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New Cassava (Manihot Esculenta Crantz) Varieties for MID and Low Land Agroclimatic Condition of Ethiopia

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Abstract
Cassava verity verification trial was conducted at different agroclimatic condition of Ethiopia (Jima on station and two farmers field, Areka on station and two farmers field, Dilla on station and two farmers field, and Sekota on station and two farmers field). Unfortunately the trials at Sekota were devastated by drought and were not evaluated by variety releasing committee. The rest were visited and approved to be released for further production. Accordingly two out performing candidate varieties were selected and officially released. The two selected varieties were AWC-1 (MM96/7151) and 191/0427(TMS 191/ 0427) which yielded more than 45 t/ha on both research managed and on farmer managed conditions. Among the candidates, AWC-1 yielded 51.5 and 46.7t/ha on station and on farmers field respectively. On average the yield was by far higher than the local and standard checks. The yield advantage of the candidate variety AWC-1(Hawassa-4) over the standard and local checks was 58 and 86% respectively. In the same way, 191/0427 yielded 48.4 and 37.6 t/ha on station and on the farmers field respectively. The yield advantage of the candidate variety was 38 and 63% over the standard check and local check respectively. Eventually the two varieties has given names which can easily be understood by farmers, processors, merchants, consumers and others, and popularization through pre-extension demonstration is being carried out at different locations in the country.
Keywords: Cassava, Candidate, Popularization, Wider production

Introduction

Cassava (Manihot esculenta Crantz) together with maize, sugar cane and rice constitutes the most important source of energy in the tropics. Native to south America (Olsen and Schaal 2001), cassava was domesticated about 50000 years ago and has since been extensively cultivated in the tropics and sub tropics of the continent (Bernando and Ceballos, 2012).

Cassava (Manihot esculenta Crantz) is grown by smallholder farmers in more than 100 tropical and subtropical countries. Thanks to its efficient use of water and soil nutrients, and tolerance to drought and sporadic pest attacks, cassava can produce reasonable yields, using few if any inputs, in areas with poor soils and unpredictable rainfall. The roots of cassava are very rich in carbohydrates, which makes them an important source of dietary energy. They can be consumed fresh after cooking, processed into food products, or fed to livestock. Cassava root starch can be used in a wide array of industries, from food manufacturing and pharmaceuticals to production of plywood, paper and bio-ethanol. In some countries, cassava is also grown for its leaves, which contain up to 25 percent protein. The global average yields have increased by almost 1.8 percent a year over the past decade, to 12.8 tons per hectare. With better crop and soil management, and higher yielding varieties more resistant to drought, pests and diseases, cassava could produce average root yields estimated at 23.2 tones (FAO, 2013).

Cassava was introduced into Africa from Brazil in the 16th century, can grow and produce reasonable returns even under very poor soil and climatic conditions. It has now become one of the continent's leading food crops, giving Africa a worldwide leader. (Nweke, 1992). Even if the introduction of the crop to Ethiopia is not well documented, it cultivation counted more than a century. But, it is mainly cultivated by small resource poor farmers on smallholding plots of land (Tesfaye et al., 2013). More over the bulk of its production situated in south, south western and western parts of the country and most of the varieties are low yielding, bitter type and containing high hydrogen cyanide (Anshebo, et al., 2004) .

The average total coverage and production of cassava per annum in Southern region of Ethiopia is 195055 hectares with the yield of 501278.5 tones indicating the average productivity of cassava in the country is not more than 25 ton per hectare (SNNPR, BoA, 2014), which is by far lower than the yield obtained by other tropical countries such as Nigeria, 35.00 tons per hectare per year (FAOStat, 2013)

To alleviate these problems a number of research activities focusing on crop variety improvement were conducted in different agro ecological locations and two out performing varieties were found and officially released in 2005 (MoA, 2005). But the genetic diversity for the widen options to the farmers is still very low. So that the national sweetpotato, cassava and other root crops research project in collaboration with regional and federal research center conducted intensive research activities and came up with high yielding, disease and insect

pest resistant varieties to be verified for further production. Hence, Four among the proposed four candidate varieties, two were officially released and increased the variety pool by two. Thus the objective of this paper was to highlight the natural characteristics of the released varieties and thereby to avail information for scientific and production communities.

Materials and Methods

The trial was conducted at different agro-ecological areas of the country: Hawassa, Areka, Sekota, Dilla and Jima Agricultural research centers. Planting of the candidate varieties was carried out in the aforementioned research centers and two farmers field around each of the center. The performance of candidate varieties at some of the research centers and farmers' field were damaged by manmade and natural calamities. So that harvesting and general recommendation were carried out from Areka, Jima, Dilla agricultural research centers and farmers in their vicinities.

Four candidate varieties were proposed for final release but trimmed to three as one of them was morphologically alike to the other one. From the remain three one is also failed to fulfill the requirement of the variety release procedures and finally two varieties were selected for eventual release. The candidate varieties were AWC-1, AWC-2, AWC-3 and I90/04270. Beside these one standard check (Qulle) and one farmers' variety (Local Check) were included for comparison. The candidate varieties were planted on 10mx10m single large plot by using the recommended 1m between rows and 1m between plants spacing. Data was taken from the middle 8 rows and 8 plants from each row i.e. from 64m2 harvestable plot. Yield and other agronomic performance data such stand count at emergence (SCAE), stand count at harvest (SCAH), percent of survival of the seedling(PS), marketable storage root yield in kilogram per plo (Mkgp), marktable storage root yield in ton per hectare (MTPP), unmarketable storage root yield in killogram per plot (Unmkgp), unmarketable storage root per hectare in ton (Unmtp), total storage root yield ton per plot (Tkgp), total storage root yield ton per hectare (TTpp), marketable root number (MRN), unmarketable root number (URN), total root number (TRN), average root number per plant (ARNPP), leaf yield per plot (LY) and average root and stem girth were recorded. In addition crop morphological description was made. Descriptive data analysis procedure was employed, by using Microsoft excel as the trial was not yet replicated. Pearson Correlation was employed to check characters associations by using SAS soft ware developed for window 9.

Result and discussion

On station performance of candidate varieties

Great differences, among the candidates were observed with reference to leaf weight, root girth, marketable and unmarketable yields, total storage root yield and others (Fig 1). In all the cases, except for TRN, URN and MRN, the performance of candidate AWC-1 and I190/04270 are comparable. The highest marketable root number(MRN), Root girth in centimeter (RG) and leaf yield were recorded by I191/04227. Even if the highest total root number per plot was obtained from AWC-2, its storage root yield and other agronomic performance is lower than both AWC-1 and 191/0427. Stand count at emergence, stand count at harvest, percent of seedling survival of all candidates and checks were almost the same. But the highest storage root yield (marketable, unmarketable and total) was obtained from the candidate variety AWC-1 followed by 191/0427 (table 2).

On farm performance

As shown in the fig. 2 the values recorded on SCAE, SCAH, PS, ARNPP and RG of all the candidates and standard checks were alike. The storage root yield and root numbers vary with candidates. The highest total root number was observed from the candidate 191/0427 followed by AWC-2 . In the same way the marketable root number of AWC-2 and 191/0427 was also similar. But the storage root yields (marketable, unmarketable and total) of AWC-2 was low compared with AWC-1 and I91/0427.

Average of both on station and on farm performance

The average performance of the candidate varieties AWC-1 and 191/0427 was by far higher than the standard and the local checks as shown in fig. 3. But they were overcome by the candidate variety AWC-2 with regard to MRN, URN and TRN despite their higher storage root yield (table 4). The average total storage yields of the candidate varieties AWC-1 and 191/0427 were 49.1 and 43 t/ha respectively (table 4). According to FAOSTAT estimates, the average yield in 2013 for cassava growing regions of the world was 12.6 t/ha, which is well below the results obtained by this study, under experimental conditions.

Yield and yield advantage of candidate varieties

The candidate varieties performed better than both the standard check (Qulle) and local checks (local farmers' variety) with regard to marketable, unmarketable and total yields (t/ha). As shown in table 2 the candidate variety AWC-1 out performed by 52.4 and 80.1% over the standard and the local checks respectively. The other variety TMS 191/ 0427 (Chichu) outperformed the standard and the local checks by 43.2 and 69.2% percent at research station. These varieties also showed great advantage over the checks at farmers' field as shown in table 3. In general the overall storage root yield of the candidate varieties, Hawassa-4, was yielded better than the

standard and the local checks by 58% and 86% percent respectively. While the other variety, Chichu, outperformed the standard check (Qulle) and the farmers variety (local check) by 38 and 63% respectively (table 4). The finding indicated that the candidate varieties were by far better than both the local and the standard checks at research managed fields and farmer managed plots.

Characters association

As indicated on table 5 stand count at emergence was positively and significantly correlated with stand count at harvest, leaf yield and stem girth. But negatively and significantly unmarketable yield, total yield, average number of main branch and root girth. Stand count at harvest was also positively and significantly correlated with percent of survival, leaf yield and stem girth but negatively and significantly correlated with average number of main branch and root girth. Percent of seedling survival was positively and significantly correlated with total root number. Likewise unmarketable storage root yield per hectare was positively significantly correlated with average number of main branch and root girth while negatively correlated with leaf yield and stem girth. Similarly marketable storage root yield per hectare was positively significantly correlated with total storage root yield and marketable root number. Total storage root yield per hectare was positively significantly correlated with marketable root number and average number of roots per plant. Marketable and unmarketable root numbers were positively and significantly correlated with total root number. While total root number was positively and significantly correlated with average number of storage root per plant. Average number of storage root was positively and significantly correlated with root girth and negatively significantly correlated with leaf yield and stem girth. Root girth was negatively significantly correlated with leaf yield and stem girth while leaf yield was positively and statistically significantly correlated with stem girth. Indicating that, positively and significantly correlated characters indirectly help to select clones for their storage root based on their morphological behaviors even in the early stage of the crop. The result obtained by this study is in line with the finding of Ntawuruhunga and Dixon (2010) who concluded that storage root number ,storage root size and storage root diameter were the main yield components contributing to yield enhancement in cassava. The current result also confirmed the findings of Kundy et al., 2014. They indicated that, the three characters, number of roots per plant had the highest contribution followed by plant height and stems girth, can possibly serve as basis for selection in cassava improvement.

Conclusion and Recommendation

Cassava is one of the most important crop with diverse important and use. It is being produced by a number of countries for its starchy root and succulent leaves. But, in Ethiopia, it is mainly cultivated by small resource poor farmers on smallholding plots of land from which the bulk of its production situated in south, south western and western parts of the country and most of the varieties are low yielding, bitter type and containing high hydrogen cyanide. The candidate varieties, however, are higher yielding and preferred by the farming communities. Their yield advantage over the local and the standard checks was very astonishing. They have also grater dry matter content which have positively correlated with the starch content that could be utilized by a number of factories as a row material. The candidate varieties also provide additional option for the diversification of alternatives for cassava producing farmers.

Thus the candidate varieties should be scaled up/out for wider popularization, dissemination and popularization. In line with variety popularization, Capacity building on utilization for home consumption and industrial purpose should be carried out by research and extension organization. More over seeking for earl maturing and low HCN containing varieties is crucial as all varieties released so far were late maturing (requires more 18 months for full maturity) that most of the farmers especially in cereal belt regions are refused to produce cassava crops despite its versatility, wider value and food security behavior.

It has been shown from this study that the storage root yield and other agronomic characters of the candidate varieties were greatly higher than the existing and farmers varieties. But, nutritional analyses, such as starch, fat, HCN, crude protein, mineral and vitamins content, were not included in this study as the required equipment were not functioning and/or costly. Thus this issue should be addressed for further consideration of the varieties.

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Table 1. Morphological characteristics of released varieties

Candidate variety	Morphological characteristics	Measurement or description
TMS 191/ 0427 (Chichu)	Petiole color	Red
	Leaf color	Light green
	Color of leaf vein	Reddish green in less than half of the lobe
	Orientation of petiole	Inclined upwards
	Color of stem cortex	Light green
	Color of stem epidermis	Light brown
	Color of stem exterior	Orange
	Growth habit of stem	Straight
	Color of end branches of adult plant	Green
	Branching habit	Dichotomous
	Shape of plant	Umbrella
	Mean dry matter content	39.26%
	Average Storage root yield	35.27t/ha
MM96/7151 (Hawassa-4)	Petiole color	Greenish red
	Leaf color	Light green
	Color of leaf vein	Green
	Orientation of petiole	Horizontal
	Color of stem cortex	Light green
	Color of stem epidermis	Dark brown
	Color of stem exterior	Green yellowish
	Growth habit of stem	Straight
	Color of end branches of adult plant	Green purple
	Branching habit	Trichotomous
	Shape of plant	compact
	Storage root yied	42t/ha
	Mean Dry matter content	46.81%
MM96/5280	Petiole color	Red
	Leaf color	Light green
	Color of leaf vein	Reddish green in less than half of the lobe
	Orientation of petiole	Inclined downwards
	Color of stem cortex	Light green
	Color of stem epidermis	Light brown
	Growth habit of stem	Straight
	Color of end branches of adult plant	Green
	Branching habit	Dichotomous
	Shape of plant	umbrella

Table 2: On station storage root yield (t/ha) of candidate cassava varieties and their yield advantage

Trt	Marketable yield t/ha			Unmarketable yield t/ha			Total storage yield t/ha	Yield advantage (%)	
	Dilla on station	Areka on station	Average	Dilla on station	Areka on station	Average		Over St.check	Over local check
AWC-1	54.1	41.1	47.6	0.1	7.7	3.9	51.5	52.4	80.1
AWC-2	31.5	23.4	27.5	0.0	9.8	4.9	32.4	-4.1	13.3
191/0427	44.6	50.8	47.7	0.1	1.3	0.7	48.4	43.2	69.2
Qulle	26.0	39.5	32.7	0.0	2.0	1.0	33.8	0.0	18.2
Local	25.0	30.3	27.7	0.0	1.8	0.9	28.6	-15.4	0.0
SD	12.7	10.5	10.3	0.0	3.9	2.0	10.3		

Table 3: Yield advantage of candidate varieties over the standard and local checks at farmers field

	Marketable yield t/ha					Unmarketable yield t/ha						Yield advantage	
Trt	G/Reketa	Chichu	Wormuma	Achura	Average	G/Reketa	Chichu	Wormuma	Achura	Average	Total yield t/ha	Over St.check	Over local check
AWC-1	29.1	59.4	48.3	44.8	45.4	0.0	0.1	3.3	1.97	1.3	46.7	64	93.0
AWC-2	29.8	25.4	38.8	39.1	33.3	0.0	0.1	2.8	3.05	1.5	34.8	23	43.8
191/0427	19.3	37.0	41.6	48.4	36.6	0.0	0.1	1.7	2.27	1.0	37.6	32	55.4
Qulle	12.1	33.0	19.4	45.0	27.4	0.0	0.1	0.8	3.28	1.0	28.4	0	17.4
Local	9.6	37.0	28.6	19.1	23.6	0.0	0.1	0.3	2.27	0.7	24.2	-15	0.0
SD	9.3	12.7	11.4	11.8	8.5	0.0	0.0	1.3	0.6	0.3	8.7		

Table 4: Average performance of candidate cassava varieties and yield advantage over the checks

	Average			Yield Advantage (%)	
Trt	Marketable yield t/ha	Unmarketable	Total	over standard	over local
AWC-1 (Hawassa-4)	46.5	2.6	49.1	58	86
AWC-2	30.4	3.2	33.6	8	27
191/0427(Chichu)	42.1	0.9	43.0	38	63
Qulle	30.1	1.0	31.1	0	18
Local	25.6	0.8	26.4	-15	0
SD	8.9	1.1	9.2		

Table 5: Correlation of candidate cassava storage root and other agronomic performances

	SCAE	SCAH	PS	MTPP	Unmtp	TTpp	MRN	URN	TRN	ARNPP	ANMB	RG	LY	SG
SCAE	1.00	0.92	0.18	-0.01	-0.50	-0.08	0.04	0.12	0.09	-0.35	-0.83	-0.72	0.73	0.66
		<.00	0.52	0.97	0.05	0.75	0.86	0.66	0.72	0.19	<.00	0.00	0.00	0.00
SCAH		1.00	0.54	0.07	-0.36	0.01	0.21	0.29	0.30	-0.25	-0.83	-0.76	0.60	0.56
			0.03	0.78	0.17	0.95	0.44	0.28	0.26	0.36	0.00	0.00	0.01	0.02
PS			1.00	0.29	0.14	0.30	0.49	0.42	0.57	0.15	-0.33	-0.36	-0.05	0.01
				0.29	0.61	0.26	0.06	0.10	0.02	0.57	0.22	0.17	0.84	0.97
MTPP				1.00	0.13	0.98	0.62	-0.06	0.41	0.48	-0.01	0.06	-0.05	0.03
					0.63	<.00	0.01	0.81	0.12	0.06	0.96	0.82	0.85	0.89
Unmtp					1.00	0.28	0.05	0.32	0.20	0.40	0.64	0.52	-0.88	-0.82
						0.29	0.85	0.24	0.47	0.13	0.00	0.04	<.00	0.00
TTpp						1.00	0.61	-0.01	0.43	0.53	0.08	0.14	-0.18	-0.09
							0.01	0.96	0.10	0.04	0.75	0.60	0.49	0.72
MRN							1.00	0.28	0.87	0.49	-0.30	-0.15	-0.03	-0.04
								0.30	<.00	0.05	0.27	0.58	0.90	0.88
URN								1.00	0.71	0.34	-0.21	-0.18	-0.11	-0.08
									0.00	0.21	0.44	0.50	0.68	0.76
TRN									1.00	0.53	-0.32	-0.20	-0.08	-0.07
										0.04	0.23	0.46	0.76	0.79
ARNPP										1.00	0.32	0.50	-0.35	-0.30
											0.24	0.05	0.19	0.26
ANMB											1.00	0.82	-0.73	-0.69
												0.00	0.00	0.00
RG												1.00	-0.68	-0.68
													0.00	0.00
LY													1.00	0.96
														<.00
SG														1.00

Note: SCAE(stand count at emergence), SCAH (stand count at harvest), PS (Percent of seedling survival), MTPP (Marketable yield ton per hectare), Unmtp (Unmarketable yield ton per hectare), TTpp (total storage root yield ton per hectare), MRN (Marketable root number), URN (unmarketable storage root number per plot), TRN (total storage root number per plot), ARNPP (average storage root number per plant), ANMB (average number of main branch), RG (storage root girth in cm), LY (leaf yield in kg/plot) and SG (stem girth in cm/plant)

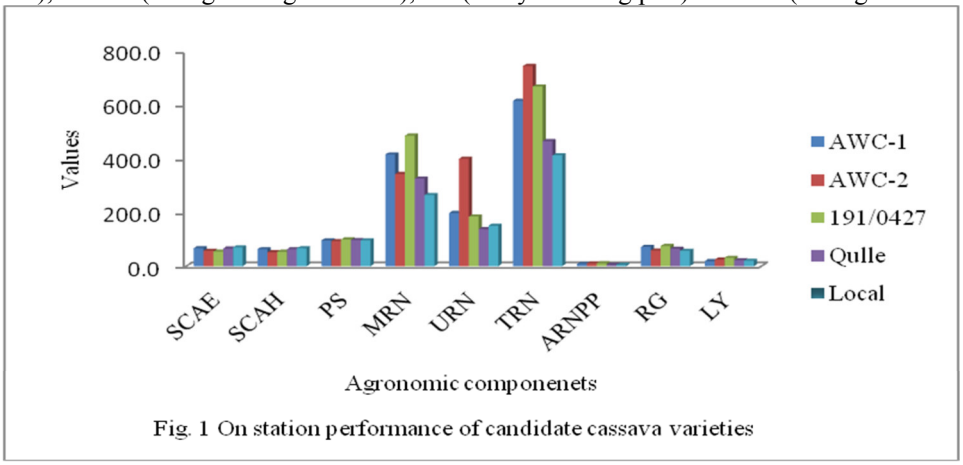

Fig. 1 On station performance of candidate cassava varieties

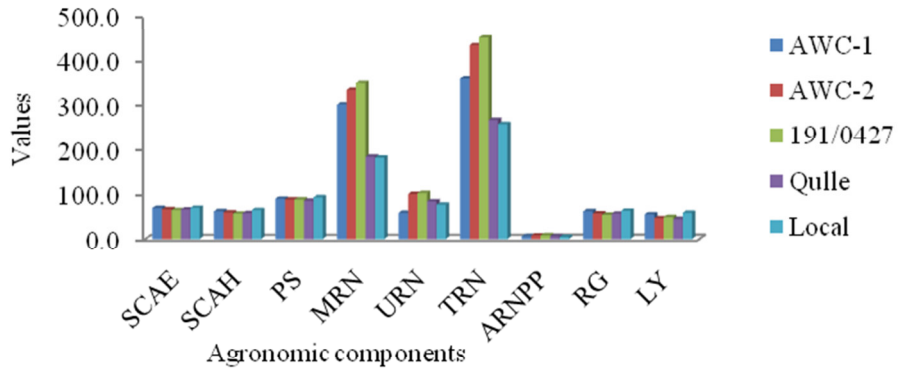

Fig. 2 On farm performance of candidate casava varieties

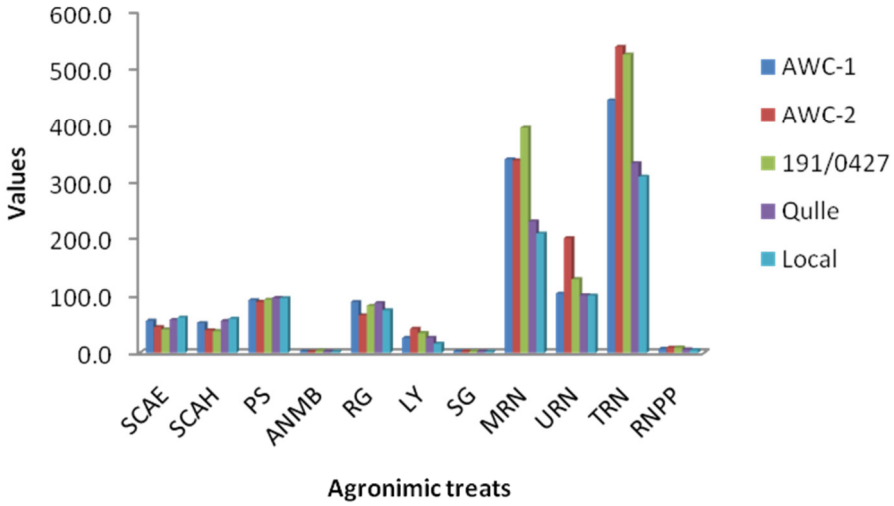

Fig. 3 Agronomic performance of candidate varieties

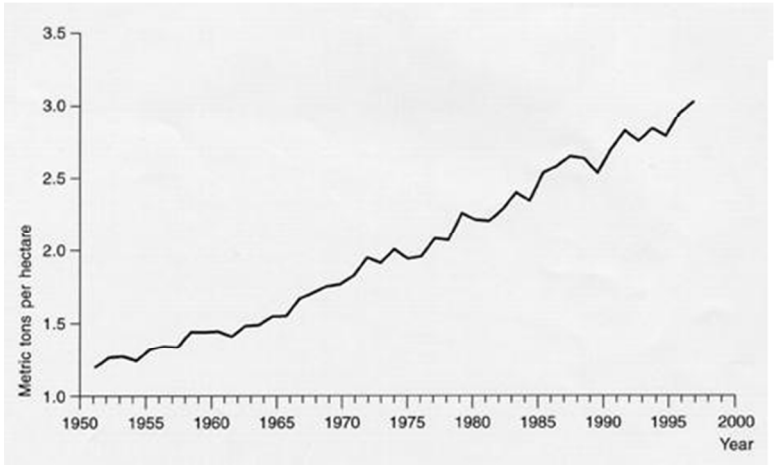

Figure 1. The Trend of Economic Development
Description for the above figure.