INTERNATIONAL JOURNAL OF RESEARCH AND SCIENTIFIC INNOVATION (IJRSI)
ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue III March 2026

Characterization of Cassava Cultivars Morphological and Agronomic Features for Compatibility with Mechanized Farming Practices in Nigeria

Henry Okolie[1]*, Iwuagwu C. Christian[1], Obidiebube A. Eucharia[1], Obasi C, Chiamaka[1], Umeh A. Ogechukwu[1], Jane Mbadianya[1], Anigbogu Gabriel[1] and John L. Chioma[1]

Department of Crop Science and Horticulture, Nnamdi Azikiwe University, P.M.B. 5025, Awka, Anambra State, Nigeria

***Corresponding Author**

DOI: https://dx.doi.org/10.51244/IJRSI.2026.1303000102

Received: 09 March 2026; Accepted: 16 March 2026; Published: 02 April 202

ABSTRACT

Objective. This study examined the diversity of improved cassava varieties using their morphological and agronomic characteristics to determine their compatibility with field mechanization and processing.

Materials and Methods. The Randomized Complete Block Design (RCBD) experiment was conducted in 2025 cropping season.The treatments were recently developed twenty (20) cassava genotypes and one local check.Using three replications, nine (9) stands of each genotype were planted at 1m x 1m spacing on 3m x 3m plots. The shoot morphologies were evaluated using their traits before and during harvest while their storage roots were sampled at 9 and 12 months after planting (MAP).

Results. showed that some of the tall cultivars (2.3 – 3.5m) UMUCASS 50 ,TMS 920057 and Local check have erect stems with cylindrical plant shape, while the remaining UMUCASS 39,32 and 54, have high dichomotous or trichomatous narrow angle branches which gave umbrella plant shape were all compatible with field mechanical operations like stem harvesting, leaves stripping and packing. In addition with TMS 980505,NR 87184 and NR 8082 they also have cylindrical/conical root shape storage roots that weighs (1.5 -11.33kg/plant) that were high in dry matter(15 – 64%) and starch(12 - 37%) which also made them compatible with mechanical processing.

Conclusion. UMUCASS 50, 39,32, 54,TMS 920057, 980505, NR 87184 , NR 8082 and the Local check have shoot morphological and storage roots agronomic characteristics that are compatible with field mechanization and processing. Provided that some of a given cassava genotype traits are known, we developed a comprehensive chart that shows the level of field and processing mechanization of any given cassava genotype.

Keywords: cassava genotypes,characterization,mechanization,morphology, compatibility.

INTRODUCTION

Although grown as an annual crop,cassava (*Manihot esculenta* Crantz) is a perennial woody shrub with edible roots, grown in tropical and subtropical parts of the world and the crop is gradually gaining a strategic position in world trade as a result of the efforts by various governments and the private sector in developing novel, value-added cassava-based products for human consumption and industrial uses (Dixon *et al.,* 2005, Oliveira and Miglioranza, 2014).

It gives stable yields even in the face of drought, low soil fertility, and low intensity management (Dixon *et al.,* 2005).Nigeria was rated the world's largest producer of cassava with an annual output of 59 million tonnes in 2017 (Otekunrin and Sawicka, 2017; Wossen *et al.*, 2017), It can be used in product of many types, such as food (abacha, fufu, tapioca, cassava flour and confectionery, sweeteners, glues, plywood, textiles, papers, and biodegradable products, also in the manufacture of monosodium glutamate and medicines, dry chips, and alcohol (IITA 2005). Considerable progress has recently been made in developing new high-yielding cassava varieties but this was not enough to significantly reduce production costs or increase competitiveness.

To compete in these markets, the costs of producing cassava must be kept as low as possible. The progress made recently in developing cassava varieties with high yield potential has helped improve the crop's productivity and competitiveness but the crop requires intensive labor, especially for planting and harvesting. Nigerian farmers are now less able to employ workers so full benefits of using improved inputs, such as stems, fertilizers, and herbicides in cassava production cannot be achieved without the use of improved tools or machines. (Tarawali, et al., 2013).

A two-row planter can plant 7–10 ha in one day, depending on the terrain. It is faster and 50% less expensive than planting by hand (Tarawali, et al.,2013). Cassava can also be harvested using a manual lifter and a motorized harvester. Cassava lifter can harvest up to 200 plants per hour and reduces the drudgery in lifting roots (Chamsing et al., 2012). The motorized cassava harvester used by large-scale farmers usually cuts, digs, and raises up soil containing the cassava root cluster (Chamsing et al., 2012).

A two row whole Stalk sugar cane harvester can cut, strip and pack cassava stems especially the erect and side branching cultivars. Models described by Ma et al., (2014) can conveniently handle cylindrical and umbrella shaped cassava cultivars stem harvesting, leaves stripping and packing with little modifications. Cassava mechanical planters, harvesters and root peelers can be bought locally in Nigeria (Tarawali et al.,2013). The effectiveness of these cost efficient machine depends on the roots and shoot morphologies of these cassava cultivars.

This project will identify some high-yielding and early maturing cassava genotypes and categorize them based on their shoot and root morphologies compatibility to field and processing operations using these affordable machines. It will also gear breeding efforts towards the development and improvement of these compatible cultivars.

MATERIALS AND METHODS

Experimental site:The experiment was carried out in 2025 cropping season at Awka, Nigeria. Awka is located within latitude 6^0 16'N and longitude 7^0 7'E with an altitude of 422m and an average rainfall of 1650mm to 1824 per annum, a mean minimum and maximum temperatures of 27^0C and 32^0C respectively and a relative humidity of 75-80%. The rainfall distribution is bimodal; between April and July and between September and November with a short break in August.

Experimental Materials:The are high yielding and improved planting materials that were sourced from the breeder seed field of the National Root Crops Research Institute (NRCRI) in Umudike,Nigeria.They include: UMUCASS 37,UMUCASS 39, UMUCASS 44, UMUCASS 45, UMUCASS46,UMUCASS47(GameChanger),UMUCASS50(BABA-70),UMUCASS 52(HEADMASTER),UMUCASS53(SECURITY),UMUCASS54(NO-HUNGER),NR8212,NR 8083,NR87184,TMS 98/0581,TMS 980505,NR-8082,TMS 920057,TMS 982123 and a Local check(Nwaopokopo) Egesi,(2023).

Experimental Design. A Randomized Complete Block Design (RCBD) experiment. Each plot of $9m^2$ contained 9 stands of each cultivar planted 1m x 1m in 3 rows. Each replication contained 21 cassava cultivars at $9m^2$ and measured 21m x 9m ($189m^2$). The field was replicated three (3) times. The total Experimental size with 1m walkways between plots and replications was $570m^2$.Samples was collected from plants in the middle rows to reduce boarder effects.

Agronomic Operations. After site clearing, the ridges were cultivated at 1m spacing's and cured dry poultry manure applied at 1kg per plot. The cultivars healthy cut stems of 15 cm long were planted in three rows at 1m x1m at 45^0 position on the ridge crests. Weedings and other post planting operations were done as need be.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue III March 2026

Agronomic parameters measurements and scoring: The shoot morphologies were evaluated using their traits before and during harvest while their storage roots were sampled at 9 and 12 months after planting (MAP).The grading was done on this wise based on Fukuda,et al.,(2010) scoring except where another author was stated:

a. plant height (cm) Measured vertical height from the ground to the top of the canopy. Expressed in cm.

b. Height to first branching (cm) Measured vertical height from ground to first primary branch. Zero = no branching.

c. Branching habit..Observed at the lowest or first branching.We recorded the most frequent occurrence on the plot.The scoring is:1. Erect/Side branching 2.Dichotomous 3.Trichotomous 4. Tetrachotomous.

d. Angle of branching. Measured at first primary branching (not side branches).Measured angles were later divide the angle by two.

e. Shape of plant. Recorded the most frequent occurrence on the plot.The scoring is:1 Compact 2 Open, 3 Umbrella .4 Cylindrical.

f. Leaf size:We measured the length and the widest part the middle leaf lobe(cm^2).

Yield parameters measurements and scoring: This was done at harvest to measure and score storage roots parameters.

a. Extent of root peduncle.This was done on main roots only and on the most frequent occurrence. The scoring is: 1. Sessile 2. Pedunculate. 3. Mixed

b. Root constrictions.We recorded the most frequent occurrence.The scoring is:

1. Few to none (3 or less), 2. Some (4-6) 3. Many(more than 6)

c. Root shape.We recorded the most frequent occurrence.The scoring is:

1. Conical (globular) 2. Fusiform 3. Cylindrical. 4. Irregular

d. Number of commercial roots per plant.We recorded the number of roots from three plants with length greater than 20 cm.

e. Weight and size of commercial storage roots (kg) per plant. The root length and diameter of these storage roots was determined using a vernier caliper while their weights were determined on a weighing scale. The scoring is:1. Very High yielding (≥5kg/plant) 2. High yielding 3.5 – 5kg/plant) 3.Moderately yielding (2-3kg/plant) 4.Low yielding (≤2kg/plant)

f. Storage Root Cluster Spread.This is used to evaluate their storage root cluster spread(geometry)and ease of uprooting which determines rate of storage roots damage.It was categorized them into:i. Directional spread.Where the all the basal and nodal storage roots are located only in the same direction with the planted stack (only obtainable in slant planted stacks) (Amponsah *et al.,*2017)..

ii. Radial spread .Where all the basal and nodal storage roots are located round the planted stack despite planting orientation (Amponsah *et al.,*2017).

g. Cortex ease of peeling.The ease of peeling of the roots was assessed on a scale of 3, with 1 denoting ‘easy to peel’ and 3 denoting ‘difficult to peel’ (Akingbala *et al.,* 2005). 1.Easy. 2 .Relatively easy.3. Difficult.

h. Commercial storage roots maturity. This was used to evaluate the storage root maturity(commercial dry matter accumulation) and categorize them into:

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue III March 2026

1. Early maturing (7 -11MAP), 2.Medium maturing (12-15MAP) 3.Late maturing (16-24MAP) Anikwe and Ikenganyia(2018).

Laboratory Data Analysis: Evaluation of dry matter and starch were done at 9 and 12 months after planting using the standard methods of the Association of Official Analytical Chemists (AOAC, 2005).

RESULTS

Table 1: Shoot Morphological Parameters at 9 MAP.

CULTIVARS	Harvest Index	AB	GT	HT	WCLft	LCLft
UMUCASS50	0.53	0.00	20.00	230.00	4.00	16.00
TMS 920057	0.54	0.00	29.00	306.00	5.00	20.00
UMUCASS 54	0.72	90.00	29.00	265.00	4.00	11.00
UMUCASS 39	0.55	110.00	33.00	353.00	5.00	18.00
TMS 980505	0.52	100.00	29.00	214.00	4.00	12.00
UMUCASS53	0.63	90.00	28.00	202.00	2.00	11.00
UMUCASS 46	0.52	80.00	16.00	154.00	4.00	16.00
UMUCASS 32	0.50	90.00	33.00	268.00	6.00	16.00
UMUCASS 37	0.78	130.00	21.00	235.00	3.00	13.00
UMUCASS52	0.62	100.00	24.00	153.00	3.00	17.00
NR87184	0.78	90.00	19.00	183.00	4.00	15.00
UMUCASS47	0.75	80.00	27.00	143.00	3.00	14.00
UMUCASS36	0.75	90.00	29.00	50.00	3.00	12.00
NR 8082	0.63	80.00	27.00	150.00	4.00	18.00
TMS98/0581	0.54	80.00	17.00	157.00	5.00	14.00
UMUCASS44	0.52	70.00	15.00	120.00	3.00	14.00
NR-8083	0.52	100.00	19.00	200.00	3.00	13.00
UMUCASS45	0.00	108.33	27.00	116.00	3.00	10.00
NR 8212	0.76	80.00	22.00	187.00	3.00	12.00
TMS 982123	0.62	90.00	25.00	145.00	3.00	15.00
Local check	0.64	0.00	21.00	210.00	4.00	15.00
LSD@5%	0.13	7.27	2.62	6.57	0.62	2.41

Key Notes: Harvest Index (HI), first branching angle (AB), stem girth(GT),plant height(HT), central leaflet width (WCLft), central leaflet lenght (LCLft)

The Harvest Index (HI) is the ratio of the economically valuable part of the crop to the total above-ground dry biomass of the plant. Harvest index analysis performed at 9MAP showed that UMUCASS 37 and NR87184 (0.78) had the highest although not significantly different from other 4 cultivars .The least came from UMUCASS 32 (0.50) which was significantly the same with other 8 cultivars.UMUCASS 37 had the widest first branching angle (130^0) while the least (90^0) were found in other 4 cultivars.The largest stem girth(33cm) was recorded in UMUCASS 39 and 32 while the least girth (15cm) came from UMUCASS 44 and 46.T he tallest cultivar, UMUCASS 39 (353cm) was significantly followed by TMS 920057 (306cm). UMUCASS 45 (116cm) had the shortest stem..UMUCASS 32 (6cm) had the largest central leaflet width(6cm) and followed by 3 other cultivars(5cm),while TMS 920057 had the longest central leaflet length(20cm)**.** and followed by 2 other cultivars(18cm) on table 1.

Table 2: Storage Roots Morphological Parameters at 9 and 12 Map

CULTIV ARS	WSRo.9 MAP	SRo.L 9MAP	SRo.D9 MAP	Pulp: Peel	No.SRo .9MAP	WSRo.1 2MAP	SRo.L1 2MAP	SRo.D1 2MAP	No.SRo.1 2MAP
UMUCA SS50	2.60	37.00	15.00	4.10	9.00	7.00	40.00	22.00	10.00

TMS 920057	3.80	50.00	14.00	3.10	11.00	4.00	36.00	23.00	6.00
UMUCA SS 54	1.60	28.00	15.00	4.10	4.00	6.20	33.00	21.00	5.00
UMUCA SS 39	6.00	51.00	18.00	3.00	9.00	8.67	62.67	21.67	10.00
TMS 980505	4.00	35.00	29.00	4.20	8.00	11.33	64.00	24.00	9.00
UMUCA SS53	1.70	26.00	16.00	2.40	7.00	7.00	51.00	19.00	7.00
UMUCA SS 46	1.70	28.00	13.00	3.60	5.00	4.50	44.00	18.00	7.00
UMUCA SS 32	2.60	39.00	15.00	3.50	5.00	9.30	66.00	21.00	6.00
UMUCA SS 37	2.90	39.00	15.00	3.30	8.00	4.40	46.00	20.00	5.00
UMUCA SS52	1.70	29.00	20.00	3.80	6.00	5.20	60.00	17.00	13.00
NR87184	6.10	35.00	15.00	3.50	13.00	7.00	39.00	17.00	10.00
UMUCA SS47	2.70	35.00	14.00	4.00	11.00	4.00	36.00	21.00	7.00
UMUCA SS36	3.00	56.00	11.00	2.80	8.00	5.00	20.00	17.00	17.00
NR 8082	2.50	40.00	14.00	4.00	8.00	6.80	44.00	20.00	14.00
TMS98/0 581	4.00	34.00	16.00	3.10	8.00	3.60	37.00	22.00	6.00
UMUCA SS44	0.30	18.00	13.00	3.00	2.00	1.50	34.00	14.00	11.00
NR-8083	1.50	16.67	12.00	2.40	3.00	2.00	62.00	11.00	5.00
UMUCA SS45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NR 8212	1.60	32.00	12.00	3.50	6.00	3.30	33.00	16.00	10.00
TMS 982123	1.80	40.00	12.00	2.80	8.00	4.00	48.00	15.00	10.00
Local check	3.00	65.00	20.00	3.50	3.00	3.50	42.00	12.00	9.00
LSD@5%	1.23	2.17	2.27	1.20	2.3	1.57	5.23	3.58	2.47

Keynotes: Weight of storage roots (WSRo.9MAP), Storage root length (SRo.L9MAP), Storage root diameter, Number of storage root, Weight of storage at 12 months Pulp:Peel,

At 9 MAP, NR 87184 (6.10kg) and UMUCASS 39 (6.00kg) had the largest root weight followed by 3 cultivars that have 3.5 – 4.5kg/plant yield (TMS 980505, TMS 980581and TMS 920057).About 2 cultivars had 3kg/plant yield.The least came from NR 8083 (1.5kg).The longest root came from local check (65cm) followed by UMUCASS 36 (56cm), the least came from), UMUCASS 44 (18cm).The thickest root was TMS 980505(29cm) followed by the local check and UMUCASS 52 (20cm).Pulp : peel ratio was statistically the same for in 5 cultivars(4), NR 8083(2.4) produced the least peel. NR 87184 produced the largest number of marketable roots (13cm) which was statistically followed by TMS 920057 and UMUCASS 47 (11cm), The least came from UMUCASS 44 (2cm). Table 4.2At 12MAP, TMS 980505 produced the highest marketable roots weight (11.33kg/plant), other 9 cultivars had the same grade A (Very high yielding) range of (≥5kg/plant),7 cultivars had grade B(High yielding) range (3.5 – 4.5kg/plant),2 cultivars had grade C(Moderately yielding) range(2.0 – 3kg/plant) while 1 cultivar UMUCASS 44 had grade D(Poor yielding) range(-2 kg/plant). UMUCASS 32 produced the longest root (66cm) which was significantly the same with TMS 980505 (64cm)). The shortest marketable roots(20cm) came from UMUCASS 36.(Table 2).The thickest root also came from TMS 980505

(24cm) and flowed by TMS 920057 (23cm), TMS 982123 produced the least (15cm). UMUCASS 36 produced the largest number of marketable roots (17) followed by NR 8082 (14),the least (5)came from 3 cultivars.

Table 3: Qualitative Architectural Traits.

CULTIVARS	Branching Type	Shape Of Plant	Root Cluster Spread	Root Shape	Ease of Peeling	Root Peduncle
UMUCASS50	1	4	1	3	2	1
TMS 920057	1	4	2	4	1	3
UMUCASS 54	2	2	1	1	2	3
UMUCASS 39	2	2	1	4	2	3
TMS 980505	3	3	1	1	1	3
UMUCASS53	2	2	1	3	1	3
UMUCASS 46	3	1	2	3	1	3
UMUCASS 32	2	2	1	3	1	1
UMUCASS 37	3	2	2	1	1	1
UMUCASS52	2	1	2	3	2	3
NR87184	3	2	2	3	2	3
UMUCASS47	2	2	1	3	1	1
UMUCASS36	3	2	1	1	1	1
NR 8082	3	2	1	4	2	1
TMS98/0581	2	2	1	3	2	1
UMUCASS44	3	2	1	3	2	1
NR-8083	3	2	2	3	2	1
(UMUCASS45	2	4	0	0	0	0
NR 8212	3	2	2	4	2	3
TMS 982123	2	2	2	3	1	3
Local check	1	4	2	3	1	3

Quantitative parameter of the cassava cultivars

Only three (3) cultivars that had cylindrical plant shape have erect stem with or without side branching, UMUCASS 50 and TMS 920057 had erect stems without side branching while the local check (Nwaopokopo) had erect stem with side branching. Three cultivars UMUCASS 39, TMS 980505 and TMS 9810581 had umbrella plant shape with high and narrow angle branches. while 15 cultivars with trichotomous low and wide branches had open and compact shapes. Most of the cultivars (11) had directional storage root cluster i.e nodal and basal roots are arranged in the same direction in relation to the mother stem while 9 cultivars had their arranged radial on the mother stem. Most of the cultivars (13) had cylindrical shaped storage tuber while 5 cultivars had irregular shaped storage tuber. Tuber ease at peeling was the same at 9 and 12 months after planting. 10 of the cultivars were easy to peel while 10 were relatively easy. 9 were sessile, the storage roots were directly attached to the mother stem and 11 had mixed (sessile and pedunculate) attachment of root to the mother stem (Table 3).

Table 4. Storage Roots Physio-Chemical Parameters At 9 And 12 Map.

CULTIVARS	%DM9M	%STH9M	%DM12M	%STH12M
UMUCASS50	26.47	21.98	44.44	31.96
TMS 920057	16.52	13.96	26.62	22.89
UMUCASS 54	15.85	13.51	29.52	25.67
UMUCASS 39	19.67	18.05	23.67	16.00
TMS 980505	41.91	37.32	33.79	30.15
UMUCASS53	21.86	17.71	38.94	29.98
UMUCASS 46	20.97	21.09	38.49	31.68
UMUCASS 32	25.60	21.25	24.14	20.32

UMUCASS 37	15.14	12.44	64.07	35.21
UMUCASS52	19.57	17.52	43.89	32.19
NR87184	23.53	20.26	30.40	20.82
UMUCASS47	22.24	19.85	44.33	32.82
UMUCASS36	16.87	13.44	34.45	28.88
NR 8082	29.24	24.53	46.26	35.10
TMS98/0581	15.31	12.50	45.34	25.10
UMUCASS44	17.53	14.18	44.44	31.96
NR-8083	26.39	21.77	26.62	22.89
UMUCASS45	0.00	0.00	29.52	25.67
NR 8212	15.76	13.75	23.67	16.00
TMS 982123	18.01	15.07	33.79	30.15
Local check	24.75	21.64	38.94	29.98
LSD@5%	3.07	1.94	38.49	31.68

Keynote: Dry matter content @ 9 MAP (%DM9M), 12 MAP (%DM12M), starch content @ 9 MAP (%STH9M), 12 MAP (%STH12M).

At 9 MAP TMS 980505 had the highest dry matter content (41.9%) followed by NR 8082 (29.24%).The least came from UMUCASS 37 (15.14%) which was not statistically different from 2 other cultivars. TMS 980505 also had the highest starch content (37.32%) also followed by NR 8082.UMUCASS 37 (12.44%) still scored the least. At 12MAP, UMUCASS 37 (64%) had the highest dry matter content though not statistically different from 10 other cultivars.The least came from TMS 92007(23%) which was not statistically different from 5 other cultivars. UMUCASS 37 (35.21%) also had the highest starch content (37.32%) also followed by NR 8082(35.10%) although not statistically different from 17 other cultivars.UMUCASS 39 and TMS 920057 (16%) scored the least (Table 4).

Table 5: Descriptors State of the Cultivars.

Traits Scoring	Branching Type	Shape of Plant	Root Peduncle	Root Shape	Weight of Roots @9MAP	Weight of Roots@12MAP	Storage Roots Cluster	Cortex Easy of Peeling	Roots Maturation @9MAP	Roots Maturation @12MAP
1 (Very compatible)	**3**	**3**	**9**	**4**	**5**	**17**	**10**	**10**	**5**	**17**
2 Moderately compatible)	**11**	**11**	**11**	**12**	**8**	**1**	**10**	**10**	**8**	**1**
3 (Not compatible)	**7**	**7**	**-**	**4**	**7**	**2**	**-**	**-**	**7**	**2**

Table 5 showed that about 3 cultivars had very compatible branching type which included 2 erect cultivars (UMUCASS50, TMS 920057) with out side branches and one(1) cultivar (local check) with side branches.Nine (9)cultivars with high dichomatous branching habit and two (2)cultivars (TMS 980585 and NR 8082) with high trichomatous branching habit that gives umbrella shape are moderately compatible while seven (7) cultivars that have relatively low and wide trichomatous branching habit that gives compact or open plant shape were not compatible with mechanical stem cutting and stripping. On root peduncle nine (9) cultivars were sessile and so very compatible while 11 cultivars were pedunculate. Four cultivars had globular root shape (TMS 980505 and Yellow flesh cultivars,UMUCASS 36.37 and 54)which are very easy to peel mechanically while 12 cultivars had cylindrical root shape which are relatively machine compatible. Only 4 cultivars had irregular shaped roots that are difficult to peel.Ten (10) cultivars Cortex Easy of Peeling were very compatible while ten (10) cultivars were moderately compatible. On Storage Roots Cluster,10 Ten (10) cultivars that have directional spread were very compatible while ten (10) cultivars that had radial that were moderately compatible.TMS 920057, TMS 980505,TMS98/6581,NR 87184 and UMUCASS39 produced very compatible storage root weight of 3.5 –

≥5kg/plant at 9MAP which also translates to early storage root maturation. About eight (8) cultivars were compatible,produced 2 – 3kg/plant storage root weight at 9MAP ,while seven(7) cultivars were not compatible. About seventeen (17) cultivars produced very compatible storage root weight of 3.5 – ≥5kg/plant at 12MAP while one (1) was moderately compatible(2 – 3kg/plant).About two (2)cultivars were not compatible((≤2kg/plant)About Overall Acceptability considering taste, colour, texture, flavor appearance, Three(3)cultivars, Local check,UMUCASS50 ,TMS 982123 were very compatible About seventeen (17)cultivars were acceptable and so moderately compatible.

Table 6. Cassava genotypes field and processing mechanization compatibility chart.

Provided that some of a given cassava genotype traits are known, the developed comprehensive chart below shows the level of field and processing mechanization of any given cassava genotype. The grading was done on this wise based on Fukuda,*et al.,*(2010) scoring except where another author is stated. .Evaluation of the storage root maturity(commercial dry matter accumulation) was done based on grading of Anikwe and Ikenganyia(2018).The ease of peeling of the roots was assessed on a scale of 3, with 1 denoting ‘easy to peel’ , 2 denoting ‘relatively easy to peel’ and 3 denoting ‘difficult to peel’ (Akingbala *et al.,* 2005).

Shoot morphology descriptors	**Very compatible**	**Moderately compatible**	**Not compatible**
1.Branching habit	1. Erect/Side branching	2.High Dichotomous 3. High Trichotomous	4.Low. Trichotomous 5. Low Tetrachotomous
2.shape of plant	4 Cylindrical.	3 Umbrella	1 Compact 2 Open
Storage roots morphology descriptors			
3.Root peduncle	1 Sessile	2 Pedunculate.	3.Mixed
4.Root constrictions	1 few/none	2 some	3 many
5.Storage root shape	1 Conical (globular)	3 Cylindrical	2 fusiform 4 Irregular
6.Weight of storage roots	1.Very High yielding(≥5kg/plant) 2.High yielding 3.5 – 5kg/plant)	3. moderately yielding(2-3kg/plant)	4. low yielding (≤ 2 kg/plant)
7.Storage roots cluster spread	1.Directional Spread Where the all the basal and nodal storage roots are located in the same direction with the planted stack(only obtainable in slant planted stacks).	2.Radial Spread. Where all the basal and nodal storage roots are located round the planted stack despite planting orientation	
8.Cortex ease of peeling	1 Easy	2 Relatively easy	3 Difficult
9.Commercial Storage roots maturation	1 Early maturing(7-11MAP)	2 Medium maturing(12-15MAP)	3 Late maturing(16- 24MAP)
Storage roots physiochemical descriptors			
10.Starch Content Percent	1. 30 – ≥35%	2. 20 - 29%	3. 19 – ≤ 15%

DISCUSSION

A Randomized Complete Block Design (RCBD) experiment was conducted at Awka Anambra State during 2025 cropping season to examine the diversity of improved cassava varieties using their morphological characteristics to determine their compatibility to field mechanization and processing.Shoot morphologies sampled at 9 MAP included the following traits: plant height, harvest index, height of the first branching, angle of branching, number of branches, branching type and plant shape. Some of the tall cultivars UMUCASS 50, TMS 920057, TMS 98/0581 and Local check have erect stems with cylindrical plant shape, while the remaining UMUCASS 39,32, 54,etc have high dichomotous or trichomatous narrow angle branches which gave umbrella plant shape. Generally, they all have long and wide storage roots that are high in dry matter and starch.

These cultivars are compatible with mechanical operations like stem cutting, leaves stripping and packing. According to Ceballos et al., (2011), Erect, non-branching types are often preferred by farmers because they facilitate cultural practices, enhance the production of stems (the vegetative planting material), and transport and storage of non-branched stems is easier. The long stems of non-branching types tend to retain their sprouting capacity for longer storage periods, thus it has become an important adaptive trait (Ceballos et al., 2011). A two row whole Stalk sugar cane harvester can cut,strip and pack cassava stems.Models described by Ma et al.,(2014) can conveniently handle cylindrical and umbrella shaped cassava cultivars with little modifications.

The relatively short cultivars have low first branching stems with wide angles and 3 - 4 levels of branching that produced open or compact plant shape. This was in line with the findings of Amarullah (2021) that cassava cultivars have highly varied shoot morphologies. Cassava varieties are generally distinguished from one another based on morphological characteristics such as leaf size and number, stem length and branching habit and tuber shape and colour (Chuasuwan,2017). Root morphological parameters sampled included: Storage roots length and diameter, roots shape and peel to pulp ratio,storage root cluster spread, number and weight of storage roots per plant. At 9 MAP, NR 87184 and UMUCASS 39 had the largest root weight followed by 3 cultivars that have 3.5 – 4.5kg/plant yield (TMS 980505, TMS 980581and TMS 920057). These cultivars were grouped as early maturing(7-11MAP) while at 12MAP, TMS 980505 produced the highest marketable roots weight (11.33kg/plant), other 9 cultivars had the same grade A (Very high yielding) range of (≥5kg/plant).The yields were in the range of the work of Karim and Akintayo (2021).

Pulp: peel ratio was statistically the same for in 5 cultivars.The pulp-to-peel ratios of the cassava varieties were between 2.07 – 3.96 range as reported by Karim and Akintayo (2021) . Tuber ease at peeling was the same at 9 and 12 months after planting. 10 of the cultivars were easy to peel while 10 were relatively easy. UMUCASS 39,50 ,54, TMS 980505, NR 8082, TMS 920057and local check that had compatible shoot morphologies also have compatible root morphological qualities. Dry matter content range from 15% in UMUCASS 39 to 42% in TMS 980505 at 9MAP, while at 12MAP, it ranged from 24% in UMUCASS 39 to 64% in UMUCASS 32.

The range was in line with the work of Karim and Akintayo (2021) who also worked on TMS 980505 at 9 MAP.The values obtained were relatively higher at 12MAP.Generally dry matter increases with maturity. The starch content range from 13% TMS98/0581 to 37% in TMS 980505 at 9MAP, while at 12MAP, it ranged from 16% in UMUCASS 39 to 35% in NR 8082.

The range was lower than Ikegwu et al. (2009) that noted 48.25 – 52.05% as the starch contents of 13 improved cassava cultivars studied. Age and genotypic differences can also contribute to variation in starch content. It should be noted that starch contents drop with maturity.

RECOMMENDATIONS

Cassava shows high genetic diversity, which is one of the main reasons for its wide adaptation across tropical and subtropical regions,this broad genetic diversity is expressed at morphological, agronomic, biochemical, and molecular levels.

UMUCASS 32, 39,50 ,54, TMS 980505, TMS 920057, NR 8082, NR 87184 and the local check that had compatible shoot morphologies also have compatible root morphological qualities**.** Provided that some of a given cassava genotype traits are known, the developed comprehensive chart shows the level of field and processing mechanization of any given cassava genotype.

Conflict of Interest: There is also no conflict of interest between the authors.

REFERENCES

1. Akingbala, J. O., Oyewole, O. B., Uzo-Peters, P. I., Karim, R. O. &Baccus-Taylor, G. S. (2005). Evaluating stored cassava quality in gariproduction.*Journal of Food, Agriculture & Environment, 3*(1), 75-80.
2. Amarullah , D. Indradewa , P. Yudono & B. H. dan Sunarminto, 2016. Photosynthetic Activity of Superior Varieties and Local Cassava (Manihot esculenta Crantz) Indonesia. Journal of Agricultural Science; Vol. 8, No. 8; 2016. doi:10.5539/jas.v8n8p194
3. Amponsah SK, Bobobee EYH, Agyare WA, Okyere JB, Aveyire J, King SR (2017). Mechanical Cassava Harvesting as Influenced by Seedbed Preparation and Cassava Variety.Appl. Eng. Agric. 30:391- 403.
4. Anikwe,MartinA.N.andEjike E. Ikenganyia(2018):Ecophysiology and Production Principles of Cassava (Manihot species) in Southeastern Nigeria.http://dx.doi.org/10.5772/intechopen.70828.
5. Association of Official Analytical Chemists (AOAC, 2005).
6. Cassava In Tropical Africa: A Reference Manual (1990). International Institute of Tropical Agriculture Ibadan, Nigeria.ISBN 978 131 041 3.
7. Ceballos, H.; Ramirez, J.; Bellotti, A.C.; Jarvis, A.; Alvarez, E. (2011): Adaptation of cassava to Changing Climates. In Crop Adaptation to Climate Change; Yadav, S., Redden, B., Hatfield, J.L., Lotze-Campen, H., Eds.;Wiley-Blackwell Publishers: Hoboken, NJ, USA, 2011; pp. 411–425.
8. Chamsing, A., A. Senanarong, S. Sngiamphongse, P. Sutthiwaree, Y. Ksaehancharpong, K. Wannarong, and P. Sangphanta. 2012. Research and development of a Cassava digger attached to 50 hp tractor. Agricultural Engineering Research Institute, Department of Agriculture, Proceeding of International Symposium on Agricultural and Bio-Systems Engineering for ASIA Sustainability: Opportunity and Channenge. Nong Lam University, Ho Chi Minh city – Vietnam, 29-30 March 2012.
9. Chuasuwan,C.(2017)Cassava Industry. Thailand Industry Outlook. Retrieved from https://www.krungsri.com/bank/getmedia/709bbaca-5132-40c2-970f-33253ecc5b50/IO_Cassava_2017_EN.aspx
10. Dixon AGO, OnyekaR. Bandy opadhyay, R.U. Okechukwu, andB. Bamkefa, TJ (2005) Distribution and status of bacterialblight and fungal diseases of cassava in Nigeria IITA.
11. Egesi, C.N. (2023) (Ed).NRCRI at 100. NRCRI Publications: National Root Crops Research Institute, Umudike,Abia State Nigeria.
12. Fukuda, W.M.G., C.L. Guevara, R. Kawuki, and M.E. Ferguson. 2010. Selected morphological and agronomic descriptors for the characterization of cassava. International Institute of Tropical Agriculture
13. IITA. (2013). Nigeria Releases Improved Cassava Varieties to Boost Productivity. News - 2013 archive. Retrieved from https://www.iita.org/news-item/nigeria-releases-improved-cassava-varieties-boost-productivity/
14. Ikegwu, O., Nwobasi, V., Odoh, M. & Oledinma, N. (2009). Evaluation of the pasting and some functional properties of starch isolated from some improved cassava varieties in Nigeria. African Journal of Biotechnology, 8(10), 2310-2315.
15. Karim Olayinka Ramota and Olaide Akinwunmi Akintayo (2021):Morphological And Chemical Characteristics Of Different Cassava Varieties In Relation To The Quality Attributes Of Their Gari (Roasted Fermented Cassava Grits). J Microbiol Biotech Food Sci / Karim and Akintayo 2021 : 11 (3) e2879. https://doi.org/10.15414/jmbfs.2879
16. Ma,S., M. Karkee, P. A. Scharf, Q. Zhang(2014)Sugarcane Harvester Technology: A Critical Overview.Applied Engineering in Agriculture Vol. 30(5): 727-739 727 © 2014 American Society of Agricultural and Biological Engineers ISSN 0883-8542 DOI 10.13031/aea.30.10696
17. Oliveira EJ, Filho OSO and Santos VS (2014).Selection of the most informative morphoagronomic descriptors for cassava germplasm.Pesq.Agr. Bras 49: 891-900. http://dx.doi.org/10.1590/S0100-204X2014001100008.
18. Otekunrin, O. A., and Sawicka, B. (2017). Cassava, a 21st century staple crop: how can Nigeria harness its enormous trade potentials? Acta Scientific Agriculture, 3(8), 194-202
19. Oyeyinka, S. A., Ajayi, O. I., Gbadebo, C. T., Kayode, R. M., Karim, O. R. & Adeloye, A. A. (2019). Physicochemical properties of gari prepared from frozen cassava roots. LWT - Food Science and Technology, 99, 594-599. https://doi.org/10.1016/j.lwt.2018.10.004 Phi

20. Paradis, E., and Schliep, K. (2019).ape 5.0: an environment for modern phylogenetics and evolutionary analyses in R. Bioinformatics, 35, 526–528
21. Peres-Neto, P. R., Jackson, D. A., and Somers, K. M. (2003). Giving meaningful interpretation to ordination axes: assessing loading significance in principal component analysis. Ecology, 84, 2347–2363
22. Prasad, S. 2005. Design and develop machine for digging and gathering cassava roots. Kasetsart University thesis, Department of Mechanical Engineering, Faculty of Mechanical Engineering, Kasetsart University, Thailand. (in Thai).
23. R Core Team. (2020). R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/
24. Tarawali,G., P. Ilona, I.A. Ojiako,C. Iyangbe, D.S. Ogundijo, G. Asumugha, and U.E. Udensi.(2013):A comprehensive training module on competitive cassava production. IITA, Ibadan, Nigeria.40 pp.
25. Wossen, T., Girma, G., Abdoulaye, T., Rabbi, I., Olanrewaju, A., Alene, A., Feleke, S., Kulakow, P., Asumugha, G., Abass, A. &Manyong, V. (2017).The Cassava MonitoringSurveyinNigeria. Retrievedfromhttps://www.iita.org/wpcontent/uploads/2017/The_Cassava_Monitoring_Survey_in_Nigeria.pdf