

Review Article

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Review on Characterization of Cowpea Germplasm in Terms of Distinctness, Uniformity, Stability and Novelty for Morphological, Quality and Yield Attributing Parameters

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ABSTRACT

Cowpea (*Vigna unguiculata* L.) is the most important grain legume crop grown in tropical and subtropical regions of the world. In India cowpea is grown as sole, mix-crop, inter-crop systems. Cowpea is however, the only pulse suited to both arid and semi-arid regions and adapted better than any other pulses in high rainfall regions. As a good source of proteins, calcium and iron, it is recognized for many routine uses of food, feed, forage, fodder, vegetable and a number of dishes prepared from its grains. India being a secondary centre of diversity for cowpea, possess huge germplasm and wild relatives of cowpea thus, it supplements to the genetic resources of worldwide cowpea collection. Characterization of germplasm became mandatory for varietal registration and to apply for a plant breeder right. The characterization data on various morpho-physiological and agronomic traits is essential to maintain genetic data base at seed banks. In this context, a review has been conducted for the literature regarding DUS characterization, its importance and method of experimentation, various descriptors and documentation of data. The data available in the literature has been utilized in classification of cowpea plant characters into ten distinct categories, considering the seedling, stem, leaf, flower, pod, seed and plant morphological traits. Further, under each category, distinguishable, unique and stable traits were also been formulated as DUS parameters of cowpea. The present review may help the researchers in understanding the scope of DUS test and methodology of experimentation moreover, its present day importance with respect to germplasm conservation and patents.

Keywords

DUS test, Novelty, germplasm, Pulses, Characteristics

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Introduction

The cowpea (*Vigna unguiculata*) is an annual herbaceous legume of the genus *Vigna*. Due to its tolerance for sandy soil and low rainfall it is an important crop in the semi-arid regions across India and other countries. It requires very few inputs, as the plants root nodules are

able to fix atmospheric nitrogen, making it a valuable crop for resource poor farmers and well-suited to intercropping with other crops. The whole plant is used as forage for animals, with its use as cattle feed likely responsible for its name. Four subspecies of cowpea are recognized, of which three are cultivated. There is a high level of morphological

diversity found within the species with large variations in the size, shape and structure of the plant. Cowpeas can be erect, semi erect (trailing) or climbing. The crop is mainly grown for its seeds, which are extremely high in protein, although the leaves and immature seed pods can also be consumed.

Cultivated cowpeas are known by the common names black-eyed pea, southern pea, yard long bean, catjang, and crowder pea.

They were domesticated in Africa and are one of the oldest crops to be farmed. A second domestication event probably occurred in Asia, before they spread into Europe and the Americas. The seeds are usually cooked and made into stews and curries, or ground into flour or paste.

The Indian subcontinent is very rich in biological diversity, harboring around 49,000 species of plants, including about 17,500 species of higher plants. The Indian gene centre holds a prominent position among the 12 mega-gene centers of the world. It is also one of the Vavilovian centers of origin and diversity of crop plants. Two out of the 25 global hotspots of biodiversity, namely the Indo-Burma and Western Ghats are located here.

India possesses about 12 per cent of world flora with 5725 endemic species of higher plants belonging to about 141 endemic genera and over 47 families. About 166 species of crops including 25 major and minor crops have originated and/or developed diversity in this part of the world. Further, 320 species of wild relatives of crop plants are also known to occur here. Presently, the Indian diversity is composed of rich genetic wealth of native as well as introduced types. It is also a secondary centre of diversity for African crops like finger millet, pearl millet, sorghum, cowpea, cluster bean, okra, sesame, niger and safflower

Crop description

There is a large morphological diversity found within the crop, and the growth conditions and grower preferences for each variety vary from region to region (Padulosil, 1997). However, as the plant is primarily self-pollinating its genetic diversity within varieties is relatively low. Cowpeas can either be short and bushy (as short as 20 cm) or act like a vine by climbing supports or trailing along the ground (to a height of 2 m) (Sheahan, 2012) and National Research Council (2006). The tap root can penetrate to a depth of 2.4 m after eight weeks of sowing (Egbadzor *et al.*, 2014). The size and shape of the leaves varies greatly, making this an important feature for classifying and distinguishing cowpea varieties (Pottorff, *et al.*, 2012). Another distinguishing feature of cowpeas is the long 20–50 cm peduncles which hold the flowers and seed pods. One peduncle can support four or more seed pods (Davis, *et al.*, 1991). Flower color varies through different shades of purple, pink, yellow and white and blue (National Research Council, 2006). Seeds and seed pods from wild cowpeas are very small (Davis *et al.*, 1991). While, cultivated varieties can have pods between 10 and 110 cm long (Rawal and Kanti 1975). A pod can contain 6–13 seeds that are usually kidney shaped, although the seeds become more spherical the more restricted they are within the pod (Davis, *et al.*, 1991). Their texture and color is very diverse. They can have a smooth or rough coat, and be speckled, mottled or blotchy. Colors include white, cream, green, red, brown and black or various combinations (Davis, *et al.*, 1991).

Classification of cowpea varieties based on its bean shape, size and color

(Source: India Pulses and Grains Association, www.nutritiondata.self.com, www.nda.agric.za)

Black-eyed or pink-eyed/purple hull peas

These white colored seeds have black, pink or purple eye like shape around the hilum. Seeds are not tightly packed or crowded in the pod and are kidney shaped or oblong.

Brown-eyed peas

These types of cowpeas have green to lavender colored pods. When immature seeds of this type are cooked, it has very tender and a delicate flavor.

Crowder peas

As the name suggests, this type of cowpeas are “crowded” in the pod and have seed of black, speckled and brown eyed.

Cream peas

Seeds are cream colored. This type of seeds looks like intermediate between the black-eyed and crowder types.

White acre type

Seeds are kidney-shaped with a blunt end, semi crowded and generally tan in color.

Clay types

These older varieties are medium to dark brown in color and kidney- shaped, but are rarely grown

Importance of germplasm resources in crop improvement

In order to breed qualities of resistance, adaptation and better nutritive value into crops, breeders need sources of genetic diversity to draw upon when required. This diversity is generally spoken of as ‘genetic resources’ or ‘gene pools’. These gene pools

cannot be created artificially except to a limited extent through mutation breeding or genetic engineering. Fortunately, a large reservoir of genetic diversity existed until recently in old ‘land races’ or farmers’ varieties; a great deal of useful variation also occurs in related wild species.

Modern agricultural technology and the introduction of new high-yielding varieties are largely eliminating the wide range of crop genetic diversity that has evolved during the five to ten thousand years since food plants were first domesticated. Related wild species are also on the decline because of new land use policies. These gene pools (or what is left of them) are generally spoken of as genetic resources, and are vitally needed in the creation of new crop varieties by plant breeders. Wild species and land races often furnish genes conferring resistance to diseases and pests and adaptation to environmental stresses which cannot be found in the modern crop varieties.

DUS characterization studies in cowpea

To sustain high production and productivity of cowpea, a considerable number of varieties have been developed. In addition, a number of germplasm collections are available in the gene pool for use in plant breeding programmes. However, there is lack of compilation of key diagnostic characters of these varieties and germplasm collections, which is essential to carryout scientific seed production and certification, endorse proper quality control, DUS testing and utilization of these characteristics in further breeding programmes.

The variety characterization and purity assessment are very important for maintenance, multiplication, seed certification and quality control of released varieties. The characterization is also essential for

registration and protection of varieties. Traditionally varieties were identified on the basis of their morphological characters, either in the form of seed, seedlings or growing plant characteristics.

In this context, Sarutayophat *et al.*, (2007), characterized 13 cowpea accessions based on growth habit, days to 50 per cent flowering, pod color, pod length, number of pods per plant, seed yield per plant. Similarly, Basavaraj, *et al.*, 2013, conducted an experiment to characterize 35 cowpea genotypes using different quantitative descriptors at plant level. Highly significant differences were obtained among the genotypes for the characters studied. All characters were found stable and reliable for classification except for characters number of pods per peduncle and seed yield per hectare. Hence, it's reliable to consider these stable characters in future breeding programmes of cowpea crop and quality seed production and also in protection in plant variety.

Further, Stoilova and Pereira (2013), had used 24 different morphological descriptors in order to identify accessions with specific behavior that could be exploited by plant breeders and they found that descriptors like pod length, number of seeds per pod, seed thickness and 100 seed weight were the most stable traits and they concluded these characters can be used in characterization.

Sunil Kumar *et al.*, (2015), characterized 20 forage cowpea genotypes on the basis of various morphological characters which were mentioned in cowpea germplasm catalogue of IITA, Nigeria. All genotypes showed indeterminate type of main stem and raceme type of layer in canopy; whereas genotypes viz., KBC 2, IC 249141, HC 46, CO 4, EC 3941-1, EC 101980, Kohinoor and CO 5 showed unique state of expression among nine characters viz., incidence of cowpea mosaic

virus, seed crowding in pod, texta structure, eye color, pod shape, pod attachment to peduncle, terminal leaflet shape, twining tendency and flower pigmentation, respectively.

DUS characterization studies in related pulse (Green gram)

The literature pertaining to DUS characterization in Cowpea is limited, a review is also been made by considering the green gram, a crop relative of cowpea. Rupinder *et al.*, (2017) characterized five lines released by PAU, Ludhiana (PAU911, SML668, ML818, ML613 and SML832) using morphological and molecular markers.

Phenotypically these varieties showed variation for growth habit, leaf and flower characters, pod color, position and length, plant height, seed coat lusture and seed size during different growth stages of the crop. Plant morphology characters being polygenic in nature are liable to be influenced by the environment. Hence there is a need to use alternate descriptors which are rapid, accurate and less affected by environment.

Methodology of DUS testing

The principles and methods on various aspects of DUS testing of new crop varieties have been documented as National Test Guidelines (NTG). NTG has been developed for 35 crops by the National Core Committee constituted by ICAR. NTG contains details on plant material required, conduct of tests, methods and observations, grouping of varieties, characteristics and symbols, table of characteristics, literature and technical questionnaire. Usually the DUS examination requires at least two independent growing cycles. Not less than two centers have been identified for each crop for conduction of the tests.

Distinct-Uniform-Stable (DUS)

Distinct means a variety should be clearly distinguishable by one or more essential characteristics from any other existing variety. The variety is deemed *Uniform* if it is sufficiently uniform in its relevant characteristics, subject to variation that may be expected from the particular features of its population.

The basis of assessment is normally the number of off-types in the variety, judged on the basis of a population standard and an acceptable probability fixed in the corresponding species. To identify off-types in a population, generally visual observation on characteristics may suffice.

However, in a few crops, it may be necessary to make measurements of each plant to apply statistics to decide or not whether a plant is an off-type. In most of the crops, acceptance probability of 95% has been suggested. The variety is said to be *Stable* if its relevant characteristics remain unchanged after repeated propagation. Though it is not usually possible to assess stability within a period of 2 or 3 years, the variety can be considered stable if it is shown to be uniform.

Characterization

The requirement of distinctness, uniformity and stability are assessed on the basis of characteristics. The characteristics are a feature of whole plant or part of plant. Such characteristics may be morphological, biochemical, molecular or any other nature. The table of characteristics chosen by experts forms the main part of test guidelines and of DUS testing. In Genetic resources, the term 'characteristic' is known as descriptors (with descriptor states) and describing a plant based on such descriptor is known as 'characterization'.

Morphological characterization

This is based on botanical or morphological descriptors or characters of the plant or plant part. Qualitative characteristics: Truly qualitative characteristics show discrete discontinuous states and are stable, heritable and uniformly expressed in all environments (shape, flower color, etc).

Pseudo-qualitative characteristics: Here, the range of expression is at least partly continuous varying in more than one dimension. In some cases, intermediate states of expression such as 'weakly expressed' are included between 'absent' and 'strongly expressed' (Pubescence, Pigmentation, etc.). Qualitative characteristics are assessed visually while quantitative characteristics are usually measured. The following types of assessments are recommended:

VG: Visual assessment by a single observation of a group of plants or parts of plant.

VS: Visual assessment by observation of individual plants or parts of plants.

MG: Measurement by a single observation of a group of plants or parts of plant.

MS: Measurement of a number of individual plants or parts of plant.

Grouping characteristics can be universally used, either individually or collectively, for grouping the similar varieties.

These characteristics are considered to be most reliable in distinguishing or discriminating varieties.

Biochemical characterization: Isozyme based descriptors have been widely used for identification of crop varieties because of their reliability (Smith and Smith, 1992; Cooke, 1995).

Table.1 Classification of DUS traits associated with cowpea

S. N0	DUS traits associated with	Frequency	Percentage
01	Seedling stage (Anthocynin coloration)	01	1.08
02	Stem	02	2.16
03	flower	07	7.61
04	Plant	10	10.86
05	Leaf	13	14.44
06	Pod	18	19.56
07	Seed	23	25.00
08	Response to abiotic stress	04	4.35
09	Response to biotic stress (Insect Pests)	05	5.43
10	Response to biotic stress (Diseases)	09	9.78
Total No. DUS traits Proposed		92.00	100.00

Table.2 Proposed cowpea crop descriptors

S. No	Characters	Status	Code	Adopted from
1	Seedling Anthocyanin coloration	Absent	0	IITA, Nigeria
		Present	1	
2	Stem color	Purple	1	IITA, Nigeria
		Semi purple	2	
		Green	3	
3	Stem hairiness	Non-hairy	3	IITA, Nigeria
		Sparsely hairy	5	
		Hairy	7	
4	Days to first flowering	Early (<35)	1	Cowpea catalogue, NBPGR, New Delhi, India
		Medium (35-40)	2	
		Late (>40)	3	
5	Days to 50% flowering	Early (48)	1	Cowpea catalogue, NBPGR, New Delhi, India
		Medium (48-52)	2	
		Late (>52)	3	
6	Plant height (height of main stem when supported)	Short (<55)	1	IITA, Nigeria
		Medium (55-65)	2	
		Long (>65)	3	
7	No. days to maturity	Early (<75)	1	IITA, Nigeria
		Medium (75-80)	2	
		Late (>80)	3	
8	Plant pigmentation	Moderate on base and tip of petioles	1	IITA, Nigeria
		Extensive	2	
		None or Very pale	3	
		Almost Solid	4	
9	Plant growth habit	Prostrate	1	Cowpea catalogue, NBPGR, New Delhi, India
		Semi prostrate	2	

		Intermediate	3	
		Semi erect	4	
		Erect	5	
		Acute erect	6	
		Climbing	7	
10	Twining tendency	None	1	Cowpea catalogue, NBPGR, New Delhi, India
		Moderate	2	
		Pronounced	3	
11	Vigor index	Vigorous - Height < 37.5cm and Width < 75cm	1	IITA, Nigeria
		Intermediate - Height > 37.5cm or Width > 75cm	2	
		Vigorous - Height > 37.5cm and Width > 75cm	3	
		Very Vigorous - Height > 50cm and Width > 1m	4	
S. No	Characters	Status	Code	Adopted from
12	Determinacy	Determinant	1	Cowpea catalogue, NBPGR, New Delhi, India
		In determinant	2	
13	Primary branches per plant	Less (<4)	1	Descriptors for Cowpea, IPGRI, Rome
		Medium (4-6)	2	
		High (>6)	3	
14	No. of nodes on main stem			IITA, Nigeria
15	Green fodder yield per plant			IITA, Nigeria
16	Leaf to stem ratio			IITA, Nigeria
17	Leaf texture	Cariaceous	1	IITA, Nigeria
		Intermediate	2	
		Membranous	3	
18	Stipule length (mm)	Ryuuu		
19	Stipule width (mm)	Rydrudu		
20	Leafiness	Vigorously leafy	1	Cowpea catalogue, NBPGR, New Delhi, India
		Leafy	2	
		Intermediate	3	
		Sparse, leaf size average or above	4	
		Sparse, leaf size small	5	
21	Leaf color	Light green	1	Cowpea catalogue, NBPGR, New Delhi, India
		Green	2	
		Dark green	3	
22	Leaf surface	Glabrous	1	IITA, Nigeria
		Pubescent	2	
23	Intensity of leaf green color	Light	1	IITA, Nigeria
		Medium	2	
		Dark	3	
24	Petiole length	Short	1	Cowpea catalogue, NBPGR, New Delhi, India
		Medium	2	
		Long	3	
25	Terminal leaflet shape	Sub-hastate	1	IITA, Nigeria

		Sub-Globose	2	
		Hastate (Lanceolate)	3	
		Globose	4	
26	Terminal leaflet length	Short (<8)	1	IITA, Nigeria
		Medium (8-10)	2	
		Long (>10)	3	
27	Terminal leaflet width	Narrow (<6)	1	IITA, Nigeria
		Medium (6-8)	2	
		Broad (>8)	3	
28	Leaf marking (Presence or absence of V mark on leaflet)	Absent	0	IITA, Nigeria
		Present	1	
S. No	Characters	Status	Code	Adopted from
29	Number of flushing			Cowpea catalogue, NBPGR, New Delhi, India
30	Flower pigmentation	Completely Pigmented	1	IITA, Nigeria
		Wing and standard petal has pigmented margins	2	
		Wing pigmented petal has light V-shape pattern	3	
		None	4	
		Wing has pigmented upper margin; standard petal pigmented	5	
		Wing is pigmented ; Petal is lightly pigmented	6	
31	Raceme position	Mostly above canopy	1	Cowpea catalogue, NBPGR, New Delhi, India
		Throughout canopy	2	
		In upper canopy	3	
32	Flower bud color	Yellowish	1	IITA, Nigeria
		Light green	2	
		Medium green	3	
33	Flower color	Purple	1	
		Light purple	2	
		White	3	
34	First pod bearing node			IITA, Nigeria
35	Days to first ripe pod			IITA, Nigeria
36	Pod pigmentation	None	1	Cowpea catalogue, NBPGR, New Delhi, India
		Pigmented tips	2	
		Pigmented suture	3	
		Pigmented valves with green sutures	4	
		Splashed	5	
		Uniformly pigmented	6	
37	Peduncle length	Short (<5)	1	Cowpea catalogue, NBPGR, New Delhi, India
		Medium	2	
		Long (>5)	3	

38	No. of pods per Peduncle	Less (<2)	1	IITA, Nigeria
		Moderate (2-3)	2	
		High (>4)	3	
39	No. pods per plant	Low (<15)	1	IITA, Nigeria
		Medium (15-20)	2	
		High (>20)	3	
40	Pod attachment to peduncle	Erect	1	Cowpea catalogue, NBPGR, New Delhi, India
		Angle of 30-90 o down from erect	2	
		Pendent	3	
S. No	Characters	Status	Code	Adopted from
41	Number of Clusters per plant	High (>11)	1	IITA, Nigeria
		Medium (9-11)	2	
		low (<9)	3	
42	Pod shape	Crescent	1	IITA, Nigeria
		Erect	2	
		coiled	3	
43	Pod length	Long (>10)	1	IITA, Nigeria
		Medium (8-10)	2	
		Short (<10)	3	
44	Pod width			IITA, Nigeria
45	Number of locules per pod			IITA, Nigeria
46	Pod curvature	Straight	1	IITA, Nigeria
		Curved	2	
		Slightly curved	3	
		Coiled	4	
47	Immature pod color	Green	1	IITA, Nigeria
		Dark green	2	
		Light green	3	
		Purple green	4	
48	Pod color at maturity	Yellow	1	IITA, Nigeria
		Brown	2	
49	Pod twisting	Absent	0	IITA, Nigeria
		Present	1	
50	Texture of pod surface	Smooth	1	IITA, Nigeria
		Moderately rough	2	
		Very rough	3	
51	Extent of seed crowding in pod	Non Crowder	0	IITA, Nigeria
		Semi Crowder	1	
		Extreme Crowder	2	
52	Number of seeds per pod	Medium (14-18), Low, (<14), high (>18)	1,2,3	Descriptors for Cowpea, IPGRI, Rome
53	Pod wall thickness	Thin	3	IITA, Nigeria
		Intermediate	5	
		Thick	7	
54	Eye pattern	Watson group	1	IITA, Nigeria
		Holstein group	2	

		Small eye	3	
55	Eye color	Narrow eye	1	IITA, Nigeria
		Kabba eye	2	
		Tan and Brown	3	
		Red	4	
		white, cream, brown splash	5	
		gray	6	
S. No	Characters	Status	Code	Adopted from
56	Testa texture	Smooth	1	IITA, Nigeria
		Wrinkled	2	
57	Seed size	1 (810mg/10 seeds)	1	IITA, Nigeria
		2(1400mg/10 seeds)	2	
		3(472mg/10 seeds)	3	
		4(2150mg/10 seeds)	4	
		5 (48mg/10 seeds)	5	
		6 (189mg/10 seeds)	6	
		7 (2880mg/10 seeds)	7	
		8 (117mg/10 seeds)	8	
		9 (3370mg/10 seeds)	9	
58	Seed length	Very short	1	IITA, Nigeria
		Short	2	
		Intermediate	3	
		Long	4	
		Very long	5	
59	Seed thickness	Thick	1	IITA, Nigeria
		Flat	2	
		Very flat	3	
60	Seed Shape	Kidney	1	Cowpea catalogue, NBPGR, New Delhi
		Ovoid	2	
		Crowdege	3	
		Globose	4	
		Rhomboid	5	
61	Seed color (Main color-color of largest area of seed)	White	1	IITA, Nigeria
		Light yellow	2	
		Brown	3	
		Reddish brown	4	
		Purplish brown	5	
		Black	6	
62	Seed Secondary color	Absent	0	IITA, Nigeria
		Present	1	
63	Seed secondary color	Brown	1	IITA, Nigeria
		Reddish brown	2	
		Purplish brown	3	
		Black	4	
64	Pattern of seed secondary color	Around hilum	1	IITA, Nigeria
		In veins	2	
		Mottled on part of seed	3	

S. No	Characters	Status	Code	Adopted from
		Mottled on whole seed	4	
65	Seed coat color	Buff with brown spot around hilum	1	IITA, Nigeria
		Buff without brown spot around hilum	2	
		brown	3	
		Dark red	4	
		Tan	5	
		Black	6	
		Peach	7	
66	Seed coat lusture	Shiny	1	IITA, Nigeria
		Intermediate	2	
		Dull	3	
67	Splitting of testa	Absent	0	IITA, Nigeria
		Present	1	
67	Attachment of Testa	Testa not firmly attached to seed	0	IITA, Nigeria
		Testa firmly attached to seed	1	
69	Test weight	Bold seeded (>10)	1	IITA, Nigeria
		Medium seeded (7-10)	2	
		Small seeded (<7)	3	
70	Market value	Grain type	1	IITA, Nigeria
		Vegetable type	2	
		Fodder type	3	
71	Shattering	Non-shattering	1	Cowpea catalogue, NBPGR, New Delhi
		Medium Shattering	2	
		Highly shattering	3	
72	Seed yield per plant	High (>60)	1	Descriptors for Cowpea, IPGRI, Rome
		(Medium (30-60)	2	
		Low (<30)	3	
73	Seed yield Kg per Hectare	Low : ≤ 1100	1	IITA, Nigeria
		Moderate : 1100 - 1600	2	
		High : 1600 - 2000	3	
		Very high : > 2000	4	
74	Incidence of cowpea yellow mosaic virus	None	0	IITA, Nigeria
		Green mottle	1	
		Yellow Mosaic	2	
S. No	Characters	Status	Code	Adopted from
75	Capacity for re-growth	Present/Absent		IITA, Nigeria
76	Low temperature	Low Susceptibility	3	IITA, Nigeria
		Medium Susceptibility	5	
		High Susceptibility	7	
77	High Temperature	Low Susceptibility	3	IITA, Nigeria
		Medium Susceptibility	5	

		High Susceptibility	7	
78	Drought	Low Susceptibility	3	IITA, Nigeria
		Medium Susceptibility	5	
		High Susceptibility	7	
79	High Soil Moisture	Low Susceptibility	3	IITA, Nigeria
		Medium Susceptibility	5	
		High Susceptibility	7	
80	Coried bugs	Low Susceptibility	3	IITA, Nigeria
		Medium Susceptibility	5	
		High Susceptibility	7	
81	Cowpea aphid	Low Susceptibility	3	IITA, Nigeria
		Medium Susceptibility	5	
		High Susceptibility	7	
82	Pod borer	Low Susceptibility	3	IITA, Nigeria
		Medium Susceptibility	5	
		High Susceptibility	7	
83	African bollworm	Low Susceptibility	3	IITA, Nigeria
		Medium Susceptibility	5	
		High Susceptibility	7	
S. No	Characters	Status	Code	Adopted from
84	Cowpea storage weevil	Low Susceptibility	3	IITA, Nigeria
		Medium Susceptibility	5	
		High Susceptibility	7	
85	Ascochyta blight	Low Susceptibility	3	IITA, Nigeria
		Medium Susceptibility	5	
		High Susceptibility	7	
86	Powdery mildew	Low Susceptibility	3	IITA, Nigeria
		Medium Susceptibility	5	
		High Susceptibility	7	
87	Fusarium wilt	Low Susceptibility	3	IITA, Nigeria
		Medium Susceptibility	5	
		High Susceptibility	7	
88	Pythium stem rot	Low Susceptibility	3	IITA, Nigeria
		Medium Susceptibility	5	
		High Susceptibility	7	
89	Sclerotium stem rot	Low Susceptibility	3	IITA, Nigeria
		Medium Susceptibility	5	
		High Susceptibility	7	
90	Brown rust	Low Susceptibility	3	IITA, Nigeria
		Medium Susceptibility	5	
		High Susceptibility	7	
91	Verticillium wilt	Low Susceptibility	3	IITA, Nigeria
		Medium Susceptibility	5	
		High Susceptibility	7	
92	Bacterial light and canker	Low Susceptibility	3	IITA, Nigeria
		Medium Susceptibility	5	
		High Susceptibility	7	

Table.3 Recommendable quality tests

S. No.	Nutritional Quality test	Status
1	Seed protein Content Lowry et al., (1951)	Low (<20%) Medium (20-30%) High (>30%)
Chemical tests		
2	KOH-bleach test (McDonald-MB Jr., 1985)	Negative
		Brownish yellow
		Light yellow
		Light yellow
3	Phenol test (Walls, 1965)	Negative
		Grey
		Dark brown
4	Ferrous sulphate test (Kumar et al.,1995)	Negative
		Grey
		Dark brown
5	Sodium hydroxide test (McDonald-MB Jr.,1985)	Yellow
		Light yellow
		Brownish yellow
		Light brown
		Reddish brown
		Brown

UPOV has also included electrophoresis of iso-enzymes in maize, soybean, sunflower and of seed proteins in barley, wheat as additional characters for establishing distinctness of varieties. Selection of an appropriate electrophoresis technique provides a potential tool for variety identification, DUS test or grouping of varieties.

Molecular characterization: Biotechnology has widened the possibilities for applying such technologies to the problem of characterization, varietal identification and protection (Smith, 1995). At present, molecular markers are not being used in DUS testing anywhere, but they are reliable, fast and cost effective to discriminate an EDV (essentially derived variety). Data from these methods may help resolve disputes on identity of germplasm or hybrids (Santhy *et al.*, 2003).

DUS test design

The use of experimental design with respect to the number of growing cycles, lay out of the trial, number of plants to be examined and method of observation is largely determined by the number and nature of varieties to be examined in a particular trial.

In DUS trials, because of the presence of only one treatment factor (variety), the following designs are used

Completely Randomized Design- if total number of test varieties is small. Several varieties are examined in a number of replications.

Randomized complete Block Design- the number of plots per block equals the number of varieties and all varieties are placed in each

block. The advantage is that standard deviation between plots does not contain variation due to difference in blocks.

Randomized incomplete Block Design- in case of large number of varieties. Here, the number of plots per block is less than the number of varieties.

In Poland, performed analysis of variance of the results of experiment concerning seven characters in pea varieties showed that randomized complete block and completely randomized designs were more effective than incomplete block (Pilarczyk, 1999).

Reference collection

To test whether a candidate variety meets the DUS criteria, it is compared with varieties whose existence is a matter of common knowledge. To satisfy the requirement of distinctness, a candidate variety must be clearly distinguishable from all other existing varieties. These varieties are called the varieties of common knowledge, which includes:

Protected varieties

Varieties listed in official register

Varieties, subject of an application for protection

Varieties listed in any commercial document in which varieties are offered for marketing in its territory as propagating material, especially where there is no official registration system.

Ecotypes and land races

Publicly available varieties within plant germplasm collection (genetic resources, old varieties, etc.

Literature search regarding the DUS characterization in cowpea published in peer reviewed journals and crop descriptors available in the organizations like NBPGR, New Delhi, IPGRI, Rome and IITA, Nigeria has provided an idea and list of most appropriate descriptors to characterize germplasm resources in terms of distinctness, unity, stability and novelty (DUSN). Based insight review, we classified plant parameters in to ten different categories considering leaf, stem, habitat, flower, pod and seed characteristics (Table 1).

Further, DUS traits under each category were developed according to the mode of phenotypic expression of the character in question and based on the response of germplasm to biotic and abiotic stress. The present review proposes to consider the newly identified parameters as newly proposed DUS traits for morphological characterization of cowpea germplasm (Table 2).

The distinctness among the germplasm may also be determined at biochemical level, as we know about the isozyme and allozyme biochemical marker. The prevalence of isozyme allozyme biochemical markers informs or shows a clue regarding characterization or establishing the distinctness at biochemical level. In this regard, a vast literature search related biochemical aspects of cowpea has been made and come out with following six different quality tests (Table 3) to characterize the cowpea germplasm.

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preliminary literature search has been made to identify and develop new crop descriptors. In this context, a review article has been formulated.

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