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Advanced Breeding Approaches for Developing Cowpea Varieties in Dryland Areas of Limpopo Province, South Africa

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Abstract

Cowpea is an important grain legume because it is a major source of cheap dietary protein. In the last four decades, the production of cowpea in South Africa is limited by lack of improved varieties that exhibit good agronomic traits and pest resistance. The purpose of the study was to develop cowpea varieties with important economic traits to meet the needs of the farmers. Germplasm lines were evaluated in field trials to select the promising lines that were used in hybridization to develop well-adapted elite genotypes. Pair-wise crosses were made to develop broad-based segregating populations. Pedigree, recurrent selection methods were used to advance the promising genotypes. Ten genotypes expressed high grain yield with combined pest resistance (aphids, bruchid, virus, leafhopper and bacterial blight). The implication of this achievement is that farmers can attain more grain yield per land area with reduced cost of pest control and increase the profit margin of the farmers. Furthermore, four elite varieties (JanaFod, ARC-GCI-CP76, UL-58 and UL-1010) have been registered and awaiting commercialization. The future activity is to commercialize the varieties to enhance uptake and availability of seeds to seed growers, farmers and consumers.

Keywords: breeding lines, fodder, grain yield, pest resistance, quality traits, *Vigna unguiculata*

1. Introduction

Cowpea is an important grain legume because it is a major source of cheap dietary protein which ranges from 23 to 32% [1–3] and 64% carbohydrate [4] that complements the over dependence on low-protein staple cereals and potatoes in South Africa. The largest production of this crop is in sub-Saharan Africa, where it is a staple food crop and feed for animals [5]. Cowpea can be prepared in different forms (boiled as pudding and soup, steamed as *moin moin*, fried as *akara* to meet the dietary needs of the consumers. It is an important income earner to all the stakeholders in the value chain [6–8]. Cowpea is tolerant to drought, and this makes it a very versatile crop in drought-prone regions of the tropics. Cowpea has the ability to fix atmospheric nitrogen [9, 10] for its growth thereby reducing its nitrogen demand. This makes cowpea a low input crop and a good companion crop in most intercropping systems [6, 8]. However, the production of this crop

is limited by lack of improved varieties which are resistant insect pests, diseases, parasitic weeds and other abiotic stresses. The purpose of the research was to develop cowpea varieties that would overcome these constraints through a well-designed breeding programmes and activities. Cowpea is one of the neglected orphan or underutilized grain legumes in South Africa that has great potentials for enhancing food security and nutrition for the rural masses where poverty and starvation are a reality.

1.1 Word cowpea production

According to DAFF [11] the world annual cowpea grain production is about 3 million tons that is produced on 12.5 million hectares but only a small proportion enters the international trade. West and Central Africa is the leading cowpea producing regions in the world, producing 64% of the estimated 3 million tons of cowpea seed that is produced annually. Nigeria is the world's leading cowpea-producing country followed by Brazil. Other countries in Africa include, Senegal, Ghana, Mali and Burkina Faso. Ghana, Niger and Cameroon are significant producers. The major production areas elsewhere in the world are Asia (India, Myanmar) and America (USA, Brazil, West Indies). Conservative estimates suggest that greater than 12.5 million ha are planted annually to cowpea around the world. Of this area, about 9.8 million ha are contributed from West Africa, making it the region with the largest production of cowpea in the world [2, 11].

1.2 Cowpea production in South Africa

DAFF [11] reported that small-scale farmers are the major cowpea producers in South Africa under rain-fed farming conditions but there are no records regarding the size of area under production and yields produced. However, [12] reported that the land area used by farmers to produce cowpea ranges between 0.5 and 2.0 hectares per farmer. Farmers that cultivate land area up to two hectares make use of tractor or motorized implements [7] to save cost and to produce more above their family consumption and the excess is preserved for sale. The major cowpea producing areas in South Africa are Limpopo, Mpumalanga, North-West and KwaZulu-Natal [11]. A study conducted by [7] showed that farmers grow cowpea for consumption and as source of income.

Farmers prefer important traits such as seed color, seed size, growth habit and early maturity varieties. This suggests the great opportunity that exists for the development of cowpea varieties with divers coat colors and high potentials for their demand and marketability. Based on the duration of rainfall, some farmers choose early maturing varieties, as this will assist the crop to escape moisture deficits and frost damage while others choose late maturing types because they are more interested on the fodder for livestock feeding. On the other hand, KwaZulu-Natal farmers preferred cowpea varieties based on growth habit [12]. The diverse preferences by farmers call for the need to develop varieties with different agronomic and quality traits. The purpose of the research was to develop cowpea varieties that would overcome the various limitations encountered by farmers and to meet their needs. To develop varieties that will meet the needs of farmers and consumers, a well-tailored need assessment survey was conducted in some of the cowpea production areas between 2006 and 2007 [12]. Through this survey, the dire needs of farmers and quality trait preferred by consumers were documented and used as the breeding objectives [13, 14]. Therefore aim of the research was to develop cowpea varieties that would overcome these constraints through a well-designed breeding programmes and activities while the specific objectives include:

1. Development of early maturing varieties (70–90 days). These are grain type of cowpea which are commonly cultivated in regions with short rainfall duration (**Figure 1**). In higher rain region, they can be used for double cropping (first cropping from October–December and second cropping from January to March). They are best varieties to use to evade terminal drought.
2. Development of Medium maturing variety (91–100 days). These are dual-purpose cowpea types. They are good for grain and fodder for animal feed (**Figure 2**).
3. Development of late maturing varieties (101–120 days). They are mainly for fodder and leafy vegetable production with limited seed production. The medium and the late cowpea types are of high value for integrated livestock production and rural livelihood in rural communities (**Figure 3**).
4. Development of high yielding varieties with multiple trait characteristics (adaptation and pest (insect and disease resistance). The prevalent insect pests include aphid, leafhopper, cowpea bruchid and blister beetles [13] and the diseases are bacterial blight, anthracnose as well as nematodes. Multiple pest resistance genes have been incorporated in most of the elite cowpea lines.
5. To develop high consumer quality trait varieties such as seed size, color, low cooking time and high protein content. To incorporate these quality traits in one commercial variety is practically impossible. Therefore, development of high yielding and pest resistance cultivars with different quality traits is the practice. Seed coat color and texture is an important consumer preferred quality traits. Large seed size with bright coat color command a high premium price in South Africa.
6. Common insect pests of cowpea

The common insect pests of cowpea include, cowpea aphids, leaf hopper (**Figure 4**), bruchid, blister beetles and pod-sucking bugs (**Figure 5**) [13]. The economic importance of these insects vary from one location to another depending on the climatic variables that promote their abundance and the presence of their alternate hosts. It is important to note that the presence of winter for at least 4–5 months in some provinces has reduced drastically the carryover effects of some of these pests from one cropping season to another thereby reducing insect spectra and early incidence in South Africa unlike West Africa where there is no winter. Most of the breeding parents used for the development of the elite genotypes in South Africa were introduced from IITA-Nigeria and they possess multiple resistance to both aphid and bruchid, and were incorporated into the elite lines.

Figure 1.
Two different grain cowpea varieties.

Figure 2.
Two dual-purpose cowpea varieties.

Figure 3.
Two fodder (late) cowpea types (top and bottom-Janafod).

2. Materials and methods

One the major constraints to cowpea production in South Africa is lack of improved varieties. This was identified in the need assessment survey [7, 12]. To solve this constraint, international improved varieties were introduced in 2005/6 from International Institute of Tropical Agriculture (IITA), Nigeria for adaptive breeding purposes. Some of the varieties possess economic traits (high yielding, pest resistance and quality). The introduced varieties formed the breeding stock

Figure 4.
Susceptible cowpea-IT00K-1263 to leafhopper infestation (left) resistant cowpea-UL-1010 (right).

Figure 5.
Insect pest of cowpea: Anaplocnemis curvipes (upper left), Mylabris spp (upper right), seed damaged by bruchid (lower left) and cowpea aphid (lower right).

for the development of new adapted germplasm in South Africa. Based on the screening outcomes, promising varieties were selected for pair-wise crosses with promising local South African germplasm lines such as Glenda and Betchuana white to develop broad-based F₂ population which was used to form the various segregation populations for the specific objectives. Some of the varieties possess economic traits (high yielding, pest resistance and quality). The introduced varieties formed the breeding stock for the development of new adapted germplasm in South Africa. Based on the screening outcomes, promising varieties were selected for pair-wise crosses with promising local South African germplasm lines such

as Glenda and Betchuana white to develop broad-based F_2 population which was used to form the various segregating populations for the specific objectives. Some of these genotypes were screened in hot spots (Bela-Bela and Taung) for adaptation and important traits (yield, aphid resistance, and diseases (bacterial blight and anthracnose) and advanced to subsequent generations. Between 2005 and 2007, intensive screenings were conducted on the segregation populations using Pedigree method. From F_4 - F_8 , segregating populations were subjected to selection and advancement (using pedigree selection method) in a replicated field trials for adaptation and validation of important economic traits [7, 14, 15]. From (F_{9-10})-an advanced fixed generation with promising genotypes from various traits for various specific objectives were tested in multiple locations for G X E [16–18] for adaptation. During the field evaluation processes, the populations were also subjected to aphids, bacterial blight, anthracnose screenings under natural infestation, and bruchid screening in the laboratory. Promising varieties selected from the evaluations were tested over seasons.

2.1 Data analysis

All the data collected were subjected to analysis of variance (ANOVA) procedure using Genstat Version 20 software. Means were separated using Duncan Multiple range Test (DMRT) at $P < 0.05$.

3. Results and discussion

3.1 Common insect pests of cowpea

The common insect pests of cowpea include, cowpea aphids, leaf hopper (**Figure 4**), bruchid, blister beetles and pod-sucking bugs (**Figure 5**) [13]. Most of the breeding parents used for the development of the elite genotypes in South Africa were introduced from IITA-Nigeria and have multiple resistance to both aphid and bruchid, and were incorporated into the elite lines (**Table 1**). This suggests that the parental lines used to develop the elite breeding lines have high heritability and were able to transmit the genes to their offspring [18]. The implication of the multipest resistance is that farmers can grow the varieties with reduced cost of pest control thereby enabling the farmers to maximize profit.

3.2 Development of early maturing varieties (70: 90 days)

The performance of the extra-early and early maturing varieties developed are shown in **Table 2**. Early maturity was also bred with good quality traits (seed size and color), plant type (erect or semi-erect), high yield, as well as pest resistance [10, 19]. This is to increase the acceptability and adoption of the varieties. In addition, early maturing varieties are regarded as “climate smart” and water use efficient varieties [1, 15]. Farmers in drought-prone regions of Limpopo Province can successfully grow such varieties within the short rainfall duration in their environment. The varieties are also regarded as the grain type cowpea (**Figure 1**).

3.3 Development of medium maturing varieties (91: 100 days)

Medium maturity cowpea varieties were developed for regions with higher rainfall 600–750 mm per annum with summer rainfall duration of 3–4 months. Medium cowpea types are characterized with good grain and fodder yield and are

Pedigree	Grain yield (kg/ha)	Fodder yield (kg/ha)	Resistance to				
			Aphid	Viruses	bruchid	Leafhopper	Bacterial blight
IT98K-962 X IT97K-499-35	1740.50 ^{bc}	1987.70 ^{cd}	R	R	R	R	R
IT98K-962 X IT98K-205-8	1928.50 ^b	2679.70 ^{b-d}	R	R	MR	R	R
IT98K-962 X TVX 3236	1557.90 ^{cd}	3611.00 ^a	R	R	MR	R	R
IT97K-497-2 X IT98K-962	1670.60 ^{b-d}	2796.50 ^{a-c}	S	R	R	R	R
IT97K-497-2 X Oloyin	1561.70 ^{cd}	2658.10 ^{b-d}	S	R	MR	S	MR
IT97K-497-2 X IT82D-889	1675.40 ^{b-d}	2659.50 ^{b-d}	S	R	MR	R	R
IT00K-1217 X IT98K-962	2595.20 ^a	2633.10 ^{b-d}	R	R	R	R	R
IT98K- 205-8 X Oloyin	1441.20 ^d	2283.10 ^{b-d}	R	R	MS	R	MR
IT98K-205-8 X IT98K-406-2	1807.50 ^{bc}	2488.60 ^{b-d}	R	R	R	R	R
IT90K-76 X Oloyin	1891.70 ^b	3022.00 ^{ab}	R	R	R	R	R
BW (Local check)	1858.70 ^b	1934.20 ^d	S	S	S	R	R
Grand mean	1793.5	2614					
P-level (P < 0.05)	0.001	0.001					

*R = resistant, MR = medium resistance, MS = Medium susceptible, S = susceptible (Singh et al., 1997).

Table 1.
Yield and pest resistance of elite cowpea breeding lines.

often regarded as the dual-purpose cowpea (**Table 3** and **Figure 2**) [20, 21]. They are also suitable for livestock integration. This type of cowpea also combine good quality traits (seed size and color) with, high yield, plant type (semi-erect) and pest resistance. The list of medium maturity cowpea are shown in **Tables 2** and **4**. Dual-purpose cowpea varieties under good rainfall distribution produce grain yield far above the grain type because it takes extra time to develop more photosynthetic apparatus such as leaves, canopy, branches and height which enables the varieties to produce flowers and more pods which are translated into high grain yield [19–21]. The high fodder yield is generated from the branches and leaves [2, 5].

3.4 Development of vegetable cowpea varieties

One of the ways that cowpea contribute to food security and nutrition is through the pods and leaves (**Figure 3**) which are eaten as vegetable to relish meals. This is an important cowpea menu in South Africa. It is locally called “*Morogo*”. Crosses made between IITA varieties such as IT82D-889, IT81D-1228-10 that exhibit long pods (30 cm) with TVu 13,464 (short pods with high pod load) produced genotypes with longer pods 50–75 cm (**Figure 6**). The varieties can be harvested 3–4 times

Variety	Potchefstroom			Taung		
	Grain yield kg/ha	Maturity	100seed weight (g)	Grain yield kg/ha	Maturity	100seed weight (g)
99 K-494-6	3064.6	99.22	16.49	3206.2	92.84	17.24
Pan-311	2913.3	80.22	14.58	1873.1	92.59	13.56
IT00K-1217	2894.6	92.55	15.05	1719.7	92.59	15.5
TVu 13,464	2722.9	85.88	12.96	1968.9	91.84	12.96
97 K-1069-8	2377.9	97.55	15.83	2296.2	99.59	15.43
97 K-1069-1	2321.1	94.22	16.99	2708	99.09	17.89
95 K-1491	2287.2	91.55	18.55	1972.7	94.59	18.68
83D-442	2266.7	91.55	13.18	2369	95.84	12.29
97 K-568-18	2227.2	97.22	16.91	1784.7	98.09	18.12
98 K-530-1	2180.8	95.88	18.88	1642.6	97.59	17.75
93 K-452-1	1823.7	91.55	15.05	1908	93.59	16.85
S.E.M	311.3	1.44	0.71	291.2	1.25	0.61

Table 2.
Performance of early and medium maturing cowpea varieties evaluated in two locations.

depending on duration of rainfall or irrigation. Under irrigation production, the crops needs propping of the vines to raise the pods off from the ground to reduce damage during harvesting or damage by soil borne diseases. Fresh pod yield can vary from 5 to 8 tons ha⁻¹.

Variety	Grain yield kg ha ⁻¹	Fodder Yield kg ha ⁻¹	Maturity (days)	100 seed weight (g)	Harvest index
TVU 5138	2799	5529	99.25	20.96	0.506
Bechuana white	2384	5520	103.50	14.74	0.441
TVU 8464	2010	3669	97.50	14.09	0.541
TVU 13004	1993	5101	103.75	15.26	0.410
TVU 14190	1969	4912	99.50	18.71	0.429
TVU 8016	1960	5466	95.00	18.43	0.363
TVU 2095	1639	4202	104.25	18.16	0.402
TVU 5146	1610	4311	101.75	20.42	0.387
TVU 3416	1541	6286	110.25	14.27	0.241
GLEND A	1496	4293	103.50	12.50	0.362
TVU 3391	1419	5862	112.25	12.09	0.248
TVU 13932	979	6444	144.25	16.52	0.164
TVU 1836	694	2350	103.00	14.52	0.179
TVU 9671	512	2532	109.25	19.50	0.206
P Level (P < 0.05)	0.001	0.002	0.001	0.001	0.001

Table 3.
Yield of dual-purpose cowpea varieties.

Variety	Grain yield (Kg ha ⁻¹)	Fodder yield	100 seed weight (g)	maturity (days)
6--1--1	2610.1b	8296.4a	22.67a	95.0b
6--4--1	3039.9a	5036.8c	19.29ab	95.0b
6--4--4	3059.0a	6222.2ab	19.25ab	96.0b
6--2--1	1895.1d	2601.3e	19.08c	93.0b
6--2--2	2142.6c	2800.1d	19.89ab	95.0b
6--3--1	2080.0c	3021.98d	19.20c	91.0b
JanaFod	1650.34e	6124.67ab	11.02 d	118a
P Level (P < 0.05)	0.001	0.0001	0.002	0.04
Early maturity = 80–90 days, Medium maturity 91–100 days, Late maturity = >101 days.				

Table 4.
Yield of some advanced medium maturity elite cowpea breeding lines.

Vegetable varieties offer a regular source of income to farmers as they have easy buyers of their produce in the rural markets who sell the green pods with other leafy vegetables, spinach and lettuce. The adoption of these varieties will increase family intake and improve their diet and nutrition reduce malnutrition in rural communities [6, 7].

3.5 Development of cowpea varieties for intercropping

Intercropping is an integral part of cropping system in many provinces of South Africa particularly by smallholder farmers where communal land is limiting and drought-prone. In South Africa, many small scale farmers practice intensive crop production to reduce the risk of crop failure and maximize profit per unit area [6]. Additional reason for intercropping is to reduce pest

Figure 6.
Four advanced vegetable cowpea types with long pods ranging from 30 - 75 cm.

incidence. Specific varieties were developed with particular plant architecture and canopy structure designed for alternate row and double row cereal-cowpea intercropping system for maximization of land equivalent ratio (LER). Cowpea with narrow leaf blade and canopy width has been developed for alternate row intercropping system with cereals (**Figures 7 and 8**). They require reduced inter- and intra-row spacing for maximization of plant density per hectare. The varieties developed for intercropping particularly the early maturing varieties can always fit in any intercropping system. The implication of this is that the varieties increase the productivity and profitability of the farmers using poor marginal soils (**Figure 8**) [8, 14].

3.6 Development of cowpea varieties with combined pest resistance

One of the ways to reduce over dependence on chemical spray for the control of prevailing pest spectrum of cowpea is to develop varieties with increased host plant resistance. This has been achieved by deploying varieties with combined insect pest resistance as breeding parents to develop new germplasm with medium to high resistance to different insect pests (**Table 1**). The promising genotypes were screened for resistance for each insect pest for confirmation of resistance using appropriate screening technique [22, 23]. The elite lines with combined pest resistance have the advantage of requiring minimum insect spray. This will ultimately reduce production cost and increase the profit margin of the farmers.

3.7 Development of late maturing varieties (101: 120 days)

Few varieties were developed for late maturity. They are photosensitive and suitable for fodder and leafy vegetables (**Table 5 and Figure 3**). The fodder yield is very high with low grain yield. Some varieties if planted in October/November may not produce seed until the month of March when day length is shorter. To produce seed of such varieties, planting should be done during the first week of January while for fodder production planting can be done in the months of October or November. JanaFod is one of the late maturing varieties (**Table 6 and Figure 3**) developed for fodder and could produce 6000 kg ha⁻¹ of haulm [2]. The advantage of producing late maturing varieties is that it will enhance hay/fodder production particularly by commercial farmers who can use irrigation in their production system. The fodder

Figure 7.
Narrow leaf cowpea types developed for high density monocropping and intercropping.

Figure 8.
Cowpea shows its ability to meet its nitrogen requirement as compared to maize.

produced can be bailed and sold to other farmers during offseason or farmers who cannot produce fodder for their animals. The fodder production from the developed varieties will enhance feed security for livestock industry in South Africa.

3.8 Development of cowpea varieties for quality traits

Important quality traits apart from the nutrient elements addressed through breeding programme include, seed coat color, texture and size. These traits influence consumer preferences and demand pull [24]. Fortification of the varieties with nutrients such as protein, zinc and iron is an integral part of our breeding activities. Elite varieties are subjected to nutrient analyses in search of varieties with higher nutrient contents to be used as breeding parents (**Tables 7 and 8**). To meet the needs of consumers, different seed coat, and eye colors (**Figure 9**) with different

Variety	Grain yield kg/ha	Fodder yield kg/ha	Maturity	100-Seed weight (g)	Harvest index
TVu 3310	3947	21,293	140.937	10.30	0.1539
TVu 13,437	525	13,524	123.604	11.93	0.0560
TVu 1878	2371	10,584	134.270	17.41	0.2235
TVu 7530	2076	6255	89.134	14.33	0.4315
TVu 11,955	2220	6065	92.937	14.30	0.4213
TVu 1645	3170	6026	94.604	9.49	0.6635
TVu 1979	1940	5966	92.937	11.85	0.3352
Bechuana white	2223	5005	103.270	14.88	0.4424
TVu 13,953	127	4669	136.937	*	0.0215
TVu 14,719	2424	4323	98.604	12.71	0.5576
IT00K-1060	1110	4280	103.937	18.42	0.2942
TVu 7757	1886	3053	88.604	11.16	0.6177
Glenda	1179	3019	106.937	13.72	0.4033
P-level (P < 0.05)	0.010	0.01	0.001	0.001	0.002

Table 5.
Performance of fodder cowpea varieties evaluated at Taung.

Variety	Fresh pod weight	Maturity	100-seed
	Kg ha ⁻¹	(days)	weight (g)
TVu 1916	5143a	99b	13
TVu 1727	2743b	106a	18.4a
TVu 15654	2183c	89c	18a
TVu 6439	1888d	96b	15.3d
TVu 14868	1303e	92c	16.1c
TVu 14,868	1232f	90c	16c
TVu 2852	825 g	98b	15d
TVu 6477	721 g	107a	14.4e
TVu 14861	684 h	92c	15.8d
P Level (P < 0.05)	0.001	0.001	0.001

Table 6.
Performance of vegetable cowpea varieties.

coat textures (smooth, rough and wrinkled) were developed. Consumers’ feedback suggests that rough and wrinkled seeds cook faster because they imbibe water faster during cooking as compared to smooth-coated varieties. These quality traits were achieved by crossing parents with different coat colors, eye colors and seed coat textures as well as seed size. The variation in nutrient content indicates variation in the genetic makeup of the varieties. The fortification of the varieties with nutrients especially zinc and iron will enhance the nutrition of the consumers and in addition, it offers opportunity for the varieties to be used for further crop improvement to generate new genotypes with higher nutrient contents. The different quality traits exhibited by the varieties give the farmers the opportunity to make choice and select their preferred varieties. This will improve their intake and nutrition and reduce malnutrition [7]. The availability of the varieties will enhance food security and nutrition in South Africa.

3.9 Cowpea varieties registered and released

As many genotypes are in the pipeline of development and selection, some of the advanced breeding lines that have been test in multiple locations and seasons were submitted for registration with the intension to release them for commercialization. In the light of this, four cowpea varieties have been registered for a release at the National Department of Agriculture (DAFF), Genetic Resources, Pretoria. The varieties are:

1. JanaFod (ARC-09-001, ZA 20125043) cream cowpea
2. ARC-GCI-CP76 (VL 2009/7536) brown cowpea
3. UL-589 (VL 2017/10266) white cowpea
4. UL-1010 (VL 2017/10267) white cowpea

In addition, six early/medium maturity cowpea varieties have been submitted for registration at the National Department of Agriculture (DAFF), Genetic Resources, Pretoria and they include

Genotypes	Maturity days	Maturity periods	Seed weight	Seed size	Seed color	Eye color	Coat Texture
IT98K-962 X IT97K-499-35	94	Early	20.46	Large	White	Black	Wrinkled
IT98K-962 X IT98K-205-8	91	Early	18.30	Large	White	Black	Wrinkled
IT98K-962 X TVX 3236	96	Early	18.61	Large	White	Brown	Wrinkled
IT97K-497-2 X IT98K-962	93	Early	22.70	Large	White	Black	Rough
IT97K-497-2 X Oloyin	95	Early	18.60	Large	Cream	Brown	Smooth
IT97K-497-2 X IT82D-889	95	Early	20.52	Large	Brown	Brown	Smooth
IT00K-1217 X IT98K-962	96	Early	22.08	Large	White	Black	Smooth
IT98K- 205-8 X Oloyin	95	Early	19.28	Large	Brown	Black	Rough
IT98K-205-8 X IT98K-406-2	89	Early	19.39	Large	White	Black	Rough
IT90K-76 X Oloyin	94	Early	21.86	Large	White	Brown	Wrinkled
BW (Local check)	95	Early	15.67	Medium	White	Gray	Smooth

Early maturity = 80–90 days, Medium maturity 91–100 days, Late maturity = >101 days. Large seed = above 18 g, Medium size = 12–18 g.

Table 7.
Some quality traits (seed size, seed color, eye color and coat texture) of elite cowpea breeding lines.

Variety	CP (%)	Zn (ppm)	Fe (ppm)
Bechuana W.	20.30a	16.55abc	49.95abc
Glenda	24.70a	36.73abc	79.43abc
IT00K-1060	25.72a	36.50abc	107.08abc
IT00K-1263	25.26a	26.88abc	94.65abc
IT84S-2246-4	24.35a	18.05abc	123.30abc
IT86D-1010	19.03ab	59.57ab	145.77ab
IT86D-719	24.05a	59.75ab	150.55a
IT95K-1156-3	25.00a	38.80abc	113.70abc
IT95 K-1491	27.05a	42.35abc	108.60abc
IT97K 390–2	25.45a	60.45a	121.55abc
IT98K-1105	25.30a	15.75abc	47.35abc
IT98K-463-6	29.85a	17.13abc	55.67abc
IT98 K-530-1	23.23a	34.00abc	133.80abc
IT98K-690	26.63a	30.97abc	130.03abc
IT99K-316-2	22.25a	44.20abc	110.65abc
IT99 K-494-6	26.60a	46.3abc	94.33abc

Variety	CP (%)	Zn (ppm)	Fe (ppm)
IT99K-529-1	27.90a	18.60abc	47.20abc
JanaFod	26.40a	39.40abc	20.00c
TVu 13464	21.25a	38.55abc	108.45abc
P-Level	0,04	0,04	0,03

Table 8.
Nutrient contents of improved cowpea varieties.

Figure 9.
Different seed coat colors bred for south African consumers.

- 1. UL-11
- 2. UL-12
- 3. UL-13
- 4. UL-14
- 5. UL-15
- 6. UL-16

These varieties upon registration and release will enhance the food and nutrition security of people in South Africa. Farmers will have seed of improved and pure varieties available to plant, and as they cultivate these varieties their profit margin will increase with better nutrition. This will also create jobs for all the value chain in cowpea production [7].

4. Conclusions

Cowpea production in South Africa is limited by lack of improved varieties that exhibit good agronomic traits and pest resistance. In the last decade and a half, significant breeding efforts as shown in the results of this study have attained great achievements in cowpea improvement to address the limitations in cowpea production. Several elite cowpea genotypes in the pipeline of development have been achieved, varieties that exhibit good agronomic and quality traits to enhance intake and nutrition in the rural communities have been developed 10 genotypes expressed high grain yield with combined pest resistance (aphids, bruchid, virus, leafhopper and bacterial blight). The implication of this achievement is that farmers can attain more grain yield per unit land area. In addition, the cultivation of these genotypes will reduce the cost of pest control and increase the profit margin of the farmers. Another important achievement of the study is that four elite varieties (JanaFod, ARC-GCI-CP76, UL-58 and UL-1010) have been registered while six varieties (UL-11, UL-12, UL-13, UL-14, UL-15 and UL-16) have been submitted for registration. The future activity is to commercialize the varieties to enhance uptake and availability of seeds to seed growers, farmers and consumers. The availability of seeds of these varieties will increase cultivation by farmers, enhance food security and nutrition and reduce malnutrition in South Africa. Since breeding is a continuous process, some of the varieties and other promising genotypes will be used through recurrent selection to develop new germplasm that are more adapted to the region as well as being climate smart.

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