

**Original Article****Survey of cowpea (*Vigna unguiculata* (L.) Walp.) landrace germplasm for seed characterisation and virus disease symptoms in two agro-ecological zones of Northern Nigeria**

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ABSTRACT

Virus is a major biotic constraint of Cowpea (*Vigna unguiculata*) with significant damage to crop yield and grain qualities. A survey on cowpea fields across cultivating areas in two Northern agroecological zones of Nigeria was carried out to assess the prevalence and distribution of cowpea viruses as well as its impacts on seed morphological traits. Ten cowpea fields from five (5) local government areas of Kano and Niger States were surveyed for virus disease symptoms, and data were obtained on incidence as well as severity. Leaf samples were randomly collected from fields for confirmatory test and detection of viruses using enzyme-linked immunosorbent assay (ELISA). Symptomology observation revealed mosaic pattern, mottling, vein-banding, chlorosis and leaf deformation. The incidence varied from 21.74% to 96.23% at a sampled field in Niger (NG-MOK-008) and Kano (KN-AJG-003), respectively. The severity ranged from 5.22% at NG-MOK-008 to 40.25% at NG-BOS-005 in Niger State. A total of five (5) viruses were detected which includes; Cowpea mottle virus (CMV), black eye cowpea mosaic virus (BICMV), Cowpea aphid-borne mosaic virus (CABMV), Southern Bean Mosaic Virus (SBMV) and Cowpea mottle virus (CPMMV). Morphological characterisation of the seeds sampled revealed great variability in the seed traits with specific accession being favoured by different traits. Significantly ($P < 0.05$) highest seed length and width were recorded in accession NG-WUS-004 and KN-WRN-007 with the value of 1.40 cm and 0.62 cm, respectively. Qualitative characteristics of seed coat colour showed that White-Cream was most abundant among the accessions, followed by Light Brown while Red and Black were the least represented. The seed shape varied within and across the landraces with more than a shape being found in an accession and rhomboid being the most abundant shape among the accessions. Therefore, none of sampled field is totally immune again virus despite their diversity in the seed morphology.

Keywords: Accession, Cowpea, ELISA, Germplasm, Landraces and Seed Traits

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INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp.] is an important crop in sub-Saharan Africa (SSA) including Nigeria. Cowpea is one of the few crops that are commonly grown in mixtures or rotation with cereals because of its capability to fix atmospheric nitrogen into the soil [1]. Cowpea is extensively cultivated in the Savannah [2] regions of Western and Central African countries. However, the Centre of maximum diversity of cultivated cowpeas and landraces is found in West Africa in a region comprising the Sudan Savannah zone of Nigeria (at 4 million ha), having the largest area of cowpea cultivation. Most cowpeas are grown on the African continent, particularly in Nigeria and Niger, which account for 66% of world production. [3].

Cowpea plays an important role in the diet and economy of hundreds of millions of people in Africa and Asia. It is consumed singly or as a complement to cereal food crops such as rice and maize and its haulm is extensively fed to livestock in form of fodder [4]. Cowpea leaves and green pods are consumed as vegetables and the dried grain is used in many different food preparations. The crop is grown mostly for their edible beans, although the leaves, green seeds and pods can also be consumed, meaning the cowpea can be used as a food source before the dried peas are harvested [5]. Like other legumes, cowpeas are cooked to make them edible, usually by boiling. Cowpeas can be prepared in stews, soups, purees, casseroles and curries [6].

Despite the numerous nutritional benefits of cowpea, adaptation and tolerance to harsh conditions of the Northern Nigeria where it's highly cultivated, the crop is

generally grown as landraces over the years without directional selection beyond the environment and the farming system itself. Also, Nigeria has long standing reports of multiple important cowpea viruses and frequent mixed infections. Cowpea has been reported to be susceptible to over 140 viruses and about 20 of these viruses are known to have widespread distribution [7]. Infection by any virus induces about 80 % yield loss, and a total yield loss is associated with mixed virus infections. Recent regional update show changes in virus incidence and emergence spread of viruses highlighting that distribution can shift over time. However, most national surveys are old with many recent studies focusing on south west. There are weak up to date survey of viruses and strains of cowpea at present across the distinct Northern agroecological belts (Sudan, and sudano-Guinea transition). Low yield is also associated with a lack of improved genotypes for specific climate and ecology. Abiotic and biotic constraints, such as insect pests and diseases have led to the low yield potential 1,500 to 2,500 kg/ha across smallholder farmers [8]. However, local landraces have been known to contain useful alleles but remain poorly surveyed and under-utilised in breeding programs of the crop. Surveys, germplasm collection as well as characterisation of cowpea are potential sources of genetic variation relative to target traits and are important for developing a promising resistance variety in its breeding program. The exploitation of the genetic variation in the available landraces germplasm of cowpeas for various traits could contribute to the improvement of the crop and selection of elite genotypes. Thus, a germplasm collection, phenotypic

characterisation for seed and virus symptoms of representative set of cowpea landraces from two selected major production areas across Northern Nigeria (Niger and Kano) was carried out.

MATERIALS AND METHODS

Study location and field survey

The study was carried out in selected cowpea-growing communities within Kano and Niger State, Nigeria. The surveyed sites were selected based on cowpea production intensity, availability of traditional landraces and agroecological variation.

Germplasm Collection and Seed Collection

A total of 20 selected cowpea farms were sampled, comprising ten farms from each of state within the agro-ecological zone. The coordinates of each site will be captured using a Global Positioning System (GPS-4300; Ethrex Garmin, Taiwan). Cultivated landrace seed were identified and collected from two farms in 5 selected local government from each state. The collected landraces were given a unique accession number and packaged in moisture proof containers.

Field Disease Assessment

The selected farms were randomly sampled for virus disease symptoms by walking across a field in a "W" shaped path. At a regular spaced distance (30 steps), the total number of plants within a small area (10×10) foot as well as plants showing virus symptoms were counted and recorded. The process was repeated across the fields. The sampled plants with symptoms of virus infection and scored for disease severity using a 1 – 5-point scale according to Konaté *et al.* [9] as follows:

1 = No symptom on the topmost leaf surface; 2 = Mosaic on 10 – 30 % of the topmost leaf surface; 3 = Mosaic on 31 – 50 % of the topmost leaf surface; 4 = Mosaic on 51 – 70 % of the topmost leaf surface; and 5 = Mosaic on >70 % of the topmost leaf surface.

Data obtained were used to calculate the percentage incidence (PI) and disease severity index (DSI) of disease plants using the formula below

$$\text{Percentage Incident} = \frac{\sum(\text{Number of Diseased Plants})}{\text{Total Number of Plant Assessed}} \times 100$$

$$\text{Percentage Disease Index} =$$

$$\left(\frac{\sum(\text{Class Frequency} \times \text{Score of Rating Class})}{\text{Total Number of Plant Assessed} \times \text{Maximum Scale Value}} \right) \times 100$$

Furthermore, serological analysis was done on the sampled leaves using Antigen - coated plate ACP-ELISA method described by Kumar [10]. Symptomatic (virus-like symptom leaves) and asymptomatic (apparently healthy) leaves were collected from each sampled farm for virus identification. Sampled leaves were properly labelled and kept a ice-pack cooler for transportation and transferred to laboratory. The leaves samples were subjected to tests using antisera specific for Cowpea Aphid Borne Mosaic Virus (CABMV), Blackeye Cowpea Mosaic Virus (BICMV), Cowpea Mosaic Virus (CMV), Cowpea Yellow Mosaic Virus (CYMV), Cowpea Mottle Virus (CPMOV), Southern Bean Mosaic Virus (SBMV) and Cowpea Mild Mottle Virus. All absorbance of ELISA reactions were read at 405nm optical density (OD) after 1 hour and overnight using a 800 TS microplate reader. Samples were considered positive for virus

detection when the absorbance value were at least twice that of the mean for negative control.

Seed Morphological Evaluation

The collected accessions from the selected field were assessed both quantitative and qualitative traits. The seeds of each landrace were assessed using the procedures described by IBPGR [11] and Ikhajiagbe *et al.* [12].

Quantitative characteristics: The quantitative traits measured includes; seed length, seed width, seed thickness, 10-seed weight, and 20-seed volume. This was carried out using the methods described by Ikhajiagbe *et al.* [12]. Trait such as seed length, seed width and seed thickness were determined by measurement of 10 randomly selected seeds from each accessions using venire caliper. The dimensions measured were in

Table 1: Qualitative Characterisation of Cowpea Seeds

Traits	Descriptive key
Seed Coat	No Color, Eye 1, Eye 2, Holstein, Watson, and Full Coat
Seed Shape	1 kidney, 2 ovoid, 3 crowder, 4 globose, 5 rhomboid shapes
Eye pattern	0 absent, 1 very small, 2 kabba group (the eye fills the narrow groove all around the hilum and the body has some form of speckling and a blue hallow is found around the hilum), 3 narrow eyes (hilum ring. eye fills the narrow groove around the hilum and spills out of this grove in front of the hilum but for a short distance but has an indistinct front margin), 4 small eye, 5 Holsten group (i.e., the eye circles the back of the hilum in a narrow ring, widens at the sides and then extends the margin of the eye is very distinct), 6 Watson group (eye encircles the back of the hilum as a narrow ring, widens at the sides and spills over the non-micropylar end of the seed with an indistinct margin. The extra width at the sides of the hilum distinguishes this group from 3, narrow eyes)
Testa texture	1 smooth, 3 smooth to rough, 5 rough (fine reticulation); 7 rough to wrinkled
Testa Splitting	0 Absent; 1 Present (testa split exposing cotyledons)
Testa Attachment	0 Testa not firmly attached to seed; 1 Testa firmly attached to seed

Source: IBPGR [11]

cm and their average values were calculated and recorded. Determination of 10-seed weight was done by weighing 10 randomly selected seeds with a high-precision SF-400C weighing scale. Water displacement method was used to assess 20-seed volume. Randomly selected 20 seeds of each landrace were added to a mixture solution of 50mL; 95% ethanol and 5% water in a 100mL measuring cylinder. The volume of fluid displaced was taken as the volume of the seed.

Qualitative characteristics: The qualitative traits were assessed visually and scored by nominal codes as presented in standard descriptor for cowpea by the IBPGR [11]. The qualitative traits assessed were seed coat, seed shape, eye color, eye pattern, testa texture, testa splitting, and testa attachment as described by Herniter *et al.* [13] and Ikhajiagbe *et al.* [12].

Data analysis: Counted data disease incidence and severity were expressed as the percentage of the total plant assessed. Quantitative data obtained were pooled for one-way analysis of variance to test for significant differences among the accessions at $p \leq 0.05$ while Duncan's multiple ranged test (DMRTs) post hoc test was used to separate the mean where there were differences using SPSS version 24 statistical package.

RESULTS

Germplasm, Symptomology and Disease Incidence and Severity

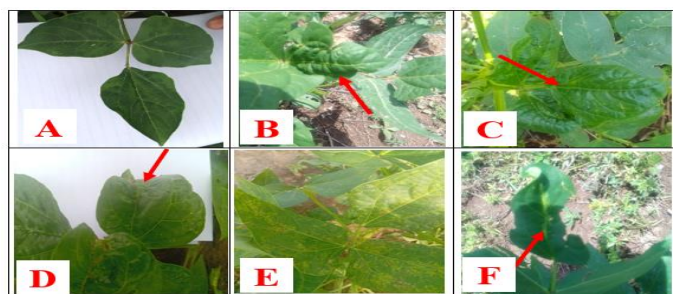
A total of 20 landraces were collected from 10 local government and 20 villages and accession number assigned (Table 1). Visual examination of all the assessed field indicated that all the landraces display foliar symptoms of virus infection at varying degrees. The disease symptoms display varied from mosaic pattern, mottling, chlorosis, vein banding and distortion of leaves (Plate I). Analysis of the collected leaves sampled using ELISA

revealed detection of one or more viruses in a single sample. A total of five (5) viruses were detected which includes; Cowpea mottle virus (CMV), black eye cowpea mosaic virus (BICMV), Cowpea aphid-borne mosaic virus (CABMV), Southern Bean Mosaic Virus (SBMV) and Cowpea mottle virus (CPMMV). Cowpea Yellow Mosaic Virus (CYMV) was not detected in all the accessions (Table 2).

Disease incidence and severity evaluation of the sampled field revealed that none of the landraces cultivated by the farmers in totally immune to virus. The disease incidence showed in variation in percentage infected plants from farm-to-farm with a ranged value of 21.78% to 96.23% in NG-MOK-008 and KN-ATG-003. The result of disease severity revealed that highest severity effects of the viruses was recorded in NG-BOS-005 farm with the value of 40.25% and the lowest of 5.22% was detected at NG-MOK-008 accessions farm. The severity score varied from farm to farm with the maximum score value of 4 using a rating scale of 5 (Table 2).

Table 2: Accession Number, Local Government Area, Village and Location of Study Area

Accession	LGA	Village	Latitude	Longitude
NG-SHR-001	Shiroro	Kuta	9.975370	6.710636
NG-SHR-002	Shiroro	Galkogo	10.02896	6.825642
NG-WUS-003	Wushishi	Akare	5.907850	5.907840
NG-WUS-004	Wushishi	Tungan Kawo	9.680042	6.110000
NG-BOS-005	Bosso	Garatu	9.543642	6.478276
NG-BOS-006	Bosso	Maikunkele	9.625038	6.415374
NG-MOK-007	Mokwa	Ja'agi	9.249799	5.042262
NG-MOK-008	Mokwa	Rabba	9.354797	5.107522
NG-KON-009	Kontagora	Kawo	10.42226	5.54582
NG-KON-010	Kontagora	Tungan Wawa	10.27008	5.39724
KN-TDW-001	Tugun Wada	Yaryasa	11.354157	8.307542
KN-TDW-002	Tugun Wada	Dankade	11.25000	8.40000
KN-AJG-003	Ajingi	Gurduba	12.021875	8.999473
KN-AJG-004	Ajingi	Chula	11.989550	8.967110
KN-BCH-005	Bichi	Muntsira	12.189276	8.222834
KN-BCH-006	Bichi	Kyauta	12.205895	8.327882
KN-WRW-007	Warawa	Garun Dau	11.802264	8.828425
KN-WRW-008	Warawa	Katarkawa	11.946473	8.822444
KN-DWK-009	Dawakin Kudu	Tsakuwa	11.791949	8.645025
KN-DWK-010	Dawakin Kudu	Jido	11.921737	8.652455



A: Mosaic pattern, B – D: mottling of leaves; vein banding and leaf deformation. E: severe systemic chlorosis and necrosis, mottling with leaves F: Vain clearing and yellowing

Plate I: Field Symptoms of Cowpea Leaves Infected by Viruses

Table 3: Viruses and Viral Disease Indices of Surveyed Cowpea (*V. unguiculata*) Farms from Two State in Northern Nigeria

Accessions	Disease Incidence (%)	Severity (%)	Score range	BCMV	CMV	CYMV	SBMV	CABMV	CPMMV
NG-SHR-001	74.12	33.18	1-4	3.36	0.52	0.19	1.20	1.24	2.37
NG-SHR-002	92.86	30	1-3	3.35	0.40	0.43	0.50	0.62	1.46
NG-WUS-003	73.47	25.31	1-4	3.26	0.40	0.18	0.39	0.49	1.02
NG-WUS-004	71.23	25.75	1-3	2.50	0.39	0.17	2.17	0.78	0.75
NG-BOS-005	86.25	40.25	1-3	3.29	0.50	0.19	1.77	2.24	1.97
NG-BOS-006	76.53	31.22	1-4	2.86	0.43	0.15	0.05	1.73	1.06
NG-MOK-007	69.09	27.27	1-3	2.76	0.42	0.13	2.33	1.94	0.91
NG-MOK-008	21.74	5.22	1-2	2.66	0.42	0.10	0.61	2.16	0.76
NG-KON-009	77.78	16.67	1-2	2.56	0.41	0.08	0.89	0.28	0.61
NG-KON-010	82.46	22.81	1-2	2.46	0.41	0.05	1.17	2.60	0.46
KN-TDW-001	83.78	29.19	1-4	2.37	0.44	0.02	0.38	2.81	1.31
KN-TDW-002	76.19	28.33	1-3	2.27	0.39	0.00	2.11	1.03	0.16
KN-AJG-003	96.23	33.21	1-3	2.17	0.39	0.03	1.01	3.25	1.01
KN-AJG-004	85.71	30	1-3	2.07	0.38	0.06	1.17	0.07	2.14
KN-BCH-005	88.16	37.63	1-4	1.97	0.38	0.08	0.50	3.68	0.59
KN-BCH-006	66.67	40	2	1.88	0.57	0.11	1.30	3.90	2.49
KN-WRW-007	54.65	22.09	1-4	1.78	1.07	0.14	0.09	1.12	0.59
KN-WRW-008	71.62	23.24	1-3	1.68	0.36	0.16	1.04	2.34	0.74
KN-DWK-009	71.01	20.29	1-3	1.58	0.46	0.19	0.39	0.55	0.89
KN-DWK-010	64.63	27.07	1-4	1.48	0.39	0.22	0.63	2.77	1.04
Disease	-	-	-	3.62	3.28	2.55	3.18	3.17	2.71
Healthy	-	-	-	0.61	0.19	0.24	0.19	0.22	0.23
Buffer	-	-	-	0.30	0.19	0.15	0.15	0.22	0.21

Reading at OD*405 at Overnight Reading

NG- Niger State and KN - Kano State, Cowpea mottle virus (CMV), black eye cowpea mosaic virus (BICMV), Cowpea aphid-borne mosaic virus (CABMV), Southern Bean Mosaic Virus (SBMV), Cowpea Yellow Mosaic Virus (CYMV) and Cowpea mottle virus (CPMMV)

Seed Quantitative Characterisation

The results of quantitative characters showed great variation among the seeds accession collected. Significant variation was observed in seed length with the longest seed value of 1.40 cm obtained in NG-WUS-004 and least in KN-DWK-010 with the value of 0.29 cm. These values are significantly different from one another and from the values of all other accessions. Similarly, KN-WRW-007 had the highest seed width with the value of 0.62 cm while KN-DWK-010 had the least of 0.29 cm. This shortest width value (0.29 cm) is not significant to the value of 0.30 cm recorded in KN-BCH-005 (Table 4). The seed thickness ranged from 0.30 - 0.68 cm with the lowest and highest values recorded in

accession NGBOS-006 and KN-WRW-007, respectively. The highest value obtained in KN-WRW is not significantly different from the value of 0.67 cm recorded in KN-DWK-009. For seed weight, significantly highest weight of 2.95 g was recorded in NG-WUS-004 and the lowest of 0.98 g in KN-DWK-010. This highest and lowest value were significantly different from one another and from the value of all other accessions. Volume of 20 seeds sampled varied significantly with KN-AJG-008 having highest volume of 6.33 ml³ and NG-KON-009 had the least with volume of 1.33 ml³. This lowest value is not significantly different from the value of 1.60 ml³ recorded in KN-DWK-010 but differed from the value of all other accessions (Table 4).

Table 4: Quantitative Characterisation of Cowpea (*V. unguiculata*) Landraces from Cultivated State in Northern Nigeria

Genotype	Seed Length (cm)	Seeds Width (cm)	Seed Thickness (cm)	10 Seeds Weight (g)	20 Seed Volume (cm ³)
NG-SHR-001	1.39±0.06fg	0.44±0.07abcd	0.49±0.05abc	2.73±0.13hij	4.67±0.33hi
NG-SHR-002	1.32±0.05defg	0.36±0.05ab	0.42±0.06ab	2.76±0.08hij	5.33±0.33ij
NG-WUS-003	1.26±0.05defg	0.43±0.10abcd	0.46±0.06ab	2.82±0.04ij	6.01±0.00jk
NG-WUS-004	1.40±0.08g	0.48±0.05abcd	0.38±0.05ab	2.95±0.10j	3.67±0.33efg
NG-BOS-005	1.39±0.05fg	0.56±0.14bcd	0.55±0.05bc	2.62±0.10hi	5.33±0.33ij
NG-BOS-006	1.23±0.05de	0.35±0.06ab	0.30±0.05a	1.84±0.12ef	3.33±0.33def
NG-MOK-007	1.20±0.02d	0.37±0.06abc	0.49±0.05abc	1.45±0.06bc	3.33±0.33def
NG-MOK-008	1.21±0.03d	0.51±0.06abcd	0.51±0.06bc	1.73±0.05cd	4.33±0.33gh
NG-KON-009	1.22±0.04d	0.42±0.07abcd	0.49±0.06abc	1.32±0.02b	1.33±0.33a
NG-KON-010	1.33±0.05defg	0.44±0.07abcd	0.51±0.07bc	2.08±0.04g	4.33±0.33gh
KN-TDW-001	1.29±0.05defg	0.36±0.05ab	0.54±0.05bc	1.86±0.03efg	4.00±0.00fgh
KN-TDW-002	1.25±0.04defg	0.48±0.06abcd	0.50±0.06bc	1.74±0.04cd	3.00±0.00cde
KN-AJG-003	1.24±0.0def	0.47±0.06abcd	0.52±0.05bc	2.54±0.01h	6.33±0.33k
KN-AJG-004	1.38±0.04efg	0.33±0.06ab	0.54±0.05bc	2.03±0.09fg	4.00±0.00fgh
KN-BCH-005	1.23±0.03de	0.30±0.07a	0.42±0.07ab	1.62±0.13cdf	3.00±0.00cde
KN-BCH-006	1.20±0.03d	0.40±0.06abcd	0.54±0.07bc	1.74±0.19cd	4.33±0.33gh
KN-WRW-007	0.84±0.02b	0.62±0.01d	0.68±0.01c	1.57±0.02cd	2.40±0.24bc
KN-WRW-008	0.77±0.01ab	0.40±0.00abcd	0.40±0.01ab	1.25±0.08b	2.67±0.21cd
KN-DWK-009	1.00±0.05c	0.61±0.00cd	0.67±0.04c	1.63±0.01cdf	3.00±0.32cde
KN-DWK-010	0.67±0.01a	0.29±0.02a	0.37±0.01ab	0.98±0.01a	1.60±0.24a

Means with the same letter(s) within a set of treatment column are not significantly different at $p \leq 0.05$ using DMRTs

Qualitative Characterisation of Seed: The qualitative traits of the collected cowpea varied across the landraces Table 5. Result of seed coat colour showed that White-Cream colour was the most abundant

accessions which a total of 9 landraces, followed by Light Brown coated seeds with 4 landraces and Red (NG-SHR-002) as well as Black (KN-DWK-010) had the least represented by one (1) accession each.

The seed are diverse in shape, varied within and across the landrace of the cowpea. Of the 20 accessions collected 10 of the landraces (NG-SHR-002, NG-WUS-003, NG-BOS-005, NG-BOS-006, NG-KON-009, NG-KON-010, KN-BCH-006, KN-WRW-008, KN-WRW-009, and KN-DWK-010) had Kidney, Ovoid and Rhomboid seeds shape, while four (4) of the landraces (KN-TDW-001, KN-TDW-002, KN-AJG-004 and KN-BCH-005) had Ovoid, Globose, Rhomboid. Also, Ovoid and Rhomboid shape were represented in five (5) accessions (NG-SHR-001, NG-WUS-004, NG-MOK-007, NG-MOK-008 and KN-AJG-003) and only KN-WRW-007 had Kidney and Globose shape. All the accessions seed sampled had 5 (rhomboid) shape. Seed eye pattern also varied among the accesssion with seeds eye encircles the hilum as a narrow ring,

widens at the sides and spills over the non-micropylar end been the most predominant represented in 8 accessions and only accessions KN-BCH-006 presented the kabba group (the eye fills the narrow groove all around the hilum and the body has some form of speckling and a blue hallow is found around the hilum). In terms of testa splitting and testa attachment none of the landraces had seeds with splitting testa (0 and the testa are firmly attached to the hilum (1) for all the collected accessions. The seeds testa texture varied from 1 (smooth) to 5 (rough with fine reticulation). Seeds with smooth texture (1) are the most abundant (represented in 13 accessions), followed by smooth to rough (3), found in five (5) accessions and the rough with fine reticulation (5) were represented by 2 accessions (Table 5).

Table 5: Qualitative Characterisation of Cowpea (*V. unguiculata*) Landraces from Cultivated State in Northern Nigeria

Accessions	Seed Colour	Seed Shape	Eye Pattern	Testa Splitting	Testa Attachment	Testa Texture
NG-SHR-001	1 Light Brown	2 Ovoid, 5 Rhomboid	1	0	1	1
NG-SHR-002	6 Tan Red	1 Kidney, 2 Ovoid, 5 Rhomboid,	6	0	1	5
NG-WUS-003	0 White-Cream	1 Kidney, 2 Ovoid, 5 Rhomboid,	6	0	1	1
NG-WUS-004	0 White-Cream	2 Ovoid, 5 Rhomboid,	3	0	1	1
NG-BOS-005	1 Light Brown	1 Kidney, 2 Ovoid, 5 Rhomboid,	0	0	1	1
NG-BOS-006	0 Cream	1 Kidney, 2 Ovoid, 5 Rhomboid,	0	0	1	1
NG-MOK-007	2 Brown	2 Ovoid, 5 Rhomboid,	3	0	1	3
NG-MOK-008	1 Light Brown	2 Ovoid, 5 Rhomboid,	5	0	1	1
NG-KON-009	0 White-Cream	1 Kidney, 2 Ovoid, 5 Rhomboid,	3	0	1	5
NG-KON-010	0 White-Cream	1 Kidney, 2 Ovoid, 5 Rhomboid,	5	0	1	1
KN-TDW-001	0 White-Cream	2 Ovoid, 4 Globose, 5 Rhomboid	6	0	1	1
KN-TDW-002	0 White-Cream	2 Ovoid, 4 Globose, 5 Rhomboid	6	0	1	1
KN-AJG-003	0 White-Cream	2 Ovoid, 5 Rhomboid	6	0	1	1
KN-AJG-004	3 Red	2 Ovoid, 4 Globose, 5 Rhomboid	6	0	1	3
KN-BCH-005	0 White-Cream	2 Ovoid, 4 Globose, Rhomboid,	6	0	1	3
KN-BCH-006	2 Brown	1 Kidney, 2 Ovoid, 5 Rhomboid,	2	0	1	3
KN-WRW-007	0 Cream	1 Kidney, 4 Globose, 5 Rhomboid	6	0	1	1
KN-WRW-008	0 White-Cream	1 Kidney, 2 Ovoid, 5 Rhomboid,	5	0	1	1
KN-DWK-009	1 Light Brown	1 Kidney, 2 Ovoid, 5 Rhomboid,	1	0	1	3
KN-DWK-010	5 Blue Black	1 Kidney, 2 Ovoid, 5 Rhomboid,	0	0	1	1

DISCUSSIONS

Germplasm resources are crucial for advancing both taxonomic and breeding

research, as they provide the genetic diversity essential for understanding species classification and for developing

improved crop varieties [14]. Genetic variability of virus host plant has been reported to be an important factor for when new resistance genes are tested for, to minimize the possibility of resistance breakdown [15]. Expression of typical foliar disease symptoms by all the inoculated plants is an indication that none of the landraces were totally immune to the viruses. The incidence of disease symptoms in all the landraces farms, also revealed the virulence and pathogenicity of the viruses. Similarity in response of the farmer to the disease severity across the farms indicates that, the infection increases over period and could be due to the initial combat between virus particles, inherent plant defense mechanism as well as the outcome of their interactions in the host plant. Inconformity to the result of this study, with present of CMV in all the field sampled, Odedara *et al.* [16] attributed the widespread occurrence of CMV in the crop to its seed borne nature and greatly contributed to the widespread adapted nature of the virus [17]. The presence of Cowpea aphid-borne mosaic virus (CABMV) in all the sampled field could be attributed to the abundance and adaptation of the vector (Aphids) favoured by high temperature of the region, thus transmitting the virus infection from one field to another. The observation of this study confirmed the work of Ogunsola *et al* [18] that reported the prevalent of seven viruses in a surveyed field, with CYMV having least prevalent and multiple infections of the viruses were detected in samples of the fields. Also, Odedara and Lava [17], reported presence six viruses in Nigeria sampled cowpea with SBMV having the highest virus incidence in all the cowpea growing regions in Nigeria.

Landraces constitute a major part of the local germplasm, encompassing

substantial diversity levels, conserved both naturally and by farmer's selection of crop tolerance species [19]. The significant variation in the seed morphological traits among the landraces revealed some level of diversity among the landraces which could be explore in breeding programme of the crop. Similar to the results obtained in this study is in line with the work of Zafeiriou *et al.* [20], that reported significant high amount of variation among 87 landraces germplasm of Institute of Plant Breeding and Genetic Resources, Hellenic for the seed morphological traits, the seed colour and eye colour. Similar to observation of Musvosvi [21], kidney, ovoid, rhomboid and additional globose seed shape with an accession having mixed presence of more than one shape

The seed colour and pattern along with seed size are determinants of the cowpea's market price and have been considered as major breeding targets [22]. The variation in seed colour and pattern among the accessions studied could be an expression of their genetic composition and environmental factors. Han *et al.* [14] had earlier reported that morphological diversity observed in plants is the result of the complex interaction between genes and the external environment. Furthermore, Phenotypic traits, which are influenced by gene expression and regulation, often provide valuable insights into the underlying genetic diversity. Also, this variability could be the reflection of the resistance level of the landraces to the viruses based on their genetic composition and physiological architecture. Similar to this observation Walters and Fountaine [23], reported that the extent of induced resistance expressed by plant, might be cultivar specific, and differed in lines carrying different race-specific resistance

genes, most marked in partially resistant cultivars.

CONCLUSION

The study provides a foundation of seeds collection and systematic analysis of the morphological traits on which selection could be based for the improvement of the plant. Also, confirmed that all sampled plants (accessions) were susceptible to virus with adverse effects on all plants.

Authors' Contribution

Abubakar, A., Falusi O. A. and Adebola, O.M., conceptualized the study and designed the study. Abubakar, A. and Daudu, O.A.Y. participated in fieldwork and data collection. Abubakar, A. performed the data analysis; Abubakar, A., Bello, I. M. and Salaudeen, A. J. interpreted the data. Abubakar, A. prepared the first draft of the manuscript, reviewed by Daudu, O.A.Y. All authors contributed to the development of the final manuscript and approved its submission.

Disclosure of Conflict of Interest: *None*

Ethics Approval and Informed Consent

This study did not use human or animal subjects. Therefore, ethical consideration was not applicable.

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