ROOT CROPS PROGRAMME

Application for Release of Two Cassava Varieties: **NARO-CASS1 & NARO-CASS2**

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NATIONAL CROPS RESOURCES RESEARCH INSTITUTE

Application for Release of Cassava Varieties

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Species:	*Manihot esculenta* (Crantz)
Origin of Parents:	Agricultural Research Institute (ARI-Kibaha), Tanzania.
Mode of Generation of Test Materials:	Natural Sexual Recombination
Locations of Evaluation & Selection:	Namulonge, Kamuli, Tororo, Kaberamaido, Arua, Hoima, Lira and Nakasogola,
End Use:	Human and Livestock use
Check Varieties:	Nase 14.

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Summary

Initiatives to increase cassava production and productivity in Uganda with the dual roles of increasing food security and household income have been, and continue to be a major objective of the Root Crops Programme. Certainly, attainment of this objective requires that cassava breeding be highly responsive to pressing threats, particularly viral diseases, which are key yield-robbing stresses in Uganda.

Cassava brown streak disease (CBSD) is a notable viral challenge to optimal cassava productivity in Uganda. The disease has since 2004, caused a formidable challenge to the cassava industry. From the initial less than 10 districts affected in 2005, CBSD rapidly spread to over 30 districts by 2011. This rapid increase was in part due to cultivation of super susceptible CBSD varieties that had dominated production on the estimated 400,000 ha under cassava production. In 2011, NARO released four tolerant varieties from Ugandan selections (Nase 14, Nase 15, Nase 18 and Nase 19). These varieties, on the limited acreage they are grown, have significantly reduced yield losses associated with CBSD and/or with cassava mosaic disease. It's therefore necessary to continue to select for increased tolerance.

Accordingly, we introduced ~5000 botanical seeds from Tanzania in 2004, and these have been undergoing phenotypic mass selection for CBSD in Uganda. From these selections, two varieties TZ/130 and MM06/0130 have been identified as outstanding. The botanical seeds were established at Namulonge in 2005. Culling for both CBSD and cassava mosaic disease, was initiated at Namulonge, a hot spot for both viruses, for six years up to 2011; only disease-free clones were advanced to the following year. Thus, in 2012, replicated trials for surviving clones were established at diverse locations and evaluations undertaken for other key agronomic traits. Evaluations where conducted at eight locations during 2012-2014: Namulonge (central region), Nakasongola (central and drought prone region), Hoima (western region), Lira (northern region); Kamuli (eastern region); Tororo (eastern region); Kaberamaido (eastern region); and Arua (west Nile region). Selections and evaluations at these respective sites were either done on farmers' fields and/or NARO affiliated research institutes.

Specifically, these varieties have been evaluated for desirable agronomic (plant health, plant type, yield potential) and root quality (cyanogens, taste, mealyness, and aroma) traits. At the evaluation sites both varieties TZ/130 and MM06/0130 were sweet, had good aroma, and had low levels of cyanogens. For the agronomic traits, TZ/130 was characterized by: dry matter content (31 to 36%); fresh root yield (22 to 55 t/ha); harvest index (0.4 to 0.7) and CBSD root incidence < 10%. On the other hand, MM06/0130 was characterized by: dry matter content (33 to 38%); fresh root yield (14 to 38.2 t/ha); harvest index (0.4 to 0.6) and CBSD root incidence < 10%.

The two selected varieties have been evaluated for about nine years. The first six years (2005 to 2011) were exclusively done at a single site Namulonge, for purposes of culling for CBSD, while the last four years (2012 to 2014) were done at eight different sites either once or twice depending on availability of planting materials. We are therefore confident that the selected varieties will be rapidly adopted owing to the desirable agronomic trait combinations they have. Because these varieties are considered to be tolerant to CBSD (i.e, lower root severities and incidence), when combined with phytosanitation, they can then qualify to be deployed in major cassava growing areas experiencing CBSD. It is proposed that the candidate varieties for release (TZ/130 and MM06/0130), be officially released as NARO-CASS1 and NARO-CASS2, respectively.

Acknowledgment

This application for official release comes only after four years since the previous release in 2011. This was made possible because of botanical seeds introduced from Tanzania; these botanical seeds from which the candidate varieties were selected, were kindly provided by Dr. Edward Kanju, for whom we are very grateful.

Financial support to undertake these evaluations and selections were largely sourced from the East African Agricultural Productivity Project (EAAPP).

Staff of the Root Crops Programme, the extension agents and farmers in the evaluation and selection sites (Nakasongola, Tororo, Lira, Arua, Kaberamaido and Kamuli) are highly appreciated. They displayed teamwork and commitment during the evaluation and selection process. .

We also thank the National Agricultural Research Organisation (NARO), which provided us with conducive research environment and other logistical support.

1.0 Background

Initiatives to increase cassava production and productivity in Uganda with the dual roles of increasing food security and household income have for long been, and continue to be, a major objective of the Root Crops Programme. As of this writing up to 19 cassava varieties have been released, and this has taken place between 1990 and 2011. Some of these varieties like NASE 3 and NASE 14 have been adopted extensively, while others like Nase 5, Nase 6 and Nase 7, were adopted to limited extent, as reflected by the acreage planted to each variety. On average, 67% of cassava grown in Uganda are improved varieties that have primarily been disseminated by NARO.

The complexity associated with cassava brown streak virus, the causative agent of CBSD, justifies continued breeding efforts to generate varieties that minimise the yield losses associated with CBSD. This is particularly critical in regions like Uganda, where the disease is relatively new. In CBSD endemic regions like coastal Tanzania, co-evolution of the virus together with the host plant cassava, have been underway since the 1930s. Indeed, the Tanzania breeding programme, has since the inception of formal cassava breeding in the 1930s, identified a number of varieties that are highly tolerant to CBSD. This isn't the case for Uganda, and thus the motivation for us to introduce germplasm from Tanzania. Thus, herein, we report the evaluation and selection of candidate varieties, which were part of the 5000 seeds that were introduced in Uganda in 2004.

2.0 Methodology

Breeding methods developed for cross-pollinated crops can practically be applied to cassava. The breeding methodology in cassava involves selection of parents (based on complimentary traits), crossing (via controlled or open pollinations) and simple phenotypic selection of individual clones based on performance across years and locations. The vegetative nature allows fixation of genotypes throughout the selection process. However, a common feature of most cassava breeding programmes is that the initial stages of evaluation and selection are usually unreplicated and during then, emphasis should be on traits of high heritability. Excellent reviews of hybridization, evaluation and selection, which we adopted for this work, have been documented (see Kawano, 2003).

Thus in this evaluation, up to 5,000 open pollinated seeds were introduced from Tanzania. These seeds were derived from a polycross that had parental lines considered to be tolerant to CBSD. All this activity was undertaken in Tanzania by Dr. Edward Kanju. In April 2005, these seeds were established in a seed nursery for germination at Namulonge. When seedlings attained a height of 20 - 25 cm, they were transplanted to the field at spacing of 1 m x 1 m for evaluation and selection. We employed the phenotypic mass selection scheme between 2005 and 2011.

Thus, for each annual selection event, only clones with CMD severity indices in the range of 1-2 were advanced. For CBSD, only clones with <10% root incidence and foliar incidence of <5% were advanced. All these six evaluations and selection exercise was undertaken at Namulonge, a hot spot for both CBSD and CMD. Data on the agronomic performance of the surviving clones by 2012 are presented in Table 1.

During the period 2012-2013, all planting material of promising clones (TZ/130 and MM06/0130) were used to establish replicated trials (three replicates and 25 plants/plot) at three sites: Namulonge, Kaberamaido and Tororo (the trial at Masaka was abandoned due to poor establishment). The candidate varieties were evaluated together with other breeding lines, and the released variety Nase 14, for comparison purposes. Data were collected on root weight (kg/plant), shoot weight (kg/plant), and harvest index (HI) computed as a ratio of the fresh root weight to the total biomass on a fresh weight basis. At each site, CBSD was scored using the standard 1-5 scale.

During the period 2013-2014, additional replicated trials (four replicates and 36 plants/plot) were established at four sites: Namulonge, Kaberamaido, Kamuli and Tororo. For these trials, the candidate varieties were evaluated together with one outstanding breeding line (MH04/0300) and the released variety (Nase 14). At harvest, data were collected on HI, root dry matter content (DMC) and CBSD root necrosis. Estimation of DMC was by the specific gravity method (Kawano, 2003). In addition, the staff of the Ministry of Agriculture Animal Industry and Fisheries (MAAIF) were invited to participate in the morphological characterization of the varieties. A selection of the morphological descriptors of these varieties are presented in Table 2 and Figure 1.

On-farm evaluations were also carried out in Arua, Hoima, Lira and Nakasongola during the period 2012-2013. Expert cassava farmers that have grown the crop for several years were selected for this purpose. At each site up to six varieties were evaluated in replicated plots of 49 plants/plot. In addition to the key agronomic traits, other culinary attributes examined included: taste (sweet, fairly sweet, flat, slightly bitter and bitter); mealyness (mealy, average, watery); texture (fairly hard, fibrous, hard, soft); and flavour (aroma and no aroma). These evaluations were done on cooked cassava.

3.0 Results and Discussion

Results presented in this report were obtained from on-station and/or on-farm trials conducted during the period 2012 to 2014, and established at eight sites: Namulonge (central region), Nakasongola (central and drought prone region), Hoima (western region), Lira (northern region); Kamuli (eastern region); Tororo (eastern region); Kaberamaido (eastern region); and Arua (west Nile region). Data presented in Table 1 reveals the agronomic performance of surviving clones (after six years of exposure to CBSD at Namulonge) selected from introduced seed from Tanzania. These clones are were part of the of TZ/130 and MM06/0130, as they were part of the introduced botanical seed sourced from Tanzania. Because, these two clones (TZ/130 and MM06/0130) were outstanding, they were from 2012, established in replicated plots to generate performance data for their registration and/or official release

Data for the agronomic performance of the candidate varieties during the period 2012-2013 at the different sites are presented in Tables 3, 4 and 5. At Kaberamaido, yield of the evaluated clones ranged from 14 t/ha (tamale) to 32 t/ha (TZ/130); the other candidate variety MM06/130 registered average yields of 31 t/ha (Table 3). Also, CBSD root incidence for the candidate varieties were less than 3%, while some of the other evaluated varieties, had up to 80% CBSD root incidence at Kaberamaido (Table 3). At Namulonge, TZ/130, MM06/0130 and Nase 14, had respective CBSD root incidences of 16%, 22.5% and 36.4% (Table 4). At Tororo, candidate varieties TZ/130 and MM06/0130 had respective yields of 43 t/ha and 38 t/ha, with CBSD root incidences of less than 12% (Table 5).

Data generated from on-farm trials conducted in Arua, Hoima, Lira, and Nakasongola are presented in Table 6. At each of the evaluation sites, the candidate variety was compared to five varieties that are popular in each of the evaluation sites (Table 6). The popular varieties at the evaluations sites were Omo, Kanyali, Olepo and Njule, respectively, at Arua, Hioma, Lira and Nakasongola (Table 6). Yield of the candidate variety TZ/130 ranged from 27.5 t/ha at Nakasongola to 53 t/ha at Lira (Table 6). Yield of the check variety (Nase 14), ranged from 6.5 t/ha in Nakasongola to 53 t/ha in Lira (Table 6). The candidate variety TZ/130 had <5% CBSD root incidence. Compared to Tanzania where CBSD has been a problem for over 70 years, no immune variety has been identified. So far, all released varieties are classified as tolerant to CBSD because they either: 1) have foliar symptoms with no root symptoms or 2) have no foliar symptoms, but with a root CBSD score of 2 (Edward Kanju; personal communication). This classification is consistent with the data obtained in this report, and thus qualifies the two varieties.

Data generated from uniform yield trials established at four sites (Kaberamaido, Kamuli, Namulonge and Tororo) during the period 2013-2014, is presented in Tables 7 and 8. DMC of the candidate variety TZ/130 ranged from 31.8% at Kamuli to 36% at Tororo. On the other hand, variety MM06/0130 had DMC ranging between 33.1% at Kamuli to 38% at Tororo and Kaberamaido (Table 7). Fresh root yield ranged from 13.9 t/ha (MM06/0130) to 53 t/ha for TZ/130, while HI were greater than 0.4, with CBSD root necrosis incidence being <5% (Table 7).

True, fresh root yield varied across locations, but was generally above the national average of 13t/ha. This again demonstrates the gains that can be achieved through breeding, and thus qualify the release of the candidate varieties to increase and/or stabilize cassava production. HI is one of the agronomic traits that can substantially increase cassava productivity. The doubling of fresh root yield in cassava within a short period since the inception of cassava breeding in Latin America, was largely due to improvement in HI (Kawano et al., 2003). It's against this background that HI was considered as a key trait during the evaluations.

Data on other prevalent pests and diseases notably, cassava mosaic disease (CMD), cassava bacterial blight (CBB), and cassava green mite (CGM) are presented in Table 8. Severities of CBB on the candidate varieties were low (i.e., scores of 2). However, severities of CGM were moderate i.e., scores of 2.5 (Table 8). All the candidate varieties had no or few plants displaying CMD symptoms in the evaluated sites (Table 8).

It does suffice to note that during the multi-stage cassava selection scheme, reduction in number of genotypes evaluated at a specific stage provides an opportunity for increased precisions i.e. bigger plot sizes and higher number of replications at latter stages. During the first six years (2005 to 2011), selection was undertaken in single-row plots without replication, and the focus then was on CBSD and CBSD, which are traits of moderate to high heritability. However, during the period 2012 to 2014, evaluations and selections were done on a much reduced number of genotypes (i.e., no more than 30 clones), with relatively bigger plots (three to six-row plots), more replications (three to four replicates/site) and at different sites. All this was done to control errors, and/or to increase on the precisions associated with the data generated.

Cassava root form and quality has, and continues to play a decisive role in acceptability of a variety. In fact, it's increasingly becoming clear that desired root quality characteristics vary widely from one region to another and thus distinct quality characteristics may be required for different regions and/or markets. It's for this reason that we appraised the culinary qualities of the evaluated varieties (Table 6). The candidate varieties were competitive (in culinary traits) when compared to local varieties (Omo, Kanyali, Olepo and Njule) and/or other hugely popular varieties like TME 14 and TME 204. It is commonplace for outstanding cassava varieties to be multiplied and/or disseminated (after satisfactory evaluation) within specific localities, where evaluations have been undertaken without official release. This has been the case with TZ/130 and to a limited extent, with MM06/0130. We thus propose that these two varieties be officially released respectively as NARO-CASS1 and NARO-CASS2, as they are phenotypically distinct (Table 2 and Figure 1).

4.0 Conclusion and recommendations

The candidate varieties (TZ/130 and MM6/0130) are characterized by: 1) high levels of CMD resistance, 2) high fresh and dry root yields; 3) farmer preferred culinary root qualities and 4) CBSD tolerance. Hence, host plant resistance and/or tolerance combined with phytosanitation will make these varieties appropriate for cultivation in major cassava growing regions that are experiencing CBSD. These varieties come in timely to compliment previously released varieties notably, Nase 3, Nase 14, Nase 15, Nase 18 and Nase 19, which are phenotypically distinct from these two varieties. To fast-track the distribution of these varieties TZ/130 has been included as a variety for multiplication under the Cassava Seed System project; MM06/0130, will be included at a later stage when enough planting material has been generated.

5.0 References

Kawano, K., 2003. Thirty years of cassava breeding for productivity-biological and social factors for success. Crop Science 43:1325-1335.

Table 1: Agronomic performance of 33 surviving clones at Namulonge after six years of evaluation.

Clone	Harvest Index	CBSDi	Maximum CBSD root severity
Tz/100	0.5	100	5.0
Tz/105	0.5	23.2	2.5
Tz/110	0.4	44.7	5.0
Tz/122	0.3	72.4	5.0
Tz/138	0.6	42.9	4.5
Tz/146	0.4	67.9	3.0
Tz/147	0.4	59.2	4.0
Tz/150	0.3	9.8	4.0
Tz/160	0.4	2.2	1.5
Tz/163	0.3	13.8	3.5
Tz/164	0.4	50.0	5.0
Tz/170	0.4	4.2	1.5
Tz/173	0.5	20.0	5.0
Tz/175	0.3	42.2	3.5
Tz/177	0.3	12.6	2.5
Tz/178	0.3	12.3	4.0
Tz/42	0.4	7.7	2.0
Tz/46	0.2	100.0	5.0
Tz/61	0.4	95.7	5.0
Tz/62	0.4	17.1	5.0
Tz/64	0.3	90.5	5.0
Tz/65	0.3	10.0	4.0
Tz/66	0.3	69.3	5.0
Tz/67	0.4	32.7	2.5
Tz/69	0.3	51.5	4.0
Tz/71	0.4	95.5	5.0
Tz/73	0.4	28.8	3.0
Tz/74	0.4	20.9	3.0
Tz/75	0.5	77.1	4.0
Tz/80	0.5	2.9	1.5
Tz/88	0.4	61.8	5.0
Tz/90	0.5	11.4	3.0
Tz/92	0.5	17.1	5.0

CBSDRi = cassava brown streak root incidence; CBSDRs = cassava brown streak foliar severity. Data taken during 2012-2013. Clones were part of the batch of seed introduced from Tanzania in 2004. Clones TZ/130 and MM06/0130, were selected from this batch and subjected to multi-locational evaluations to generate sufficient data for their registration and/or official release.

Table 2: Selected descriptors of the candidate varieties TZ/130 and MM06/0130

Characteristics	MM06/0130 Descriptors	TZ/130 Descriptor
Colour of Apical leaf	Purplish_Green	Purplish_Green
Pubescence	No pubescence	No pubescence
Shape of central leaf	Lanceolate	Lanceolate
Petiole colour	Reddish_Green	Greenish-Red
Leaf colour	Light green	Dark Green
Leaf vein colour	Green	Green
Prominance of foliar scars	Intermediate Distance	Medium
Colour of stem cortex	Light Green	Light green
Growth habits of stem	Straight	Straight
Colour of end branches	Green	Green-Purple
Branching habit	Trichotomous	Dichotomous
Extent of root peduncle	Sessile	Pendunculate
Root shape	Cylindrical	Cylindrical
External colour	Dark Brown	Dark Brown
Colour of root pulp	White	Cream
Cortex :ease of peal	Easy	Easy
Texture of root epidermis	Rough	Intermediate
Root taste	Sweet	Sweet

Figure 1: Apical leaf colour, petiole colour, leaf colour, and stem characteristics of the candidate varieties TZ/130 (on left) and MM006/0130 (on right).

Table 3: Mean performance of cassava clones for selected agronomic traits at Kaberamaido during 2012-2013

Genotype	Yield (t/ha)	CBSDRi	CBSDRs	Harvest Index
09/FS13-3	23.9	85.3	4.4	0.6
09/FS13-6	27.0	63.5	3.8	0.7
09/FS15-3	25.1	12.6	2.3	0.6
09/FS27-22	21.9	13.7	2.4	0.6
09/FS27-6	16.3	10.4	2.1	0.5
09/FS3-15	23.6	52.8	3.6	0.7
09/FS3-17	19.5	6.9	1.7	0.7
09/FS31-7	22.0	10.1	3.4	0.7
09/FS33-2	20.8	26.4	2.3	0.6
09/FS43-27	18.3	4.1	1.6	0.6
09/FS53-23	26.2	12.3	4.0	0.7
09/FS53-26	28.4	33.9	4.4	0.6
09/FS8-7	24.7	24.0	2.3	0.7
09/FS9-2	19.1	32.1	3.7	0.5
09/FS9-7	22.5	41.9	3.6	0.7
09/FS9-8	16.7	4.1	1.4	0.5
Kabwa	15.5	57.3	3.2	0.4
MH04/300	25.1	11.8	3.2	0.7
MH04/Unknown	29.3	8.2	2.1	0.7
MH96/0982	26.0	21.8	2.9	0.7
MM06/0123	20.8	23.5	2.9	0.7
MM06/0128	22.2	7.4	1.8	0.7
MM06/0128 G	24.4	11.8	3.4	0.7
MM06/0128B	21.2	68.9	4.0	0.6
MM06/0128G	23.5	4.1	1.4	0.7
MM06/0128W	20.5	6.9	1.7	0.7
Tamale	14.0	6.9	1.7	0.5
Unknown XYZ	26.8	2.9	1.3	0.7
Nase 14	29.1	6.9	1.7	0.7
TZ/130	**32.7**	**2.9**	**1.3**	**0.7**
MM06/0130	**31.0**	**2.9**	**1.3**	**0.7**
P-Value	0.176	<0.00	0.002	0.006
Heritability	0.27	0.78	0.7	0.53

Data are based on three replicates, with genotype considered as random factors. Heritability is broad-sense on plot basis. CBSDRi = cassava brown streak root incidence; CBSDRs = cassava brown streak root severity. Last two rows present data on performance of candidate varieties TZ/130 and MM06/0130.

Table 4: Mean performance of cassava clones for selected agronomic traits at Namulonge 2012-2013

Genotype	CBSDRi	CBSDRs	Harvest index
09 FS 136	50.6	2.7	0.5
09 FS 317	23.3	1.4	0.5
09 FS 587	28.8	1.5	0.6
09 FS 87	47.4	2.5	0.4
09/FS-2722	32.5	1.6	0.4
09/FS-315	30.6	1.5	0.5
09/FS-332	49.6	1.9	0.4
09/FS-98	42.9	1.6	0.3
09/FS 136	33.5	1.8	0.5
09/FS 26-14	49.8	2.0	0.5
09/FS 315	24.7	1.4	0.5
09/FS 332	49.2	1.9	0.4
09/FS 5326	54.8	2.7	0.5
09/FS 87	33.5	1.7	0.4
09/FS 92	26.3	1.4	0.4
09/FS 98	28.8	1.6	0.5
09/FS133	64.5	3.5	0.5
09/FS26-14	52.4	2.1	0.6
09/FS2722	29.0	1.5	0.5
09/FS276	28.1	1.4	0.4
09/FS5326	31.7	1.7	0.5
09/FS9-2	40.6	1.7	0.4
09FS-133	60.1	3.2	0.4
09FS-2614	50.8	2.4	0.6
09FS-317	28.7	1.5	0.6
09FS-87	42.9	2.1	0.5
09FS-92	44.3	1.8	0.4
09FS 276	27.5	1.5	0.4
09FS 315	24.4	1.4	0.5
09FS/13-6	62.9	2.7	0.5
09FS133	63.8	3.5	0.6
09FS27-22	40.0	1.6	0.5
09FSS3-26	47.6	2.1	0.5
Nase 14	36.4	1.8	0.5
Kabwa	30.7	1.6	0.3
MH04-unknown	38.6	2.0	0.5
MH04/0300	38.5	2.1	0.5
MH96/0982	33.4	1.5	0.5
MM06/0123	28.0	1.4	0.6
MM06/0128	21.8	1.4	0.5
tamale	35.5	1.5	0.2
MM060130	**22.5**	**1.3**	**0.5**
TZ/130	**16.0**	**1.2**	**0.5**
P-Value	0.211	0.1	0.003
Heritability	0.47	0.7	0.8

Data are based on three replicates, with genotype considered as random factors. Heritability is broad-sense on plot basis. CBSDRi = cassava brown streak root incidence; CBSDRs = cassava brown streak root severity. Last two rows present data on performance of candidate varieties TZ/130 and MM06/0130.

Table 5: Mean performance of cassava clones for selected agronomic traits at Tororo during 2012-2013

Clone	Yield (t/ha)	CBSDRi	CBSDRs
09/FS-9-2	31.6	30.2	2.5
09/FS-92	29.7	20.7	2.5
09/FS/13-6	48.9	68.4	3.8
09/FS8-7	40.2	60.7	3.9
Kabwa	23.0	13.9	2.3
MH04/300	25.6	30.1	3.2
MH96/0982	40.8	28.8	3.2
MM04/Unknown	44.1	15.4	2.1
MM06/0123	27.3	34.8	3.4
MM06/0128B	29.4	15.4	2.1
MM06/0128G	45.2	15.4	2.1
MM06/0130	**38.2**	**7.5**	**1.6**
TZ/130	**43.6**	**11.6**	**2.3**
P-Value	0.178	0.057	0.061
Heritability	0.45	0.61	0.51

Data are based on three replicates, with genotype considered as random factors. Heritability is broad-sense on plot basis. CBSDRi = cassava brown streak root incidence; CBSDRs = cassava brown streak root severity. Last two rows present data on performance of candidate varieties TZ/130 and MM06/0130.

Table 6: On-farm evaluation of selected cassava varieties at four locations in Uganda during 2012-2013

Arua	Genotype	Yield (t/ha)	CBSDi	CBSDs	CBSDRi	CBSDRs	Cook taste
	Tz/130	47.5	0	1	0	1	3
	Omo	28	0	1	0	1	1
	Nase 14	36	0	1	1.2	2	1
	Nase 4	43.5	61	3.1	2.2	2.2	4
	TME 14	31.5	0	1	2	2	2
	TME 204	39.5	6.4	2	1.8	2	1
Hoima							
	Tz/130	46.5	0	1	0	1	2
	Nase 14	13.5	7.8	2	11.1	2.8	1
	Nase 4	2.5	100	3	25	2.2	3
	TME 14	5	40	2	0	1	1
	TME 204	27.5	23	2	7.1	2	1
	Kanyali	7	20	2	6.3	2	1
Lira							
	Tz/130	53	0	1	0	1	3
	Nase 14	53.5	0	1	0	1	1
	Nase 4	47.5	29	2	1.7	2	4
	Olepo	40.5	0	1	0	1	1
	TME 14	45.5	0	1	0	1	2
	TME 204	48	0	1	0	1	1
Nakasongola							
	Tz/130	27.5	4.7	2.2	5	2.7	4
	Nase 14	6.5	19.3	2	25	2.6	2
	Nase 4	5.5	45	3	36	2.3	5
	Njule	9.5	100	2	4.7	2.3	2
	TME 14	6.5	53.3	2	28	2.1	3
	TME 204	39	41.9	2	10	3	1

Data are based on three replicates, with genotype considered as random factors. CBSDi = cassava brown streak foliar incidence; CBSDs = cassava brown streak foliar severity; CBSDRi = cassava brown streak root incidence; CBSDRs = cassava brown streak root severity.

Table 7. Agronomic performance of candidate varieties under uniform yield trials established at four locations during 2013- 2014.

Location	Genotype	DMC	Yield T/ha)	Harvest Index	CBSDRi	CBSDRs
Kaberamaido	MH04/0300	37.0	7.4	0.5	28.3	1.8
	MM06/0130	38.0	13.9	0.6	3.7	1.1
	TZ/130	35.6	22.8	0.7	2.3	1.0
	NASE 14	36.2	22.2	0.5	12.5	1.4
Kamuli	MH04/0300	27.5	14.8	0.5	0.6	1.0
	MM06/0130	33.1	16.7	0.5	1.9	1.0
	TZ/130	31.8	28.9	0.4	1.9	1.0
	NASE 14	26.8	30.8	0.5	3.8	1.1
NaCRRI	MH04/0300		39.4	0.6	68.0	3.8
	MM06/0130		23.3	0.4	4.5	2.0
	TZ/130		55.6	0.5	3.9	2.1
	NASE 14		42.3	0.4	41.9	3.1
Tororo	MH04/0300	36.1	31.0	0.6	9.8	1.1
	MM06/0130	38.5	20.9	0.6	4.6	1.1
	TZ/130	36.0	53.3	0.6	0.2	1.0
	NASE 14	36.7	34.2	0.6	7.5	1.2

Means based on four replicates at Kaberamaido, Kamuli and Tororo, while at Namulonge based on two replicates data. DMC = percentage root dry matter content; CBSDRi = cassava brown streak root incidence; CBSDrs = cassava brown streak root severity.

Table 8. Reaction of candidate varieties to prevalent pests and diseases in the evaluation sites during the period 2013-2014.

Location	Clone	6CMDs	6CBSDi	6CBSDs	6CBBs	6CBBi	6CGMs
Arua	MH04/0300	1	26.6	3.0	1.5	18.2	2.5
	MM06/0130	1	0.0	1.0	2.0	5.6	2.0
	NASE 14	1	2.5	1.5	2.0	16.4	2.5
	TZ/130	1	0.0	1.0	2.0	49.1	2.5
Kaberamaido	MH04/0300	1	60.2	3.0	2.0	32.2	2.5
	MM06/0130	1	2.2	2.0	2.0	35.6	2.5
	NASE 14	1	6.2	2.0	2.0	38.6	2.5
	TZ/130	1	0.0	1.0	2.5	74.1	3.0
Tororo	MH04/0300	1	4.6	2.0	2.0	12.1	2.0
	MM06/0130	1	0.0	1.0	1.5	8.6	3.0
	NASE 14	1	24.2	3.0	2.0	15.4	3.0
	TZ/130	1	0.0	1.0	2.0	47.4	3.0
Kamuli	MH04/300	1	24.7	1.8			
	MM06/0130	1	0.0	1.0			
	TZ/130	1	0.7	1.3			
	Nase 14	1	2.4	1.5			
NaCRRI	MH04/300	1	27.1	2.5			
	MM06/0130	1	0.0	1.0			
	TZ/130	1	0.6	1.3			
	Nase 14	1	4.1	1.8			

Means based on four replicates. 6CBSDs = cassava brown streak foliar severity at six months; 6CBSDi = cassava brown streak foliar incidence at six months; 6CMDs = cassava mosaic disease severity at six months; 6CBBs = cassava bacterial blight severity at six months; 6CBBi = cassava bacterial blight incidence at six months; 6CGM = cassava green mite severity at six months; no data collected on CBB and CGM at Kamuli and Namulonge owing to the low pest and/or disease pressure.