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**Original article**

# Morphological study of cultivated cowpea *Vigna unguiculata* (L.) Walp. Importance of ovule number and definition of cv gr Melanophthalmus

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**Abstract** – More than 400 cultivated cowpea accessions were studied using 29 morphophysiological characters. The analysis of data contrasts evolved cultivars and more primitive cultivars (and wild forms) according to seed size on the one hand and early and late flowering (under inductive conditions) on the other hand. The latter character is markedly correlated with ovule number. Photosensitive and early-flowering photoindependent cultivars have 11–17 ovules per pod and late flowering photoindependent cultivars have 16–25 ovules per pod. The analysis leads to assigning the accessions studied to the following different cultigroups: cv gr Unguiculata, cv gr Sesquipedalis, cv gr Biflora and cv gr Melanophthalmus, the latter newly separated from cv gr Unguiculata. (© Inra/Elsevier, Paris.)

**cowpea / *Vigna unguiculata* / photosensitivity / ovule number**

**Résumé – Étude morphologique des formes cultivées du niébé *Vigna unguiculata* (L.) Walp. importance du nombre d'ovules et mise en évidence du cultigroupe Melanophthalmus.** Une collection de plus de 400 numéros de formes cultivées de niébé, provenant en majorité du Cameroun, a été étudiée suivant 29 caractères morphophysiologiques. L'analyse montre deux tendances : une opposition entre cultivars primitifs (et formes spontanées) et cultivars évolués suivant la taille des organes et en particulier des graines et une opposition entre cultivars précoces et tardifs (en conditions inductives). Ce dernier caractère apparaît fortement corrélé au nombre d'ovules. Les cultivars photo-indépendants précoces et photosensibles ont un faible nombre d'ovules par gousse (11–17) alors que les cultivars photo-indépendants tardifs ont un nombre d'ovules élevé (16–25). Quatre cultigroupes sont mis en évidence : cv gr Sesquipedalis, cv gr Biflora, cv gr Unguiculata et cv gr Melanophthalmus, nouveau cultigroupe autrefois confondu avec cv gr Unguiculata. (© Inra/Elsevier, Paris.)

**niébé / *Vigna unguiculata* / photosensibilité / nombre d'ovules**

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## 1. INTRODUCTION

Cowpea, *Vigna unguiculata* (L.) Walp., is one of the main world pulses. Domesticated in Africa, cowpea is now cultivated in all tropical areas and in some temperate areas such as the Mediterranean Basin, Iran, China and the southern states of the USA.

Linnaeus described *Dolichos unguiculatus* L. (later renamed *Vigna unguiculata* (L.) Walp.) in 1753. Between 1753 and 1845, more than 20 binomials were described from cultivated *V. unguiculata* specimens. These binomials were considered as conspecific and ranked at infraspecific levels during the second half of the XIXth century. Now, cultivated forms are pooled in *V. unguiculata* ssp. *unguiculata* var. *unguiculata* and wild annual forms in ssp. *unguiculata* var. *spontanea* (Schweinf.) Pasquet. Wild perennial forms are ascribed to ten subspecies [17–19]. Wild annuals are easily crossed with cultivated cowpeas [16].

Two opposing approaches have been suggested for the classification of cultivated *V. unguiculata*.

One was issued from Piper's [22] study of US cultivated forms. Three groups, known since Linnean works (1763), were separated according to seed and/or pod sizes (*table I*). Later, these groups were ranked at all the possible taxonomic levels, and Westphal [28] finally used the cultigroup rank (group of cultivars). Now widely accepted [15, 16], this classification is not always convenient. Cv gr Biflora is not easily separated from cv gr Unguiculata as pod orientation is tightly dependent on pod and seed weight [22]. Steele [24], recognizing that Piper's system [22] and Verdcourt's [27] classification were not fitted with African cultivated forms, proposed a fairly complex key, including seed testa texture and photosensitivity. Later, Steele admitted Piper's trilogy, while highlighting opposition between photosensitive and photoindependent groups [25].

Another concept, strangely not used, is that of Chevalier [2]. Chevalier's classification considered the number of seeds per pod, which was an important difference with respect to Piper's classification. Chevalier divided West African cowpeas into two subspecies according to seed number per pod (*table I*). The subspecies with low seed number per pod was divided into four groups: wild, cultivated

**Table I.** Comparison of cultivated cowpea classifications.

| Linnaeus (1763) | Piper (1912) | Westphal (1974) | Chevalier (african forms) (1944) |
|---|---|---|---|
| *Dolichos sesquipedalis* | *Vigna sesquipedalis* (asparagus bean) | cv gr Sesquipedalis<br>kidney shaped seeds 9-10 mm long,<br>very long fleshy pods > 30 cm. | |
| *Dolichos biflorus* | *Vigna catjang* (catjang) | cv gr Biflora<br>rhomboid seeds 5-6 mm<br>erect pods < 12 cm long. | subsp. *lubia* var. *campestris*<br>small seeds (100 seeds weight = 4-8 g),<br>smooth testa,<br>pods 8-14 cm long with 5-10 seeds per pod. |
| *Dolichos unguiculatus* | *Vigna unguiculata* (cowpea) | cv gr Unguiculata<br>rhomboid seeds 6-12 mm<br>pendant pods 12-30 cm long. | subsp. *lubia* var. *melanophthalmus*<br>large seeds (100 seeds weight = 12-20 g),<br>wrinckled testa,<br>pods 8-15 cm long with < 15 seeds per pod.<br>subsp. *oleraceus*<br>large seeds (100 seeds weight = 12-20 g),<br>smooth testa,<br>pods 18-22 cm long, with 18-20 seeds per pod. |

with smooth testa seeds, cultivated with wrinkled testa seeds (var. *melanophthalmus* (DC.) A. Chev.), and cultivated with long inflorescence peduncles. Unfortunately, Chevalier's classification included Asian cowpeas (Piper's classification *in extenso*) and West African cowpeas without discussing the connections between the two.

The objective of this study was to obtain a better knowledge of the cowpea gene pool organization. A representative collection was studied through morphological variability.

## 2. MATERIAL AND METHODS

Among the 463 accessions studied, 24 were wild annual cowpeas *V. unguiculata* ssp. *unguiculata* var. *spontanea* (mainly from northern Cameroon), 59 were cultivated cowpeas from various origins (South Africa, Ethiopia, Togo, Zaire, Madagascar and Asia), and 380 were cultivated cowpeas from Cameroon. Accessions from Cameroon were collected during an ethnobotanical survey [20]. They belonged to 51 of the 89 cultivars identified (*table II*). Cultivars were identified through

**Table II.** Accession number. Observation number is between brackets when it exceeds accession number.

| Country | Cultivar | Number of accessions | Cultivar | Number of accessions | Cultivar | Number of accessions |
|---|---|---|---|---|---|---|
| Cameroon | CS 5 | 10 (11) | NO 144 | 1 | NO 1732 | 1 |
| | E | 9 | NO 172 | 35 (36) | NO 1795 | 16 (17) |
| | CS 15 | 18 | NO 173 | 14 | NO 2063 | 1 |
| | IRA | 7 (9) | NO 183 | 7 | NO 2206 | 3 (4) |
| | NO 3 | 14 | NO 251 | 7 (8) | NO 2208 | 1 |
| | NO 5 | 12 | NO 252 | 4 | NO 2295 | 2 |
| | NO 11 | 3 | NO 259 | 17 (20) | NO 2304 | 1 |
| | NO 15 | 3 | NO 347 | 5 (6) | NO 3157 | 4 |
| | NO 42 | 2 | NO 348 | 3 | OU 31 | 31 (32) |
| | NO 74 | 5 | NO 472 | 6 | OU 65 | 5 |
| | NO 90 | 1 (2) | NO 576 | 5 | OU 83 | 15 (16) |
| | NO 95 | 5 | NO 649 | 4 | OU 130 | 3 |
| | NO 106 | 2 | NO 760 | 2 | LI CS 5 | 9 (11) |
| | NO 110 | 2 (3) | NO 929 | 2 | LI OU 31 | 22 (24) |
| | NO 117 | 2 | NO 1036 | 1 | LI OU 83 | 6 (8) |
| | NO 125 | 2 | NO 1319 | 3 | S | 39 (44) |
| | NO 133 | 4 | NO 1616 | 3 | TVX 3236 | 1 |
| South Africa | | 28 (31) | | | | |
| Ivory Coast | | 1 (2) | | | | |
| Egypt | | 1 (2) | | | | |
| Ethiopia | | 4 (6) | | | | |
| Madagascar | | 7 (10) | | | | |
| Togo | | 1 | | | | |
| Zaïre | | 5 (6) | | | | |
| America | | 2 | | | | |
| Asia | | 9 (12) | | | | |
| unknown origin | | 1 | | | | |

S: accessions with wild seed phenotypes (tan, grey, marbled, speckled, and combination of these characters) with pods white or brown-grey. E: accessions with Small Eye seed colour pattern [20]. IRA: accessions from unknown origin obtained from Dschang (Cameroon, West province) Institut de recherche agronomique. TVX 3236: an IITA cultivar collected during the Cameroon survey. Cultivar NO 2206 (with grey seed and white pod), rare and very recently introduced in Cameroon, was not considered in the study of cultivar geographical distribution [20].

pod and seed characters and usually displayed precise areas of cultivation. Collected accessions having similar pods and seeds were pooled in the same cultivar.

Wild annual and cultivated cowpeas are self-pollinated [8, 9]. Outcrossing rates are usually very low, 1 % or less [24, 29]. Consequently, accessions were mostly single seed descents maintained by self-pollination.

Forty-one accessions were studied during two or three successive cropping cycles. Resulting data were kept as standard in the analysis. Therefore, 514 sets of data (including 35 sets of data from wild annual cowpea) were included in the analysis.

Morphological characters were recorded in SODECAO (Société de Développement du Cacao) field station in Mengang, southern Cameroon (4°N), 80 km east of Yaoundé. Accessions were sown as rows of 20 seeding holes (two seeds per seed-hole, spacing 25 cm between the seeding holes and 1.5 m between the rows), in a single block.

Twenty-nine morphophysiological characters were recorded (*table III*). All lengths and ovule counts were averages of 15 observations, each made from a different plant from the row. Because peduncle length was very variable within each plant, all peduncles from one lateral stem per plant were measured in order to reach 40 measures.

Seed testa thickness was estimated through a microscope, and palissadic cell lengths were recorded according to Lush and Evans [13]. Number of spirally thickened fibre layers in pod section [14], which eventually induced mature pod dehiscence, were also observed. In both cases, a single observation was performed for each accession and no staining was required.

Photosensitivity was studied in Niamey (13°40'N) because in Mengang (4°N), daylength variation, between 11 h 40 mins and 12 h 30 mins, was not enough to study this phenomenon. In Niamey, one plant per accession was observed, following Steele's [24] protocol.

– Sown in November, photosensitive accessions quickly flowered from the first nodes of the main stem, when days were the shortest of the year (between 11 h 10 mins and 11 h 30 mins). Photoindependent accessions flowered after 2 or 3 months, from remote nodes on stems several meters long. V09 was the number of days between sowing and first flowering during this winter cropping cycle.

– Sown in May, under increasing daylength, photoindependent accessions flowered before August, when days were the longest of the year (between 12 h 40 mins and 13 h). Photosensitive accessions flowered later, when daylength decreased. V10 was the number of days between sowing and first flowering during this summer cropping cycle.

Hierarchical cluster analysis was performed using the K-nearest neighbours method. Then, a discriminant analysis and a variance analysis were performed from the partition given by the cluster analysis. The main variables given by these analyses allowed us to suggest a key. The classification was tested through a principal component analysis which showed how variables and groups interacted.

**Table III.** Morphological and physiological characters.

| Variable | Character |
|---|---|
| V01 | Epicotyl length (mm) |
| V02 | Primary leaf length (mm) |
| V03 | Primary leaf width (mm) |
| V04 | Stipule length in mm (sixth or seventh leaf) |
| V05 | Stipule width (mm) |
| V06 | Terminal leaflet length in mm (sixth or seventh leaf) |
| V07 | Terminal leaflet width (mm) |
| V08 | Terminal leaflet length at maximum width (mm) |
| V09 | Flowering date (november sowing) |
| V10 | Flowering date (may sowing) |
| V11 | Flower length (mm) |
| V12 | Flower half-width (mm) |
| V13 | Wing length (mm) |
| V14 | Wing width (mm) |
| V15 | Calyx-lobe length (mm) |
| V16 | Calyx-tube length (mm) |
| V17 | Percentage of colored area in standard (flower color) |
| V18 | Spiral layer number in pod section (pod dehiscence) |
| V19 | Pod length (mm) |
| V20 | Pod width (1/10 mm) |
| V21 | Pod thickness (1/10 mm) |
| V22 | Ovule number |
| V23 | Inflorescence rachis length (mm) |
| V24 | Inflorescence rachis node number |
| V25 | Inflorescence peduncle length (cm) |
| V26 | Seed length (1/10 mm) |
| V27 | Seed width (1/10 mm) |
| V28 | Seed thickness (1/10 mm) |
| V29 | Palissadic cells length in µm (seed testa) |

## 3. RESULTS

Intra-accession variability was low. Coefficients of variations were in the range 0.02–0.09 for flower and pod measurements, 0.13–0.18 for leaf measurements and 0.26–0.38 for peduncle lengths. This could be expected as accessions were lineages issued from one to few seeds. Within cultivars and between accessions, coefficients of variation were higher, in the range 0.06–0.14 for flower variables, 0.04–0.25 for pod variables, 0.10–0.27 for leaf variables and 0.04–0.36 for inflorescence peduncle length. This could be also expected as cultivars were identified chiefly through qualitative characters such as seed and pod colour patterns and often had heterogeneous seed sizes.

The variables dealing with the size of the different organs were correlated to each other: 0.52–0.68 between stipule and leaflet, 0.39–0.47 between leaflet and flower, 0.45–0.64 between flower and pod (width and thickness), flower and seed, and flower and primary leaf, although correlations over 0.11 were significatively non-nul at 5 % level. Correlations within each organ were much higher: 0.82 within primary leaf, 0.74 within leaflet, 0.69–0.85 within flower, 0.71–0.92 within pod (width and thickness) and seed. Pod length was correlated with both ovule number (0.66) and seed length (0.72). High correlations were also found between inflorescence rachis length and inflorescence rachis node number (0.88), and between flower colour and seed testa thickness (0.93).

Ovule number appeared correlated with flowering date under short days (0.76) and flowering date under long days (–0.67) but the situation was more complex. There were three groups and each of these groups showed a particular habit, even if this habit was not accurately observed in our study.

i) The early photoindependent cowpeas (with ovule number lower than 17) which flower quickly from the first nodes of the main stem whatever the daylength. They show an erect habit. They belongs to cv gr Biflora and cv gr Melanophthalmus (accessions from high latitude such as India or the Mediterranean Basin).

ii) The photosensitive cowpeas (with ovule number lower than 17) which flower late with a trailing habit under long days. But they flower quickly from the first nodes of the main stem with an erect habit under inductive condition. They belong to cv gr Biflora and cv gr Melanophthalmus (accessions from low latitude such as West Africa).

iii) The late photoindependent cowpeas (with ovule number higher than 16) which flower late even under inductive conditions from remote nodes of the different stems. They show a twining habit. They belong to cv gr Unguiculata and cv gr Sesquipedalis.

These correlations allowed us to consider only 15 variables: V01, V03, V05, V07, V09, V10, V11, V15, V18, V19, V20, V22, V25, V26 and V29.

Hierarchical cluster analysis with these 15 variables provided four groups:

– group 1 included 199 observations from CG Sesquipedalis and late photoinsensitive accessions;

– group 2 included the 35 observations from the wild accessions;

– group 3 included 115 observations from photosensitive thin testa seeded accessions;

– group 4 included 165 observations, mostly from photosensitive thick testa seeded accessions.

Discriminant analysis, from the partition issued from the cluster analysis, reached 89.30 % of well classified within four steps with variables V10 (summer cropping cycle flowering date), V18 (pod dehiscence), V29 (seed testa) and V22 (ovule number). The variance analysis performed with the same partition, and the final vectors of the discriminant analysis showed that V09 (winter cropping cycle flowering date), V19 (pod lenght) and V20 (pod width) were also discriminant variables.

This allow us to propose a key identifying different cultigroups:

– fleshy pod, wrinkled when ripe, longer than 30 cm, reniform seeds spaced within the pod, ovule number higher than 17:

cv gr Sesquipedalis

– unfleshy pod, shorter than 30 cm, seed not spaced within the pod

– seed testa thin and often wrinkled, flower and seed partly white, ovule number lower than 17 (plant able to flower quickly from the first nodes under inductive conditions):

cv gr Melanophthalmus

– seed testa thick and shiny, flower and seed most often coloured

– ovule number lower than 17 (plant able to flower quickly from the first nodes under inductive conditions):

cv gr Biflora

– ovule number higher than 16 (plant flowering late, even under inductive conditions):

cv gr Unguiculata.

For practical reasons, this key emphasizes morphological characters and uses ovule number instead of flowering dates.

Cultivated cowpeas with low ovule number and thick seed testa included Asian accessions with erect pods. This group was identified with cv gr Biflora. Cultivated cowpeas with high ovule number included accession ET 35, from seeds from the *V. unguiculata* neotype chosen by Westphal [28] and corresponded *de facto* to cv gr Unguiculata. Cultivated cowpeas with thin seed testa corresponded to var. *melanophthalmus* A. Chev. and cv gr Melanophthalmus needed to be established.

Main variables distribution between cultigroups are reported in *table IV*. The lower epicotyl lengths and the higher peduncle lengths in cv gr Unguiculata can be noted. More important, the trend of the size variables, which set wild cowpeas and cv gr Biflora against cv gr Melanophthalmus, Unguiculata and Sesquipedalis can be noted. Of course, pod length (V19) and seed length (V26) emphasize cv gr Sesquipedalis and its very long pods. Most important is ovule number (V22) which sets cv gr Biflora and cv gr Melanophthalmus against cv gr Unguiculata and cv gr Sesquipedalis.

Both principal component analysis diagrams, with 15 variables or with five variables showed the same patterns, groups overlapping more while using 15 variables. The distribution of cultivated cowpea points appeared crescent shaped with the wild cowpea points external to the middle of the crescent (*figure 1*).

First axis (38.5 % of variance explained in the analysis with 15 variables and 51.8 % in the analysis with five variables) was controlled by the variables dealing with organ size (V03, V11, V15, V19, V20, V26) and pod dehiscence (V18). All these variables clearly separated wild from cultivated cowpeas and showed cv gr Biflora close to wild cowpeas (*table IV*).

Second axis (21.4 and 29.0 % of variance explained) was controlled by V29 (seed testa), V09 and V10 (flowering dates), and V22 (ovule number). V01 (primary leaf length) and V25 (peduncle length) though less important were mainly represented in this second axis.

## 4. DISCUSSION

There are four groups within cultivated cowpea, i.e. cv gr Biflora, cv gr Unguiculata, cv gr Sesquipedalis and cv gr Melanophthalmus, and two groups within morphophysiological characters: on the one hand, those related to seed size (factor 1), on the other hand, those related to ovule number and flowering dates (factor 2).

### 4.1. Overlap of seed and pod size

Our results highlight the important overlap of seed and pod size (*table IV*) which weakened Piper's [22] and Verdcourt's [27] keys, as did previous studies [5, 21, 24]. These characters are not suitable for separating groups within cultivated cowpea.

### 4.2. Ovule number

Ovule number (V22) appears more discriminant, splitting cultivated cowpea into two groups: cv gr Biflora and cv gr Melanophthalmus on the one hand, cv gr Unguiculata and cv gr Sesquipedalis on the other. This result can be found in Steele's study [24]: photoindependent accessions from Nigeria

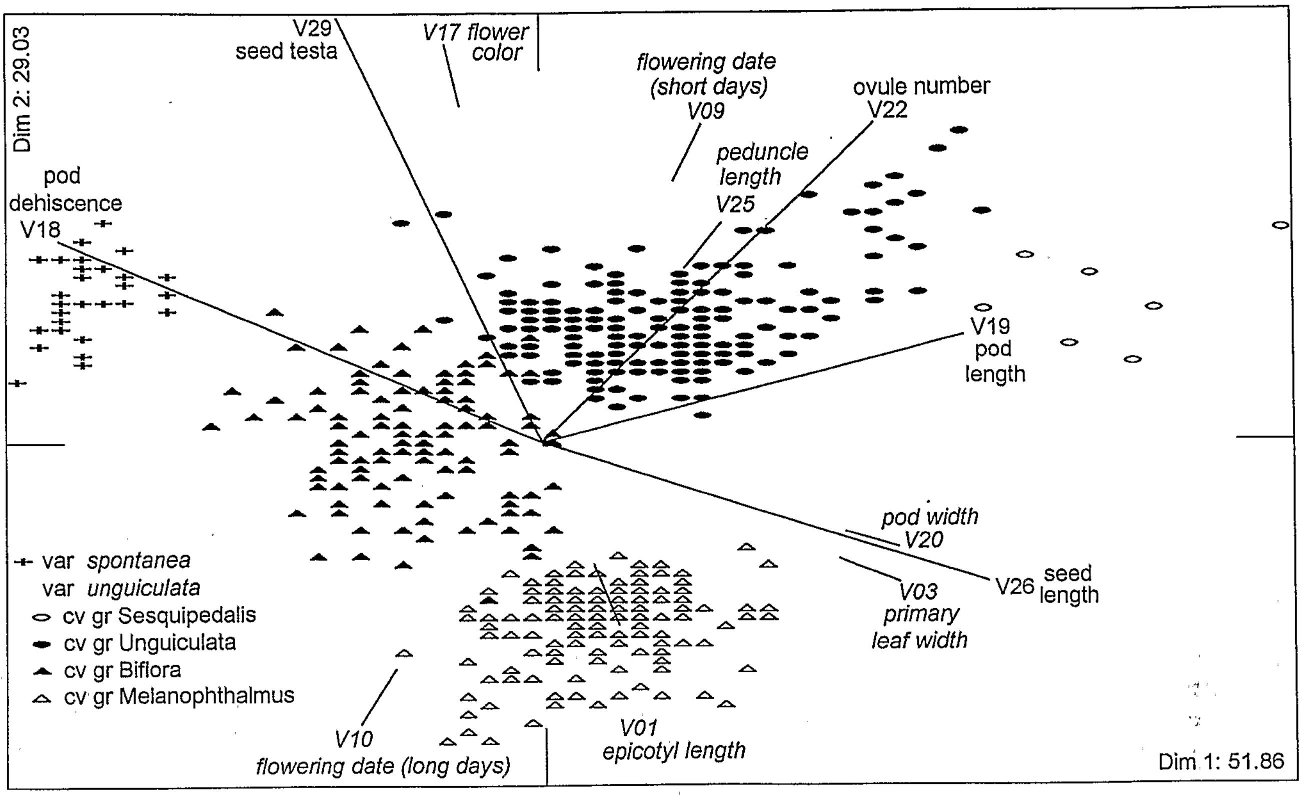


**Figure 1.** Biplot: principal components and loadings × 4. Illustrative variables are in italics.

(cv gr Unguiculata) show seeds obviously shorter than those from photosensitive accessions (cv gr Melanophthalmus and cv gr Biflora) (figure 2.2, p. 79) while both groups show similar pod lengths (figure 2.3, p. 80), which suggests a higher number of seeds per pod in photoindependant accessions from Nigeria (cv gr Unguiculata).

However, though an important yield component, ovule number or number of seed per pod were not recorded by Steele [24] and other authors [5, 7, 21]. Therefore, Steele [24] reduced ssp. *cylindrica* (cv gr Biflora) to the early photoindependent accessions with erect pods and erect habit, and was unable to find separating traits for cv gr Biflora and cv gr Unguiculata.

### 4.3. Photosensitivity versus photoindependence or ability to flower quickly under inductible conditions

Ovule number is especially important since it appears correlated with flowering dates (V09 and V10). This leads to the separation of late from early photoindependent cowpeas which was not considered by Summerfield and Roberts [26] and Craufurd et al. [3]. However, the three different habits (erect, twining and trailing) were observed by several authors [2, 15, 24], and Steele noticed that habit and photosensitivity were sometimes linked.

Steele [24] also noticed that under inductive conditions (short days), photosensitive cowpeas and early photoindependent cowpeas showed iden-

**Table IV.** Mean and standard deviation of most discriminant variables regarding the different cultigroups. F crit = 2.38 at 5 % level.

| | V09 flowering date (november sowing) | V10 flowering date (may sowing) | V17 flower color |
|---|---|---|---|
| CG Biflora | 46.7 ± 5.9 | 134 ± 27 | 83.2 ± 32.5 |
| CG Melanophthalmus | 45.1 ± 5.1 | 142 ± 12 | 23.3 ± 12.8 |
| CG Unguiculata | 72.7 ± 9.1 | 76 ± 9 | 99.4 ± 5.1 |
| CG Sesquipedalis | 61.7 ± 2.6 | 67 ± 3 | 100.0 ± 0.0 |
| var *spontanea* | 52.1 ± 4.0 | 146 ± 13 | 100.0 ± 0.0 |
| F | 435.2 | 485.8 | 444.4 |
| | **V18 spiral layer number (pod dehiscence)** | **V19 in cm pod length** | **V20 in 1/10 mm pod width** |
| CG Biflora | 1.37 ± 1.35 | 13.6 ± 1.7 | 70.0 ± 11.1 |
| CG Melanophthalmus | 0 | 17.2 ± 2.3 | 89.4 ± 10.1 |
| CG Unguiculata | 0.10 ± 0.46 | 20.1 ± 3.9 | 88.3 ± 15.5 |
| CG Sesquipedalis | 0 | 43.7 ± 6.9 | 91.7 ± 13.7 |
| var *spontanea* | 5.71 ± 0.39 | 9.2 ± 0.7 | 39.9 ± 5.8 |
| F | 509.8 | 301.8 | 162.4 |
| | **V22 ovule number** | **V26 in mm seed length** | **V29 in μ palissadic cell length (seed testa thickness)** |
| CG Biflora | 13.8 ± 1.2 | 7.4 ± 0.9 | 560.0 ± 10.4 |
| CG Melanophthalmus | 14.7 ± 1.3 | 8.7 ± 1.0 | 379.6 ± 5.5 |
| CG Unguiculata | 18.1 ± 1.6 | 8.3 ± 1.1 | 623.8 ± 3.2 |
| CG Sesquipedalis | 18.4 ± 1.0 | 11.8 ± 1.4 | 666.6 ± 2.4 |
| var *spontanea* | 14.0 ± 1.3 | 4.6 ± 0.6 | 667.7 ± 3.6 |
| F | 231.9 | 161.9 | 1549.7 |

tical habits, but sown under long days, photosensitive cowpeas and late photoindependent cowpeas showed different habits, trailing versus twining, respectively, even though maturation dates can be similar.

The difference is not exactly between photosensitive and photoindependent cowpeas but between cowpeas able or unable to early flower under inductive conditions. This ability to flower rapidly from the first nodes of the main stem under inductive conditions (physiological character) along with the ovule number (morphological character) allows cultivated cowpeas to be split into two very different main groups.

Sène [23] reported a single gene determinism for photosensitivity versus early photoindependence but genetic control of late photoindependence was not studied. Considering the ovule number, a monogenic control seems to be likely [1, 4, 10].

### 4.4. The two main morphophysiological groups

Principal component analysis performed with five variables (*figure 1*) clearly show two opposing groups. From wild cowpeas (on the left) were diverging cv gr Biflora and cv gr Melanophthalmus (toward the bottom) versus cv gr Unguiculata and cv gr Sesquipedalis (toward the top). As cv gr Unguiculata and especially cv gr Biflora are morphologically close to the wild cowpeas and look rather primitive, cv gr Melanophthalmus and cv gr Sesquipedalis appear to be the outcome of two divergent lineages. Both these latter cultigroups are characterized by the expression of several recessive genes. White flower, white seed and thin seed testa characterize cv gr Melanophthalmus. Pod fleshy, wrinkled when ripe, with spaced seeds characterizes cv gr Sesquipedalis [6].

These evolved groups (the most remote from wild cowpeas) are geographically isolated as cv gr Melanophthalmus is mainly West African and cv gr Sesquipedalis is from East Asia. However, Indian accessions are morphologically close to African photosensitive cowpeas with thick seed testa, which means that cv gr Biflora is encountered in Asia as well as in Africa. Cv gr Unguiculata is also encountered on both continents, although in Africa, this cultigroup is more characteristic of southern and eastern Africa. It was recently introduced in Cameroon [20] and presumably in rain forest areas of western Africa.

## 5. CONCLUSION

Compared to Steele's work [24], the correlation between photosensitivity (precisely the ability to flower quickly under inductive conditions) and the ovule number makes important progress in distinguishing cowpea cultigroups. This correlation allows a morphological distinction to be made between Steele's two main physiological groups (photosensitive and photoindependent), which Steele was unable to separate morphologically.

As Steele [24] demonstrated, there are two main groups separated by their physiology. However these groups are also separated by a morphological character, i.e. the number of ovules. Each main group is subdivided into a primitive subgroup (morphologically closer to wilds) and an evolved subgroup (morphologically more distant from wilds). These distinctions lead to four groups instead of the three always considered, i.e. cv gr Biflora, cv gr Unguiculata and cv gr Sesquipedalis. This work shows that a fourth cultigroup (cv gr Melanophthalmus) should be separated from cv gr Unguiculata owing to its thin and often wrinckled seed testa and its low ovule number. Morphologically, this cultigroup Melanophthalmus regarding cv gr Biflora is in the situation of cv gr Sesquipedalis regarding cv gr Unguiculata.

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## REFERENCES

[1] Aryeetey A.N., Laing E., Inheritance of yield components and their correlation with yield in cowpea (*Vigna unguiculata* (L.) Walp.), Euphytica 22 (1973) 386–392.

[2] Chevalier A., La dolique de Chine en Afrique, Rev. Bot. Appl. Agric. Trop. 24 (1944) 128–152.

[3] Craufurd P.Q., Ellis R.H., Summerfield R.J., Roberts E.H., Development in *cowpea (Vigna unguiculata)*. II. Effect of temperature and saturation deficit on time to flowering in photoperiod-insensitive genotypes, Exp. Agric. 32 (1996) 13–28.

[4] Drabo I., Ladeinde T.A.O., Redden R., Smithson J.B., Inheritance of seed size and number per pod in cowpeas (*Vigna unguiculata* (L.) Walp.), Field Crops Res. 11 (1985) 335–344.

[5] Faris D.G., Evidence for the West African origin of *Vigna sinensis* (L.) Savi, Ph.D. thesis, University of California, Davis, CA, USA, 1963.

[6] Fery R.L., Genetics of *Vigna*, Hort. Rev. 2 (1980) 311–394.

[7] IBPGR, Cowpea Descriptors, IBPGR, Rome, Italy, 1983.

[8] Kumar P., Prakash R., Haque M.D.F., Floral biology of cowpea (*Vigna sinensis* L.), Trop. Grain Legume Bull. 6 (1976) 9–11.

[9] Ladeinde T.A.O., Bliss F.A., Identification of the bud stage for pollinating without emasculation in cowpea (*Vigna unguiculata* (L.) Walp.), Nigerian J. Sci. 11 (1977) 183–194.

[10] Leleji O.I., Inheritance of three agronomic characters in cowpea (*Vigna unguiculata* L.), Euphytica 24 (1975) 371–378.

[11] von Linné C., Species Plantarum, vol. 2, ed. 1, Laurent Salvii, Stockholm, 1753.

[12] von Linné C., Species Plantarum, vol. 2, ed. 2, Laurent Salvii, Stockholm, 1763.

[13] Lush W.M., Evans L.T., The seed coats of cowpeas and other grain legumes: structure in relation to function, Field Crops Res. 3 (1980) 267–286.

[14] Lush W.M., Evans L.T., The domestication and improvement of cowpeas (*Vigna unguiculata* (L.) Walp.), Euphytica 30 (1981) 579–587.

[15] Maréchal R., Mascherpa J.M., Stainier F., Étude taxinomique d'un groupe complexe d'espèces des genres *Phaseolus* et *Vigna* (*Papilionaceae*) sur la base de données morphologiques et polliniques, traitées par l'analyse informatique, Boissiera 28 (1978) 1–273.

[16] Ng N.Q., Cowpea, *Vigna unguiculata* (Leguminosae-Papilionoideae), in: Smartt J., Simmonds N.W. (Eds.), Evolution of Crop Plants, ed. 2, Longmans, London, 1995, pp. 326–332.

[17] Pasquet R.S., Classification infraspécifique des formes spontanées de *Vigna unguiculata* (L.) Walp. à partir de données morphologiques, Bull. Jard. Bot. Nat. Belg. 62 (1993a) 127–173.

[18] Pasquet R.S., Two new subspecies of *Vigna unguiculata* (L.) Walp. (Leguminosae: Papilionoideae), Kew Bull 48 (1993b) 805–806.

[19] Pasquet R.S., A new subspecies of *Vigna unguiculata* (Leguminosae: Papilionoideae), Kew. Bull. 52 (1997) 840.

[20] Pasquet R.S., Fotso M., Répartition des cultivars de niébé (*Vigna unguiculata* (L.) Walp.) du Cameroun : influence du milieu et des facteurs humains, J. Agric. Trad. Bot. Appl. 36 (1994) 93–143.

[21] Perrino P., Laghetti G., Spagnoletti Z., Monti L.M., Diversification of cowpea in the Mediterranean and other centres of cultivation, Genet. Resources Crop. Evol. 40 (1993) 121–132.

[22] Piper C.V., Agricultural varieties of the cowpea and immediately related species, USDA, Bureau of Plant Industry, Bulletin No. 229, Washington, Government Printing Office, Washinton, DC, USA, 1912.

[23] Sène D., Déterminisme génétique de la précocité chez *Vigna unguiculata* (L.) Walp. Agron. Trop. 22 (1967) 309–318.

[24] Steele W.M., Cowpeas in Nigeria, Ph.D. thesis, University of Reading, Reading, UK, 1972.

[25] Steele W.M., Mehra K.L., Structure, evolution, and adaptation to farming systems and environments in *Vigna*, in: Summerfield R.J., Bunting A.H. (Eds.), Advances in Legume Science, Royal Botanic Gardens, Kew, 1980, pp. 393–404.

[26] Summerfield R.J., Roberts E.H., *Vigna unguiculata*, in: Halevy A.H. (Ed.), A Handbook of Flowering, CRC Press, Boca Raton, FL, USA, 1985, pp. 171–184.

[27] Verdcourt B., Studies in the Leguminosae-Papilionoideae for the flora of tropical East Africa. IV, Kew Bull. 24 (1970) 507–569.

[28] Westphal E., Pulses in Ethiopia: their taxonomy and agriculture significance, Agricultural Research Reports 815, Centre for Agricultural Publishing and documentation, Wageningen, the Netherlands, 1974.

[29] Williams C.B., Chambliss O.L., Outcrossing in southernpea, Hortscience 15 (1980) 179.