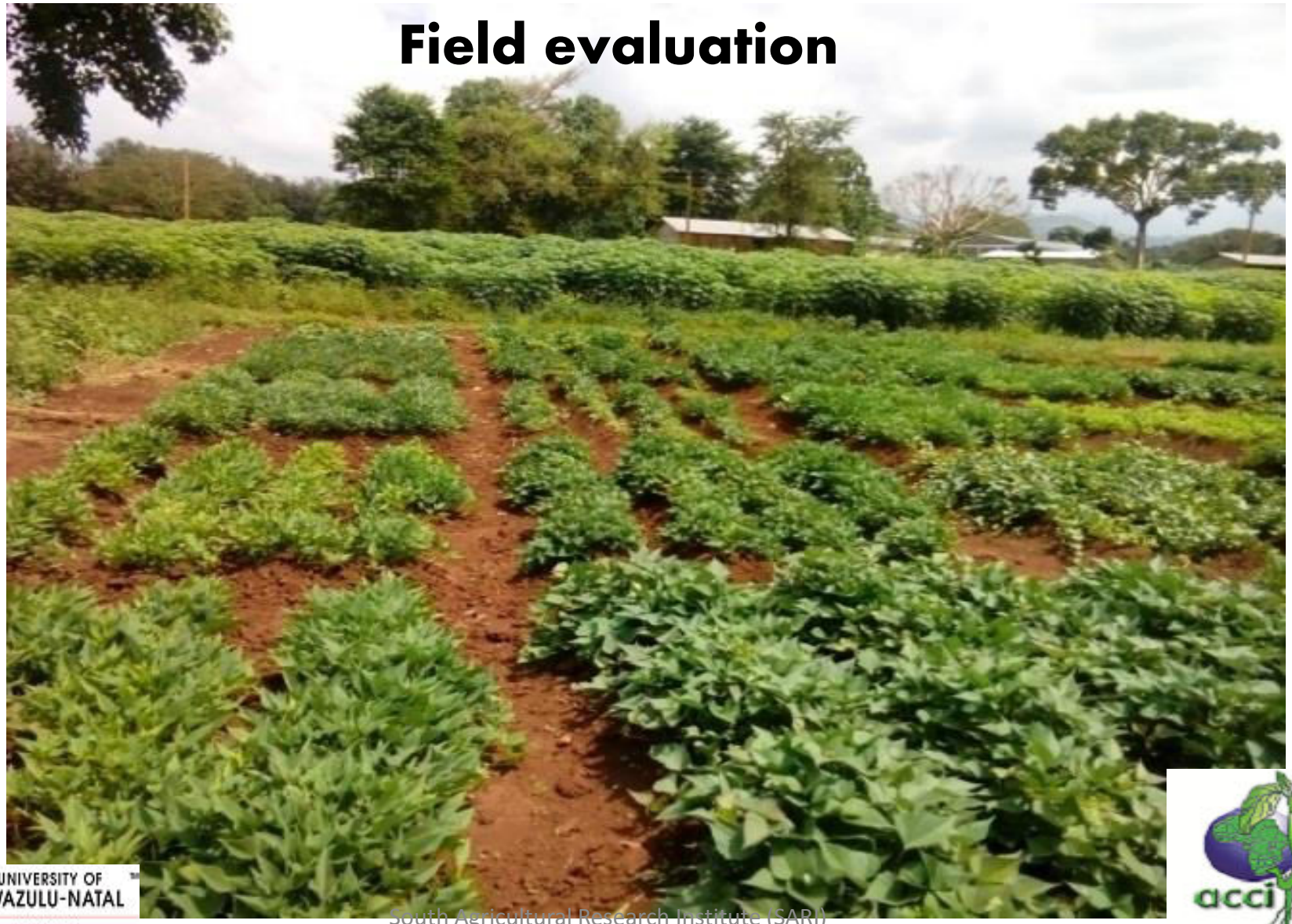
Materials and methods…



Results

- The GCA to SCA variance ratios were 0.96, 0.94, 0.74, 0.96 and 0.97 for RDMC, β-carotene content, SPVD, fresh root yield and HI, respectively, indicating that the inheritance of these traits was controlled mainly by additive genes.

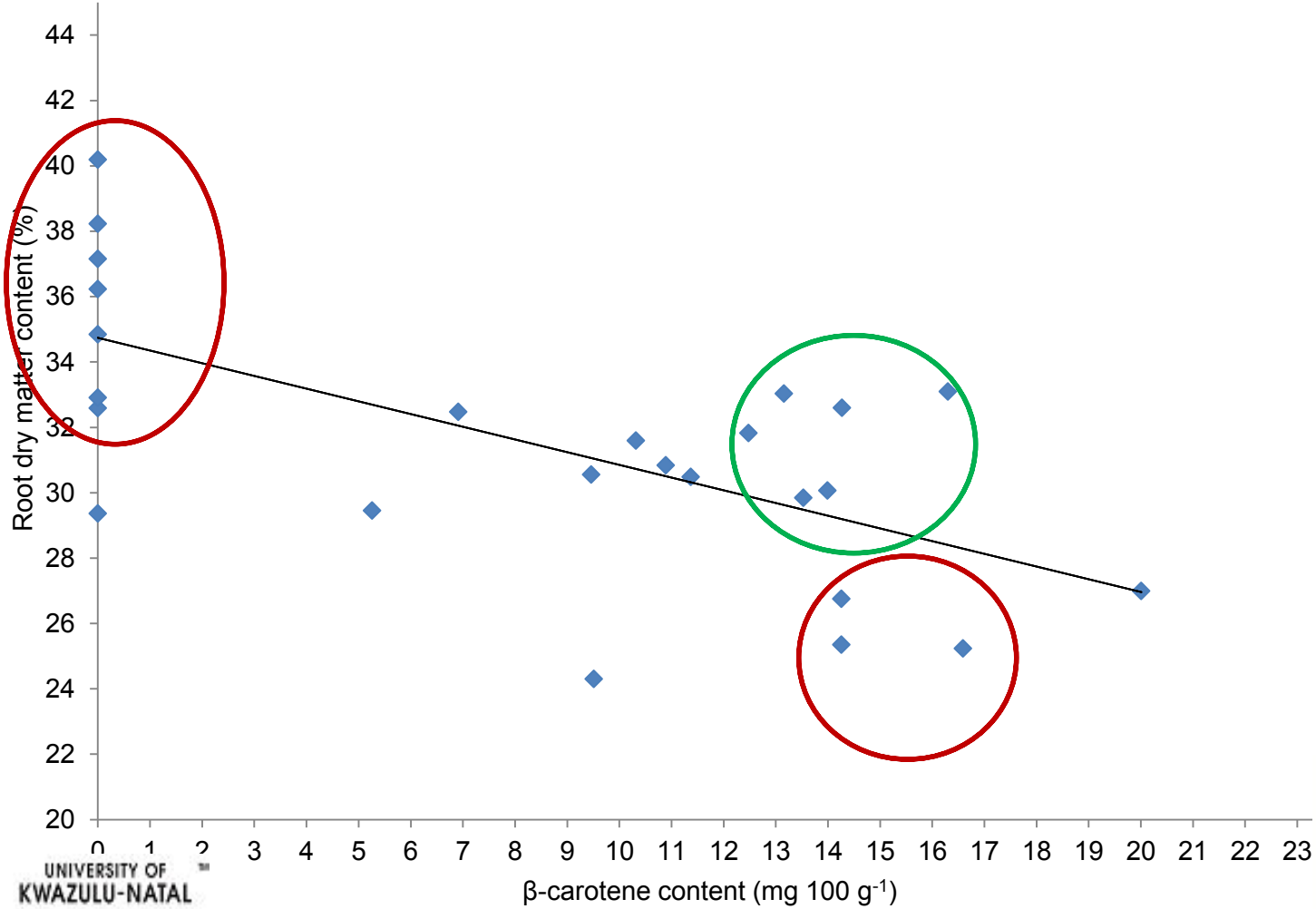
- Progenies of some of the crosses showed positive heterosis for RDMC and fresh root yield, indicating the possibility of selecting progenies that outperform both of their parents.

Results…

- Crosses such as Ukrewe x Resisto, Resisto x Ogansagan, Ejumula x PIPI and NASPOT-1 x Temesgen had:
  - High β-carotene content and
  - High RDMC that exceeded the mean of the best parent
  - Medium to high mean fresh root yield

- Continuous progeny selection among these families is important to develop OFSP varieties with high RDMC

Results…



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Genotype-by-environment interaction and stability of sweetpotato clones for root dry matter and β-carotene contents, and fresh root yield

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Introduction

- Genotype by environment (G x E) interaction is a differential response of crop varieties when grown across target environments

- Presence of G x E interaction implies the need for systematic selection and ranking of varieties across representative environments to determine their level of adaptation and yield expression prior to recommendation

Materials and methods

- The experiment was conducted at six environments
- 24 F1 progenies and one check variety were used for the G x E study
- G x E and stability analysis was conducted using GGE Bi-plot and AMMI analysis.

Results

- Environment, genotype and G x E interaction variances were found to be significant ($p < 0.01$) for RDMC, β-carotene contents, and fresh root yield

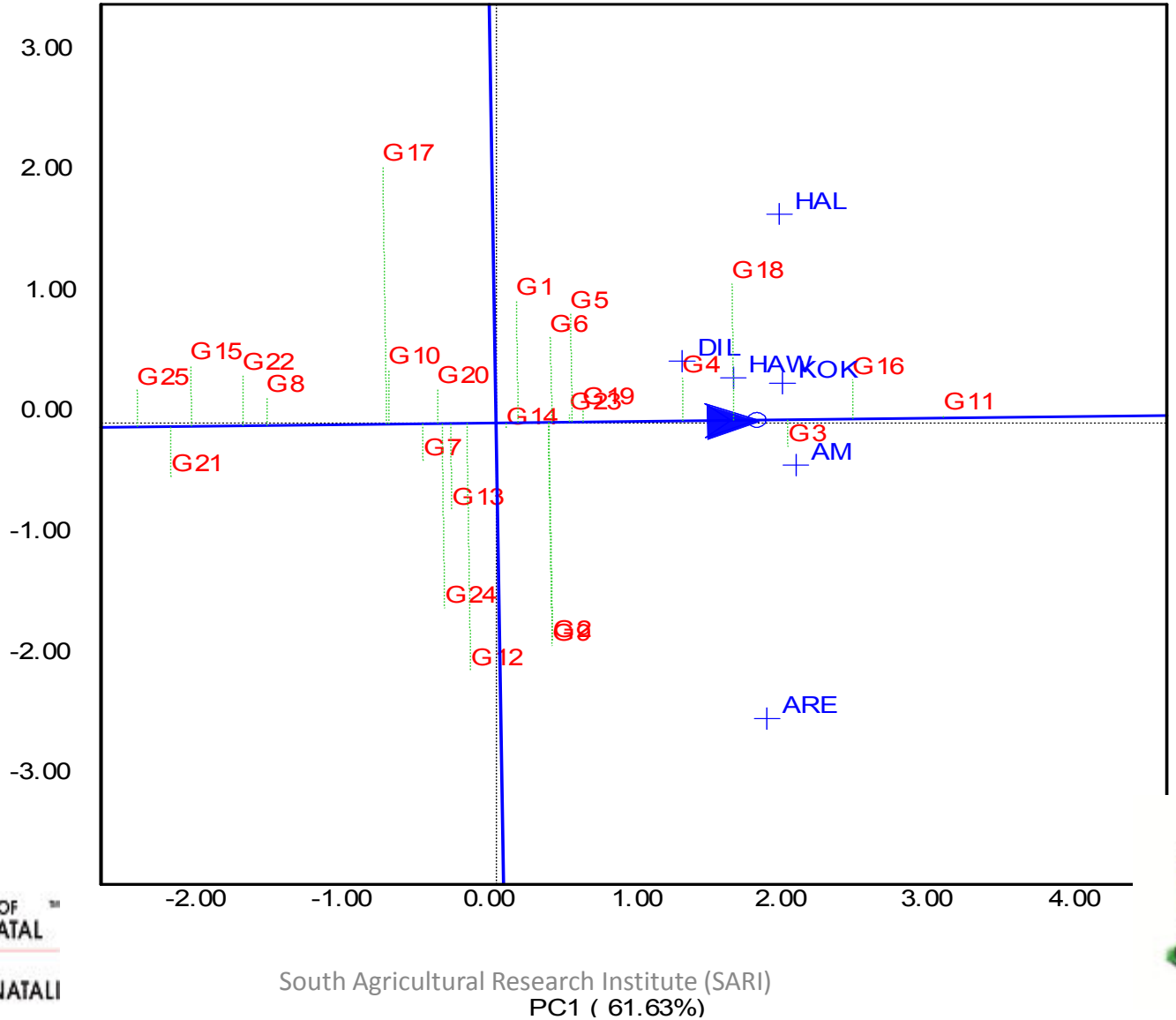
- Four clones: Ukrewe x Ejumula-10 (G1), Resisto x Ejumula-7 (G6), Resisto x Ogansagen-23 (G19) and Ejumula x PIPI-10 (G20) were selected based on their performance and stability

Results…

– These clones had:

- RDMCs of 31.82, 32.60, 33.09 and 30.06%
- High β-carotene contents of 12.48, 14.27, 16.30 and 13.99 mg 100 g^{-1} and
- Stable and high fresh root yields of 25.09, 26.92, 21.30 and 25.46 t ha^{-1}
- The study demonstrated the possibility of breeding sweetpotato varieties with a balance of high RDMC, medium β-carotene content and a high fresh root yield, with wide or specific adaptation

Results…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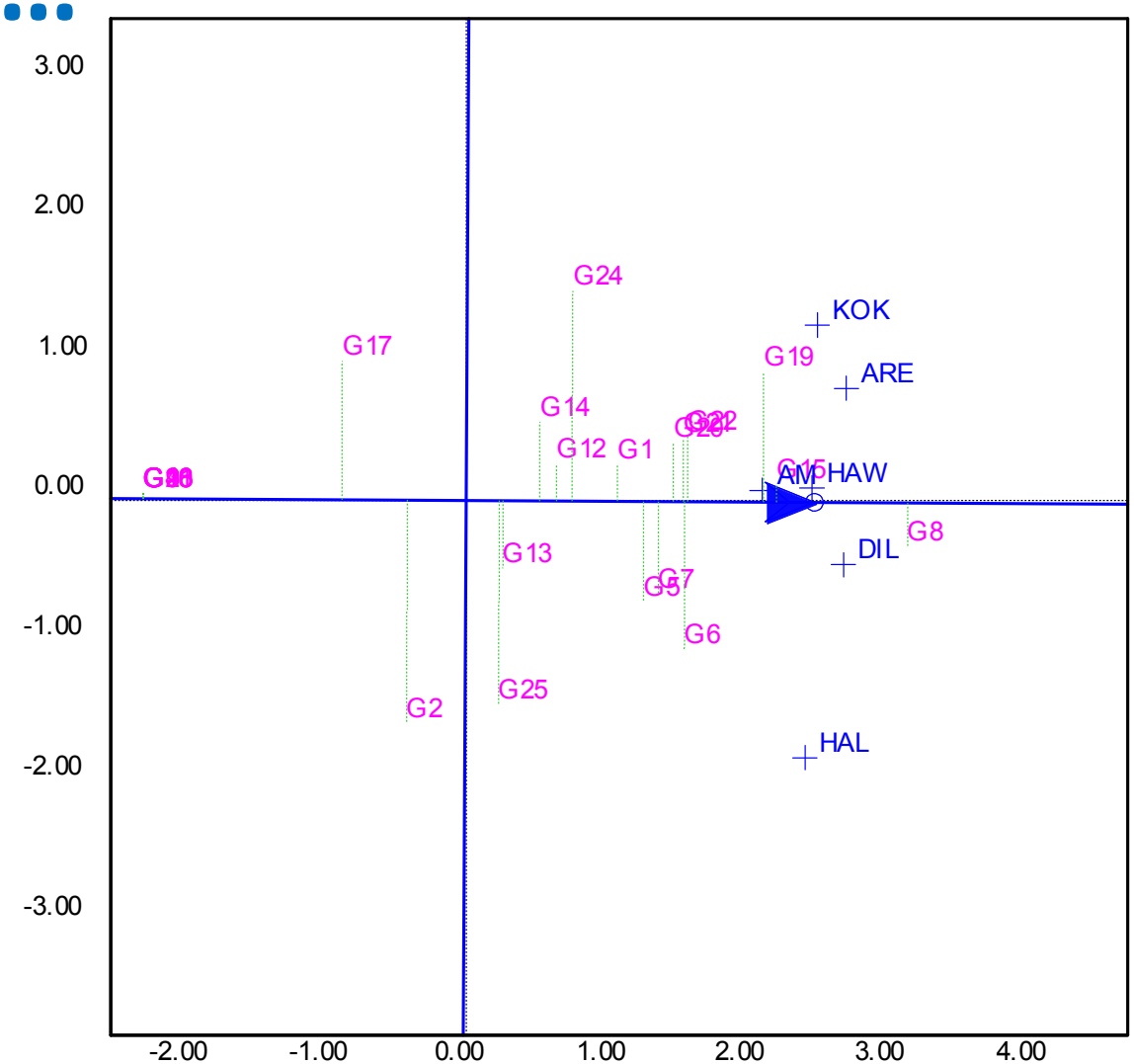
G17
HAL
G18
G1
G5
G6
G15
G22
G8
G25
G10
G20
DIL
G4
HAW
KOK
G16
G11
G14
G3
AM
G21
G7
G13
G24
G12
ARE
PC1 (61.63%)

Results…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PC1 (93.76%)
G24
KOK
G17
G19
ARE
G14
G12
G1
HAW
G8
DIL
G13
G7
G5
G6
G25
G2
HAL

Correlation and path-coefficient analyses of root yield and related traits among selected sweetpotato clones

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Results

- Root yield was positively and significantly correlated with most traits studied, indicating that component characters should be simultaneously selected for improvement of sweetpotato.
- Path-coefficient analysis showed that individual root weight, number of roots per plant, RDMC and above ground fresh weigh had high positive direct effects of 0.821, 0.776, 0.276 and 0.410, respectively, on fresh root yield
- Therefore, the above traits were identified as the most important characters determining fresh root yield in sweetpotato and can be recommended as indirect selection criteria.

Evaluation of newly developed orange fleshed sweetpotato clones for nutritional quality traits

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Materials and methods

- Fresh root samples were freeze dried at the Ethiopia Institute of Agricultural Research (EIAR), Agricultural Research Quality Laboratory

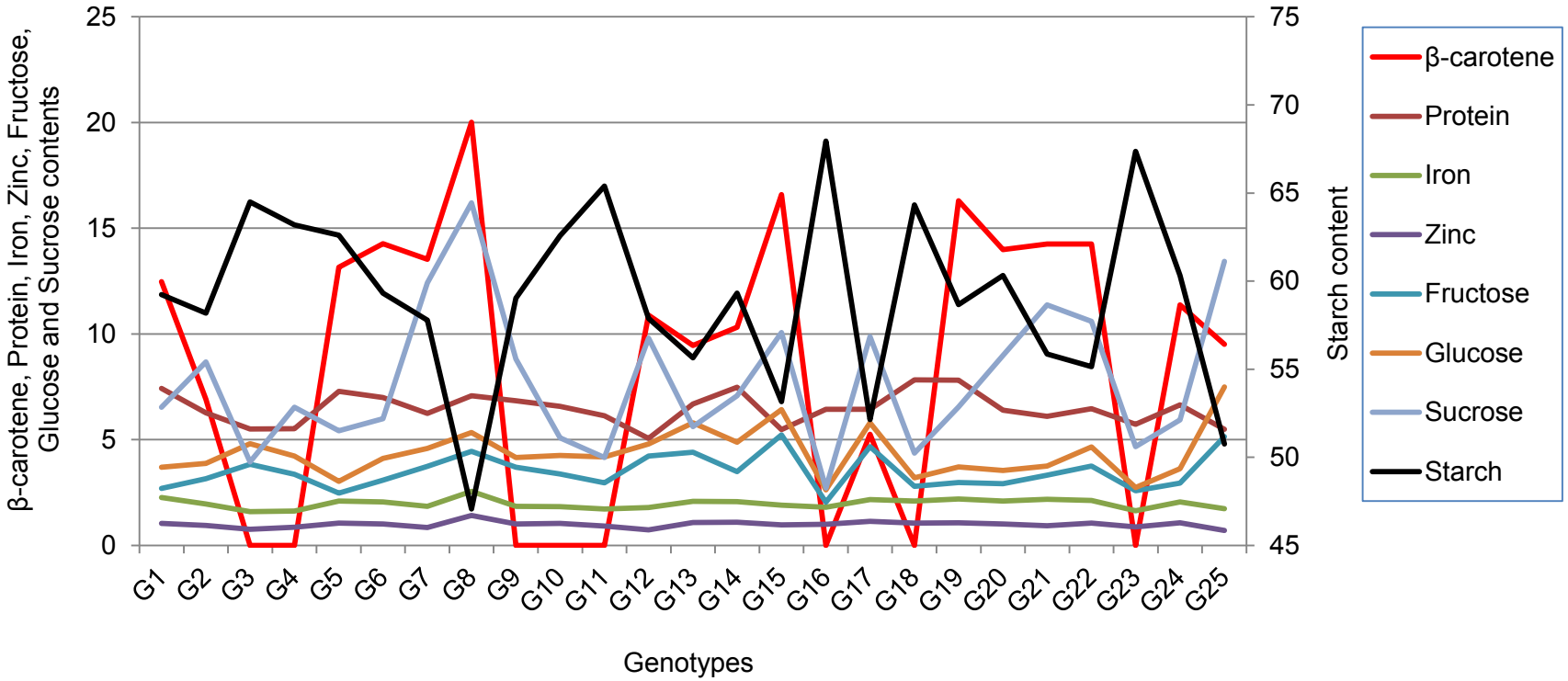
- The dried samples were sent to International Potato Center (CIP), Uganda, for analysis of β-carotene and other micro-nutrients

Materials and methods…

Results

- β-carotene content had significant positive correlations with iron (r = 0.27), zinc (r = 0.14), fructose (r = 0.1), glucose (r = 0.12) and sucrose (r = 0.36)
- This reflects the potential to breed for OFSP varieties enriched with the important micro-nutrients.
- Overall, the candidate OFSP clones, G8 (Resisto x PIPI-2), G15 (Resisto x Temesgen-23) and G19 (Resisto x Ogansagen-23) were good sources of nutritional traits such as vitamin A, iron zinc, protein, sucrose, glucose and fructose
- The selected genotypes can be recommended for large-scale production, food processing or further sweetpotato improvement to alleviate nutrient deficiencies in Ethiopia

Results…


β-carotene, Protein, Iron, Zinc, Fructose, Glucose and Sucrose contents
Starch content
Genotypes
0
5
10
15
20
25
45
50
55
60
65
70
75
G1 G2 G3 G4 G5 G6 G7 G8 G9 G10 G11 G12 G13 G14 G15 G16 G17 G18 G19 G20 G21 G22 G23 G24 G25
β-carotene
Protein
Iron
Zinc
Fructose
Glucose
Sucrose
Starch

General conclusions

- Major achievements:
  - Major sweetpotato production constraints were identified
  - Sweetpotato families with high combining ability and heterosis for RDMC, β-carotene content and fresh root yield were developed
  - Stable genotypes with high RDMC, moderate β-carotene content and high fresh root yield were identified
  - Four traits, including individual root weight, number of roots per plant, RDMC and above ground fresh weight, were identified as indirect selection criteria to improve root yield
  - It was demonstrated that the newly developed candidate OFSP clones are good sources of vitamin A, iron and zinc with high levels of protein and soluble sugars including sucrose, glucose and fructose
  - Therefore, there is a possibility of improving OFSP for high RDMC, fresh root yields and nutritional traits in Ethiopia

Acknowledgements

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- SARI
- CIP

Siyabonga!