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Research Article

Screening and Identifying Farmers’ Preferred Varieties for Adaptability and Resistance to Cassava Mosaic Disease (CMD) in Sierra Leone

Samura AE1, Fomba SN2, Conteh AR1, Mansaray A1, Norman JE2 and Dixon AGO3

1Sierra Leone Agricultural Research Institute (SLARI), Freetown, Sierra Leone
2Njala University, Freetown, Sierra Leone
3International Institute of Tropical Agriculture (IITA), Nigeria

Corresponding author: Samura AE, Sierra Leone Agricultural Research Institute (SLARI), Freetown, Sierra Leone, Tel:+23276731554, E-mail: aesamura@yahoo.com

Citation: Samura AE, Fomba SN, Conteh AR, Mansaray A, Norman JE, et al. (2018) Screening and Identifying Farmers’ Preferred Varieties for Adaptability and Resistance to Cassava Mosaic Disease (CMD) in Sierra Leone. J Plant Sci Crop Protec 1(1): 103. doi: 10.15744/2639-3336.1.103

Received Date: April 12, 2018 Accepted Date: June 14, 2018 Published Date: June 22, 2018

Abstract

Cassava plays an important role as a food security crop in Sub – Saharan Africa. However, yields of cassava in Sierra Leone are generally low. Adoption of improved varieties resistant to the Cassava Mosaic Disease (CMD) which is one of the most limiting factors of production remains low. Therefore cultivation of local varieties infected with the cassava mosaic disease dominates the farming system in Sierra Leone. The study was therefore undertaken with the general objective to screen and identify promising cassava genotypes with resistance to CMD that meets farmers’ desired traits. A total collection of 2,000 cassava genotypes introduced from the International Institute of Tropical Agriculture (IITA) and 100 local collections were initially screened at the Njala Agricultural Research Center. This was preceded by multi location trials in a randomized complete block design using cassava mosaic infected varieties an infector rows. The 1-5 scale was used to assess cassava mosaic disease. Culinary traits were assessed. The approach used in the study was a participatory varietal selection process. Most of the cassava genotypes identified by farmers had high resistance to the cassava mosaic diseases with no disease symptom. Yenkessa in the coastal plains had significantly highest severity score of 1.3. Out of the 76 varieties identified and tested, 14 genotypes had good culinary traits for use as food. MM96/7204 (4X) had the highest mean storage root yield of 47.0 t/ha followed by 06/1474 with 43.24 t/ha and were identified for use in the cassava industry. The study concluded that Kabala, Kenema and Makeni were the best environments for growing cassava.

Keywords: Cassava Genotypes; Cassava Mosaic Disease; Farmers’ Desired Traits

Introduction

In Sierra Leone, cassava is the second most important food crop after rice, the country’s staple. It is also the most important storage root and tuber crop [1]. Cassava is also grown all over the country and remarkable progress has been made in breeding for resistance to the African Cassava Mosaic Virus (ACMV). Cassava processing activities have increased at both domestic and commercial scales, although to varying degrees [2]. Yields of cassava in Sierra Leone are generally estimated at 7.4t/ha tons [3]. Much of this is as a result of the cultivation of local varieties infected with cassava mosaic disease (CMD) over improved cassava varieties that have been released by the Sierra Leone Agricultural Research Institute [4]. Furthermore there is limited access to improved varieties that meet farmers’ desired traits. The study was therefore undertaken with the general objective to screen and identify promising cassava genotypes with resistance to CMD that meets farmers’ desired traits.

Materials and Methods

Cassava Genotypes

One hundred local varieties were collected country - wide in farmer’s fields from different agro-ecologies with varying level of resistance to CMD. These materials were evaluated along with 2,000 genotypes introduced from IITA for the purpose of this study. The 2,000 cassava genotypes and 100 local varieties were collected from major cassava growing regions in the world which were grouped into different families as follows: CIAT High Protein, Stay Green Varieties from Ghana, Yellow root, Varieties from Mozambique, Castor Crosses, Castor Hybrid, Castor Hybrid (4x), High carotene, Varieties from Tanzania, Benin Gemplasm, Yellow root poundable varieties from Brazil, Varieties from Chad, Bukina Faso, Sierra Leone and Liberia, Materials from Uganda,
These locations were as follows, Njala (Forest Transition) in the Southern Province, Kenema (Rain Forest) in the Eastern Province and Kabala (Savannah Highlands), Kambia (Savannah Lowlands), Yenkessa (Coastal Plains) and Makeni (Savannah Lowlands) in the Northern Province.

**Experimental Design**

The general experimental design was a randomized complete block (RCB). In 2009, cuttings 20 – 30 cm long of each of the 2,100 varieties were planted in single row plots. Rows were 10m long with 1m between hills and 1.5m between replications. Infector rows were randomly placed between plots to ensure the presence of the cassava mosaic virus in the field. In the 2010/2011 and 2011/2012 planting seasons, a randomized complete block (RCB) with three factors which includes 76 cassava genotypes, 5 locations and 2 years was used with two replications.

**Screening for field resistance to cassava mosaic disease**

Data were collected on severity of the Cassava Mosaic Disease based on 1-5 scale (IITA, 1990) from all the 10 plants per row except the infector rows. Plants with mean CMD scores of “1” were classified as highly resistant (HR), those with a score of “1.1 to 2” were classified resistant (R), those with a score of “2.1 to 3” were classified as Moderately susceptible (MS) and those with scores of “3.1 to 4” were classified as Susceptible (S) and “4.1 to 5” were classified as highly susceptible (HS) [5].

Data collected on various parameters were subjected to analysis of variance (ANOVA) using the general linear model (GLM) for multivariate analysis and with statistical analysis system (SAS) version 9.3. Student-Newman-Keuls Test was used to test for significance at 5% probability (p<0.05) using lower case letters. Genotype, Genotype by Environment (GGE) bi-plot analysis was used to determine the best environment for growing cassava in Sierra Leone. Culinary traits analysis was subjected to simple statistics based on means and percentages.

**Results**

**Response of 2,100 Cassava Genotypes to the Cassava Mosaic Disease**

Cassava families reacted differently to the African Cassava Mosaic Disease. CIAT High protein, Ghana, Liberia, Mozambique, High carotene, yellow root poundable and TME series were the most susceptible families to ACMD with above 60% of the genotypes showing symptom of the disease. Stay green, yellow root, Castor crosses, castor hybrid (4x) and materials from Uganda provided higher number of resistant genotypes that could be also used in disease resistant breeding programmes.

Varieties collected from Sierra Leone based on field observation indicated that 12 varieties (14.8%) were ranked as highly resistant, 9 varieties (11.1%) were resistant, 25 varieties (30.8%) were moderately susceptible and 32 varieties (39.5%) were classified as highly susceptible to cassava mosaic disease.
Most of the cassava genotypes selected by farmers in 2009 exhibited high level of resistance to ACMD when screened in the field. A total of 1,827 (87%) of the 2,100 cassava genotypes assessed were classified as highly resistant with no symptom expression at 3 and 6 months after planting (MAP). Another 273, (13%) of the cassava genotypes were however susceptible to ACMD. The TME series were the most infected and included TME 235 and TME 643 with the highest severity score of 4, higher than popular local variety which had a severity score of 3. Disease symptom expression was consistent with that of cutting borne infection for all plants assessed.

Yield estimates of selected cassava genotypes at Njala in 2009

The selected cassava genotypes showed very promising yield with zero fertilizer application. Storage root yield estimates of some of the selected cassava genotypes ranged between 22 t/ha to 48 t/ha. The highest yielding cassava genotypes assessed includes, 94/0069 which had the highest yield of 48 t/ha followed by 01/1551 with 41 t/ha while the local check cocoa had 13 t/ha. Other released varieties such as SLICASS 4, and 6 had 24 t/ha and 20 t/ha respectively.

Multi location screening of farmer preferred cassava genotypes in Sierras Leone

From a total of 2,100 genotypes initially screened in 2009, seventy one (71) genotypes identified by farmers and five check varieties SLICASS1, 2, 4, 6, and the local variety Cocoa were selected for multi-location evaluation based on the general criteria adopted for selection by farmers with special emphasis on mosaic resistant varieties.

Severity of cassava mosaic disease on farmers’ preferred genotypes assessed for two years: Most of the cassava genotypes selected by farmers had high resistance to the cassava mosaic diseases. The overall mean of the genotypes assessed was 1.1. The mean severity score for most genotypes assessed were below the local check variety Cocoa with a score of 1.92 which was significantly highest score (P<.0001) but not significantly different from SLICASS 2 with a score of 1.75 (Table 1). Other check varieties released by SLARI which included SLICASS1 SLICASS 4 and SLICASS 6 exhibited no symptom of the cassava mosaic disease. Out of the 76 genotypes assessed, 59 (77.63%) showed no symptom of the disease. In general there was no significant difference in the performance of the varieties selected in the two years of assessment (P<0.05), however it was clear that symptom expression was inconsistent among some genotypes which could be attributed to the resistance of the genotypes and the environmental condition in which the crop was grown.

Severity of Cassava Mosaic Disease on farmers’ preferred genotypes across locations: The severity of cassava mosaic disease among cassava genotypes selected was low (P<.0001). Yenkessa in the coastal plains had significantly highest severity scores of cassava mosaic disease (1.32) compared to all other locations. No significant difference was observed in disease expression among genotypes in Kabala (1.013), Kambia (1.013), Kenema (1.023), Makani (1.012) and Njala (1.013) (Table 2). This result can best be presented using the GGE biplot analysis (Fig.1). The concentric circles which shows the best mega environments in response to ACMD. Yenkessa location was the worst affected location followed by the Kenema environment. Kabala, Kambia, Makeni and Njala had one cluster indicating safe environments for growing cassava.

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Table 1: Some Mean Severity of Cassava Mosaic Disease on Farmer Preferred Genotypes assessed in 2010 and 2011

| *CLONE* | *ACMD severity* |
|---------|-----------------|
| COCOA (Local check) | 1.92a |
| SLICASS 2 | 1.75b |
| 96/0595 | 1.50c |
| 01/0025 | 1.33d |
| TME 203 (4X) | 1.33d |
| TME 1674 | 1.21de |
| IFO 7010 | 1.17e |
| 07/0498 | 1.17e |
| 05/0127 | 1.08ef |
| MM97/3069 | 1.08ef |
| SM 1406-1 | 1.08ef |
| 05/1652 | 1.08ef |
| 05/0303 | 1.00f |
| CV% | 20.6 |
| SE± | 0.048 |

1List not exhausted  
*Means with the same letter are not significantly different.

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Pounding characteristics of farmers’ preferred varieties:

Based on the criteria adopted for pounding ability, 14 out of the 76 genotypes tested were considered soft after boiling for 20 minutes. These include genotypes 88/00279, 91/00143 (4X), 92/0326, 94/0069, 95/0166, 95/0902, 96/0097, 96/0595, 96/1172, CC 055, CC 2365, MM02/2101, Mocuba and an Unknown 6 (Table 3).

| Location | ¹ACMD Severity |
|----------|----------------|
| Yenkesa  | 1.32a          |
| Kenema   | 1.02b          |
| Makeni   | 1.02b          |
| Kabala   | 1.01b          |
| Njala    | 1.01b          |
| Kambia   | 1.01b          |
| CV%      |                |
| SE±      |                |

¹Means with the same letter are not significantly different.

Table 2: Severity of Cassava Mosaic Disease on farmers’ preferred varieties across six locations in Sierra Leone

Cooking Time: Significant difference was observed among genotypes tested for their cooking ability. Most of the genotypes tested had poor cooking ability. Out of the 76 varieties tested for two consecutive years, 14 possessed the ability to cook under 20 minutes. These genotypes includes 94/0069, 95/0166, 95/0902 and 96/0097. The local check Cocoa was easily cooked at 20mins. Those that did not cook after 20minutes were considered as hard or slightly cooked varieties.

Culinary traits possessed by farmers’ preferred cassava genotypes

Easy to peel varieties: Out of 76 genotypes tested by farmers, 42% (32) genotypes were found to be easy to peel. Among them included easy and hard to cook genotypes, genotypes with different inner appearance and level of poundability. Easy to peel genotypes identified included 01/0025, 02/0431, 02/0572, 03/025, 05/1652, 05/1654, 05/1661, 06/2064, 91/00143 (4X), 92/0326, 92/0475, 96/0160 (4X), 96/0409, 99/00110, CC 054, CC 103, CC 107, IFO 7010, MM001/0146, MM02/2101, MM3412, MM96/3665, MM96/5267, MM96/9181, 91B/0046, MOCUBA, TME 643, UNKNOWN 2, 3 and 6, W-820447, Z96/0012, respectively (Table 3).

Taste and smell of cassava genotypes: Out of the 76 genotypes tested by farmers, 92.1% of the 76 genotypes identified were considered to have a sweet taste. Two (2) varieties were considered to be slightly sweet and four were considered to be bitter. 85.5% i.e. 65 genotypes were considered to have a good smell. Other varieties were considered to be odourless or fair (Table 3).
ing after 20 minutes (Table 4).

Most of the cassava genotypes selected for industrial uses had tubers which remained hard when subjected to boil, taking into account the two years of study was (MM96/7204 (4X) with a mean storage root yield of 47.0 t/ha followed by 06/1474.

Significant difference was observed among cassava genotypes in terms of storage root yield. The highest mean storage root yield of whiteflies. The dry season attracted more whiteflies compared to the rainy season which did not exceed 17 whiteflies per plant.

All cassava genotypes selected were resistant to cassava mosaic disease. Cassava genotypes generally attracted low population levels characteristic farmers' preferred genotypes assessed for two year. 2010/2011 and 2011/2012.

2010/2011 and 2011/2012 and they include SM 1406-1 TME 643 and Cocoa the local check. Another 29 genotypes had white outer skin colour, 24 genotypes had a yellow outer skin colour and 20 genotypes had a cream outer skin colour.

Characteristic farmers' preferred genotypes identified for industrial uses assessed for two year. 2010/2011 and 2011/2012

Three cassava genotypes had pink skin a trait presumed to be associated with good cooking ability by farmers and they include SM 1406-1 TME 643 and Cocoa the local check. Another 29 genotypes had white outer skin colour, 24 genotypes had a yellow outer skin colour and 20 genotypes had a cream outer skin colour.

A total of 71 cassava genotypes, 93.4% out of the 76 cassava genotypes had selected by farmers had a white inner appearance of the tubers. Three cassava genotypes selected were yellow root rich in pro vitamin A and included 91B/00462, 96/0127, 05/0127, 05/1654 and CC 103.

Characteristic farmers’ preferred genotypes for industries assessed for two year

Table 3: Characteristics of some cassava genotypes with poundable trait, good cooking ability for local food

**Outer skin colour:** Three cassava genotypes had pink skin a trait presumed to be associated with good cooking ability by farmers and they include SM 1406-1 TME 643 and Cocoa the local check. Another 29 genotypes had white outer skin colour, 24 genotypes had a yellow outer skin colour and 20 genotypes had a cream outer skin colour.

**Inner appearance of tubers:** A total of 71 cassava genotypes, 93.4% out of the 76 cassava genotypes had selected by farmers had a white inner appearance of the tubers. Three cassava genotypes selected were yellow root rich in pro vitamin A and included 05/0127, 05/1654 and CC 103.

**Characteristic farmers’ preferred genotypes for industries assessed for two year**

All cassava genotypes selected were resistant to cassava mosaic disease. Cassava genotypes generally attracted low population levels of whiteflies. The dry season attracted more whiteflies compared to the rainy season which did not exceed 17 whiteflies per plant. Significant difference was observed among cassava genotypes in terms of storage root yield. The highest mean storage root yield taking into account the two years of study was (MM96/7204 (4X) with a mean storage root yield of 47.0 t/ha followed by 06/1474 with 43.24 t/ha. Most of the cassava genotypes selected for industrial uses had tubers which remained hard when subjected to boiling after 20 minutes (Table 4).

| Clone            | Easy to peel | Outer skin color | Inner appearance | Cooking texture | Smell | Tast | Cooking time (mins) | Pound ability | Yield (t/ha) |
|------------------|--------------|------------------|------------------|----------------|-------|------|---------------------|---------------|-------------|
| 88/00279         | hard         | white            | white            | cooked         | good  | sweet| 15.00               | soft          | 27.13       |
| 91/00143 (4X)    | easy         | cream            | white            | cooked         | good  | sweet| 20.00               | soft          | 22.68       |
| 92/0326          | easy         | cream            | white            | cooked         | good  | sweet| 20.00               | soft          | 33.05       |
| 94/0069          | hard         | white            | white            | cooked         | good  | sweet| 15.00               | soft          | 28.47       |
| 95/0166          | hard         | white            | white            | cooked         | good  | sweet| 15.00               | soft          | 22.11       |
| 95/0902          | hard         | white            | white            | cooked         | good  | sweet| 15.00               | soft          | 21.99       |
| 96/0097          | hard         | white            | white            | cooked         | good  | sweet| 15.00               | soft          | 34.26       |
| 96/1172          | hard         | white            | white            | cooked         | good  | sweet| 15.00               | soft          | 27.90       |
| CC 055           | hard         | white            | white            | cooked         | good  | sweet| 15.00               | soft          | 26.67       |
| CC 2365          | hard         | white            | white            | cooked         | good  | sweet| 15.00               | soft          | 18.49       |
| MM02/2101        | easy         | white            | white            | slightly cooked| good  | sweet| 20.00               | soft          | 41.76       |
| MOCUBA           | easy         | white            | white            | slightly cooked| good  | sweet| 20.00               | soft          | 26.41       |
| UNKNOWN 6        | easy         | cream            | cream            | cooked         | fair  | bitter| 20.00               | soft          | 29.76       |
| COCOA            | Hard         | Pink             | White            | Cooked         | Good  | sweet| 20.00               | soft          | 16.22       |

Table 4: Characteristic farmers’ preferred genotypes identified for industrial uses assessed for two year. 2010/2011 and 2011/2012

*List not exhausted Means with the same letter are not significantly different
Storage root yield (t/ha) of farmers preferred cassava genotypes across locations for 2011 and 2012

Significant difference in storage root yield was also observed in the overall performance of cassava genotypes tested across locations. Kabala had the highest storage root yield (P> .0001) of 35.89 t/ha significantly higher than all locations followed by Kenema with 34.83 t/ha significantly higher than Makeni with 33.55 t/ha which in turn was significantly higher than Njala with 28.69. Kambia and Yenkesa had significantly the lowest yields of 26.29 t/ha and 18.70 t/ha respectively (Table 5). This result is clearly presented as a GGE biplot for yield in (Figure 2) which shows that the Kabala environment was the best environment followed by Kenema and Makeni. The Yenkesa environment was the worst performing location for growing cassava.

| Location | Storage root yield (t/ha) |
|----------|--------------------------|
| Kabala   | 35.89a                   |
| Kenema   | 34.83b                   |
| Makeni   | 33.55c                   |
| Njala    | 28.69d                   |
| Kambia   | 26.29e                   |
| Yenkesa  | 18.70f                   |

Means with the same letter are not significantly different

Table 5: Storage root yield (t/ha) of farmers preferred cassava genotypes across locations in 2011 and 2012

Figure 2: Genotype, Genotype by Environment bi-plot for storage root yield of farmers preferred varieties across locations

Discussion

The result of this study shows that efforts by Sierra Leone Agricultural Research Institute and other development agencies in the development and dissemination of improved cassava varieties to farmers have been moderately effective. Morphological screening of 2,000 introduced cassava genotypes from IITA and 100 local collections for CMD resistance based on the 1-5 scale and classification according to, revealed that farmers are interested in disease resistant cassava genotypes [5-7]. The identification of resistant genotypes across agro ecologies for boil and eat purposes as well as industrial purposes provides enormous opportunities for increasing cassava productivity. All the cassava varieties evaluated did not meet all the traits desired by farmers. The relevance of this finding is that breeding efforts should target specific needs that meet both domestic and industrial uses. Clearly, showed that the boil and eat market for poundable cassava varieties such as Cocoa was a more profitable enterprise despite the comparatively
low yield [8]. This implies that breeding efforts should not only be geared towards resistance or pest and diseases but should also focus on other culinary traits such as easy to cook, easy of peeling and resistance to post physiological deterioration. These traits are more relevant along the value chain which addresses concerns from production, processing and marketing to improve the profitability of cassava.

Conclusion

Screening for resistance to cassava mosaic from 2,100 cassava genotypes provided a direction to which cassava families possess resistance and susceptibility to the cassava mosaic virus and from which sources of resistance should be sought. High level of cassava mosaic disease resistance varieties could be sought from families such as stay green, yellow root castor crosses, castor hybrid (4x) and materials from Uganda. Disease symptom expression was consistent with that of cutting borne infection for all plants assessed. Fourteen (14) poundable cassava genotypes and twenty high yielding genotypes resistant to cassava mosaic disease were identified with the participation of farmers for multiplication and distribution across agro ecologies. Varieties identified did not meet all the traits desired by farmers however all varieties exhibited high yield potential and resistance to pests and diseases especially the cassava mosaic disease. Most of the varieties identified for domestic and industrial use had significantly higher yield compared to the check varieties. Kabala, Kenema and Makeni had the best environment for growing cassava in Sierra Leone.

Acknowledgement

The authors wish to extend profound thanks and gratitude to the Government of Sierra Leone, the West Africa Agricultural Productivity Project (WAAPP) and the International Institute of Tropical Agriculture (IITA) for financial and technical support to this project.

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