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Research Article

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Performance evaluation of cassava genotypes (*Manihot Esculenta* Crantz) at Gamo Zone, South Ethiopia

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ABSTRACT

Five cassava genotypes were evaluated over two consecutive years at two sites in the Gamo zone of the South Ethiopia Region to assess their overall root yield and identify the best-performing varieties. The experiment was arranged using a Randomized Complete Block Design with four replications. The F-test was carried out to examine the consistency of error variances, revealing that the error variances were not homogeneous; therefore, we analyzed the data separately for each site. The analysis of variance conducted over two years at the Dembile Otora site revealed significant differences between genotypes concerning yield and related parameters, with the exceptions being stem girths and root girth, where varieties showed notable differences, and stand count at harvest, which did not exhibit significant variation among varieties. The varieties Hawassa 4 and Chichu produced the highest total root yields per hectare, achieving 61.25 and 54.48 tons per hectare, respectively. In contrast, the variety Qulle produced the lowest total root yield per hectare, measuring 39.71 tons per hectare. The analysis of variance conducted over two years at the Fudale site revealed significant differences among genotypes regarding yield and related parameters, except stand count at harvest, where varieties exhibited significant differences. The variety Hawassa 4 had the highest total root yield per hectare (51.95 tons), followed closely by Chichu (43.66 tons). Hawassa 4 and Chichu had yield advantages of 55% and 30% respectively, over the local check, while the varieties Kello and Qulle showed no yield advantage compared to the local check. The findings indicate that both Hawassa 4 and Chichu achieved superior root yields relative to the local check at both tested sites. Consequently, these varieties are suggested for pre-extension demonstration within the area and similar agro-ecological zones.

KEYWORDS: Cassava, Genotypes, Varieties, Root yield, Yield-related parameters

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INTRODUCTION

Cassava, scientifically known as *Manihot esculenta* Crantz, is a perennial woody shrub that produces an edible root. It is found in tropical and subtropical regions around the globe. This crop can thrive on marginal lands where cereals and other crops struggle to grow. It is capable of withstanding drought conditions and can flourish in soils with low nutrient levels (Enete, 2009; Howeler *et al.*, 2013).

Cassava serves as the foundation for various products, including food items. It has been chosen as the top food security crop because it flourishes even during periods of intense drought (Abaca *et al.*, 2021).

In Africa and Latin America, it is primarily utilized for human consumption. Meanwhile, in Asia and certain areas of Latin America, it is also commercially used for producing animal feed and starch-based products (Howeler, 2012).

In Ethiopia, cassava is primarily grown by small-scale farmers with limited resources on small plots of land. It serves as both a food security crop and a source of income for households. Additionally, it is becoming an important raw material for various industries, including the production of starch, ethanol, waxy starch, bioplastics, glucose, bakery items, confectionery products, and adhesives (Tadesse *et al.*, 2013). In Ethiopia, cassava cultivation is predominantly found in the southern, southwestern, and western regions of the country.

The Southern region of Ethiopia has an annual total coverage and production of cassava reaching 195,055 hectares, yielding 501,278.5tons, which indicates that the average productivity of cassava in the country is below 25tons per hectare (SNNPR BoA, 2014). This yield is significantly lower compared to other tropical nations like Nigeria, which recorded an average of 35tons per hectare annually (FAOSTAT, 2013). Cassava is a key staple food crop that makes up a substantial part of the daily diet for people in southern Ethiopia. It is also a crucial source of

carbohydrates. This research aims is to assess newly developed cassava varieties for their yield and yield components and to propose the most productive cassava varieties for cultivation in study regions and areas with comparable agro-ecological conditions.

MATERIALS AND METHODS

Description of the Study Areas

The study was carried out at two sites in the Gamo zone, located in the South Ethiopia Region, during the growing seasons of 2020 and 2021. Dembile Otora is situated at a longitude of 37°19'00" E, latitude of 5°52'30" N, and an elevation of 1450 meters above sea level. The average annual rainfall in this area is 1300 mm, and the soil texture is classified as clay loam. In contrast, Fudale is found at a longitude of 37°15'85" E, latitude of 5°53'10" N, and at an altitude of 1920 meters above sea level. The mean annual rainfall there is 1350 mm, and the soil texture is classified as sandy loam.

Experimental Materials and Design

For this research, five cassava varieties were utilized, including four released varieties and one local check. The details of the varieties, including their source and release year, are presented in Table 1. The experimental design followed a Randomized Complete Block Design (RCBD) with four replications. Each plot measured 6 m x 4 m, resulting in a total area of 24 m^2, and consisted of four rows, with six plants per row, totaling 24 plants per plot. There was a spacing of 1.5m between plots and 2 m between blocks. Healthy cuttings were planted with a spacing of 1m between rows and 1 m between plants. Cultural practices, such as weeding, cultivation, and ridging, were carried out according to recommendations. To minimize border effects, data collection was focused on the two central rows of each plot.

Data Collected

The following data were collected from the two central rows and used for analysis.

Stand count at harvest, Average number of main branches, Stem girth (cm), Marketable root number per hectare, Marketable root weight (t/ha), Total root number per hectare, Total root weight (t/ha), Root length (cm), and Root girth (cm) were collected and analyzed.

Table 1: Cassava varieties used for the study

No.	Varieties	Source[1]	Year of release
1.	Hawassa 4	AwARC/SARI	2016
2.	Chichu	AwARC/SARI	2016
3.	Kello	AwARC/SARI	2005
4.	Qulle	AwARC/SARI	2005
5.	Local check	-	-

[1]AwARC/SARI=Awassa Agricultural Research Center/Southern Agricultural Research Institute

Statistical Analysis

Analysis of variance for root yield and other characteristics was conducted for each location using SAS software version 9.0 (SAS systems, 2002). The locations were treated as random effects, while the genotypes were treated as fixed effects. The F test was utilized to evaluate the homogeneity of error variances before performing the combined analysis across locations. A combined analysis of variance for two years was executed for each location concerning root yield and other characteristics using SAS software version 9.0 (SAS systems, 2002). For the factors that exhibited significant effects, mean comparisons were performed using the least significant difference (LSD) at a significance level of 5%.

RESULT AND DISCUSSION

The F test performed earlier to evaluate the uniformity of error variances indicated that the error variances are not homogeneous; therefore we cannot conduct a combined analysis of the data.As a result, we analyzed the data individually for each location.

Dembile Otora Location

The findings from the combined ANOVA conducted over two years at the Dembile Otora location indicated a highly significant difference ($P<0.01$) among the varieties concerning yield and yield-related parameters, except stem girth and root girth, which showed significant variations ($P<0.05$), and stand count at harvest, where no significant variation was observed among the varieties (Table 2). This study's outcomes were consistent with those reported by Tadesse *et al.* (2017), who found significant variation among cassava clones regarding yield and related factors.

The varieties Chichu and Kello exhibited the highest total root counts per hectare, with figures of 75,000 and 71,251, showing no statistically significant difference between them. On the other hand, varieties Hawassa 4 and Qulle demonstrated a non-significant number of total roots per hectare, as corroborated by local checks. The greatest total root yield per hectare came from the varieties Hawassa 4 and Chichu, producing 61.25 and 54.48 tons per hectare, respectively. Varieties Hawassa 4 and Chichu exhibited total root yield advantages of 27% and 14%, respectively, compared to the local check. The lowest total root yield per hectare was noted for the variety Qulle, which recorded 39.71 tons per hectare (Table 3). The highest total root yields from the varieties Hawassa 4 (61.25 tons per hectare) and Chichu (54.48 tons per hectare) significantly surpassed yields reported in many of the world's growing regions, especially in East Africa. According to FAOSTAT (2013), as referenced by Tadesse *et al.* (2017), the average yields in countries like India, China, Brazil, and Nigeria were 34.96, 24.55, 13.92, and 14.03 tons per hectare annually. In 2013, average storage yields reported in East African countries such as Kenya, Uganda, and Tanzania were 15.89, 12.02, and 7.50 tons per hectare, respectively. The local cultivar exhibited the longest root length

at 59.33 cm, while it recorded the smallest root girth at 23.35 cm. Varieties Hawassa 4 and Chichu had the largest root girth measurements at 26.78 and 25.05 cm, respectively (Table 3).

Fudale Location

The analysis of variance conducted over two years at the Fudale site revealed a highly significant difference ($P<0.01$) among varieties for yield and related parameters, except for the stand count at harvest, which showed significant variations ($P<0.05$) among varieties (Table 4). This finding aligns with Tadesse *et al.* (2017), who reported significant variations between cassava clones for yield and related parameters.

The highest total number of roots per hectare was observed in variety Kello (67,813), followed by Chichu and Qulle (64,688 and 63,542, respectively), with no statistically significant differences among them. The local check had the lowest total root count per hectare at 52,604. The highest total root yield per hectare was recorded for the varieties Hawassa 4 (51.95 tons/ha) and Chichu (43.66 tons/ha). The varieties Hawassa 4 and Chichu exhibited yield advantages of 55% and 30% over the local check, while the varieties Kello and Qulle did not show any yield advantages compared to the local check (Table 5). The total root yields from the varieties Hawassa 4 (51.95 tons/ha) and Chichu (43.66 tons/ha) significantly outperformed those reported from most cassava-producing countries globally, and particularly in East Africa. According to FAOSTAT (2013), as cited by Tadesse *et al.* (2017), the average yields from India, China, Brazil, and Nigeria were 34.96, 24.55, 13.92, and 14.03 tons per hectare per year, respectively. In 2013, the average storage yields from East African nations, including Kenya, Uganda, and Tanzania, were recorded at 15.89, 12.02, and 7.50 tons per hectare, respectively.

Table 2: Combined over-year ANOVA for mean squares of growth, yield, and yield -related parameters for five cassava genotypes grown at Dembile Otora in South Ethiopia during 2020 and 2021

Source of variation	DF	SCAH	ANMB	SG (cm)	MRNPH	MRWPH (t ha^{-1})	TRNPH	TRWPH (t ha^{-1})	RL (cm)	RG (cm)
Yr	1	22.5**	0.144^{ns}	41.41**	3705625193**	17531.81**	3705336641**	17264.025**	1747.68**	3.03^{ns}
Rep (Yr)	6	2.12^{ns}	0.261^{ns}	0.53^{ns}	173217596^{ns}	52.07^{ns}	173215153^{ns}	51.345^{ns}	68.20*	5.80 ^{ns}
Trt	4	3.16^{ns}	2.601**	3.68*	889305595**	587.28**	889317031**	570.842**	158.95**	15.10*
Yr*Trt	4	8.06**	0.877**	6.67**	468993049**	225.01**	468961264**	227.256**	26.95^{ns}	16.32*
Error	24	1.35	0.17	1.096	70468737	48.58	70462211	46.63	22.63	4.23
Mean		**10.8**	**2.06**	**8.68**	**62041.67**	**49.40**	**62042.04**	**49.56**	**52.26**	**24.62**
CV (%)		10.74	19.995	12.06	13.53	14.11	13.53	13.78	9.10	8.36

DF=Degree of freedom, SCAH=Stand count at harvest, ANMB=Average number of main branches, SG=Stem girth (cm), MRNPH=Marketable root number per hectare, MRWPH=Marketable root weight (t/ha), TRNPH=Total root number per hectare, TRWPH=Total root weight (t/ha), RL=Root length (cm), RG=Root girth (cm)

Table 3: Mean values of growth, yield and yield related traits of five cassava genotypes grown at Dembile Otora in South Ethiopia during 2020 and 2021

Genotypes	SCAH	ANMB	SG (cm)	MRNPH	MRWPH (t ha^{-1})	TRNPH	TRWPH (t ha^{-1})	RL (cm)	RG (cm)
Hawassa 4	11.13^{a}	1.60^{c}	9.13^{a}	52917^{b}	61.25^{a}	52917^{b}	61.25^{a}	49.83^{bc}	26.78^{a}
Chichu	11.00^{a}	1.73^{bc}	9.10^{a}	75000^{a}	54.48^{ab}	75000^{a}	54.64^{ab}	47.73^{c}	25.05^{ab}
Kello	10.75^{ab}	2.10^{b}	9.00^{a}	71250^{a}	43.87^{cd}	71251^{a}	44.19^{cd}	53.45^{b}	23.63^{b}
Qulle	9.75^{b}	1.85^{bc}	8.68^{a}	52083^{b}	39.71^{d}	52084^{b}	40.04^{d}	50.98^{bc}	24.28^{b}
Local	11.38^{a}	3.03^{a}	7.51^{b}	58958^{b}	47.68^{bc}	58958^{b}	47.68^{bc}	59.33^{a}	23.35^{b}
Mean	**10.80**	**2.06**	**8.68**	**62041.67**	**49.40**	**62042.04**	**49.56**	**52.26**	**24.62**
LSD	1.20	0.43	1.08	8662.80	7.19	8662.40	7.05	4.91	2.12

Means in the same column followed by the same letters are not significantly different at 5% level of significance. SCAH=Stand count at harvest, ANMB=Average number of main branches, SG=Stem girth (cm), MRNPH=Marketable root number per hectare, MRWPH=Marketable root weight (t/ha), TRNPH=Total root number per hectare, TRWPH=Total root weight (t/ha), RL=Root length (cm), RG=Root girth (cm)

Table 4: Combined over year ANOVA for mean squares of growth, yield and yield related parameters for five cassava genotypes grown at Fudale in South Ethiopia during 2020 and 2021

Source of variation	DF	SCAH	ANMB	SG (cm)	MRNPH	MRWPH (t ha^{-1})	TRNPH	TRWPH (t ha^{-1})	RL (cm)	RG (cm)
Yr	1	0.90^{ns}	3.08**	9.33**	35156250^{ns}	16690.90**	35156250^{ns}	16690.90**	2747.31**	205.66**
Rep (Yr)	6	2.25^{ns}	0.21*	1.69^{ns}	161151647**	56.71*	161151647**	56.71*	48.10*	9.76^{ns}
Trt	4	3.60*	1.28**	4.04**	267994873**	548.99**	267994873**	548.99**	119.68**	20.17**
Yr*Trt	4	0.65^{s}	0.56**	3.63*	421137145**	82.21*	421137145**	82.21	78.59**	5.82^{ns}
Error	24	1.13	0.08	0.90	24230322	21.43	24230322	21.43	13.72	4.57
Mean		**11.20**	**1.97**	**7.78**	**61812.50**	**39.38**	**61812.50**	**39.38**	**44.70**	**20.14**
CV (%)		9.47	14.73	12.18	7.96	11.76	7.96	11.76	8.29	10.61

DF=Degree of freedom, SCAH=Stand count at harvest, ANMB=Average number of main branches, SG=Stem girth (cm), MRNPH=Marketable root number per hectare, MRWPH=Marketable root weight (t/ha), TRNPH=Total root number per hectare, TRWPH=Total root weight (t/ha), RL=Root length (cm), RG=Root girth (cm)

Table 5: Mean values of growth, yield and yield related traits of five cassava genotypes grown at Fudale in South Ethiopia during 2020 and 2021

Genotypes	SCAH	ANMB	SG (cm)	MRNPH	MRWPH (t ha^{-1})	TRNPH	TRWPH (t ha^{-1})	RL (cm)	RG (cm)
Hawassa 4	11.25^{a}	1.68^{c}	8.26^{a}	60417^{b}	51.95^{a}	60417^{b}	51.95^{a}	44.08^{bc}	22.79$_{a}$
Chichu	11.13^{ab}	1.73^{bc}	8.38^{a}	64688^{ab}	43.66^{b}	64688^{ab}	43.66^{b}	40.96^{c}	20.34^{b}
Kello	10.13^{b}	1.80^{bc}	8.04^{a}	67813^{a}	32.57^{c}	67813^{a}	32.57^{c}	41.45^{c}	18.75^{b}
Qulle	11.63^{a}	2.01^{b}	7.58^{ab}	63542^{ab}	35.20$_{c}$	63542^{ab}	35.20^{c}	46.76^{ab}	19.53^{b}
Local	11.88^{a}	2.65^{a}	6.63^{b}	52604^{c}	33.51^{c}	52604^{c}	33.51^{c}	50.24^{a}	19.29^{b}
Mean	11.20	1.97	7.78	61812.50	39.38	61812.50	39.38	44.70	20.14
LSD	1.09	0.30	0.98	5079.70	4.78	5079.70	4.78	3.82	2.21

Means in the same column followed by the same letters are not significantly different at 5% level of significance. SCAH=Stand count at harvest, ANMB=Average number of main branches, SG=Stem girth (cm), MRNPH=Marketable root number per hectare, MRWPH=Marketable root weight (t/ha), TRNPH=Total root number per hectare, TRWPH=Total root weight (t/ha), RL=Root length (cm), RG=Root girth (cm)

The local variety exhibited the greatest root length at 50.24 cm, followed by the Qulle variety at 46.76 cm. The variety Hawassa 4 had the largest root girth at 22.79 cm, while the varieties Chichu, Kello, and Qulle did not demonstrate any advantage in root girth compared to the local check (Table 5).

CONCLUSION AND RECOMMENDATION

Among the cassava genotypes evaluated, Hawassa 4 and Chichu exhibited superior root yields compared to the local check at both Dembile Otora and Fudale sites. Varieties Hawassa 4 and Chichu showed yield advantages of 27% and 14% over the local check at the Dembile Otora location, and 55% and 30% at the Fudale location, respectively, while the varieties Kello and Qulle did not demonstrate any yield advantage over the local check at either site. Consequently, it is suggested that these varieties (Hawassa 4 and Chichu) be considered for pre-extension demonstration (PED) in this area, as well as in similar agro-ecological zones.

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