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ADAPTABILITY TEST OF EIGHT (08) COWPEA CULTIVARS (*VIGNA UNGUICULATA* (L.)) IN THE HIGH GUINEAN SAVANNAH ZONE OF CAMEROON

Jean-Baptiste Noubissié Tchiagam[1]*; Marie Maidikwa[1]; Dieudonné Gnapou[3]; Gaston Mana Guiwa[2]; David Amedep[4]; Sounou Paul Alioum[2]; Bertrand Wang-Bara[2]

[1]Department of Biological Sciences, Faculty of Sciences, University of Ngaoundere, Cameroon.

[2]Institute of Agricultural Research for Development (IRAD) Garoua, Cameroon.

[3]Institute of Agricultural Research for Development (IRAD) of Ngaoundere, Regional Center of Wakwa, Cameroon.

[4]Institute of Agricultural Research for Development (IRAD) of Ngaoundere, Regional Center of Maroua, Cameroon.

*Corresponding author

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ABSTRACT

Cowpea (*Vigna unguiculata* (L.) Walp) is one of the World's major legumes that has a major role in human and livestock nutrition due to its high protein content which varies from 22 to 30% of the dry weight of grains and leaves, from 13 to 17% in haulms. It is cultivated mostly in the Tropical and Subtropical region of Africa. In Cameroon, the cultivated area is 38.000 ha with a yield of 0.827 tons/ha for a production of 31.000 tons, with the Far North as the main supplier of this production in order to develop the Cowpea sector in the high Guinean savannah zone. The study is conducted in the locality of Bini-Dang (Ngaoundéré) on eight Cowpea cultivars introduce. The experiment consisted on a genotypic evaluation of different varieties which are selected. The experimental setup is a randomized block with 3 repetitions. The analyses of variance showed a significant difference on genotypic parameters: the emergence rate, onset of flowering at 50%, the maturation at 50%, the number of leaves, the height of plants, the number of fruiting nodes, the number of pods, the length of pods, the number of seeds per pod, the hundred seed weight and the yield per plant of the different varieties. The results showed the best performing varieties on yield like TN-27-80 (3576 kg/ha) and TN985-1399 (3269 kg/ha) and IT99K573-1-2 (3000 kg/ha). The variables on the agronomic parameters are all credible to operate the selection because of their broad sense of heritabilities for all the variabilities with h^2

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comprised between 0.63 and 0.98. The correlation among studied parameters is significant (P<0.05) and positive for the number of fruiting nodes and number of leaves per plant, the number of pods, the number of seeds per pod and the yield. The weight of hundred seed and the length of pod is significantly negative between the plant height and the number of leaves. This study shows the possibility of expanding Cowpea cultivation on this high Guinean savannah zone by using the eight cultivars tested.

Keywords: Cowpea, Adaptability, Cultivars, High Guinean Savannah.

1. INTRODUCTION

Cowpea is a tropical herbaceous legume, annual and preferentially autogamous (Fery, 1985). He presents a certain rate of allogamy according to the activities of pollinators insects (Tchueugeum *et al.,* 2009; kengni *et al.,* 2012; Adamou *et al.,* 2020). He includes two forms: the cultivated forms and wild form. The cultivated form is distinguished from wild forms by indehiscent pods, grains and larger pods size (Lush and Evans, 1981). The cultivated forms are grouped in the subspecies unguiculata (Baudoin, 2001).

Vigna unguiculata is one of principal leguminous plants that play a major role in term of human consumption and animal by their contents in essential amino-acids in minerals and vitamins (Pasquet & Baudoin, 1997). Its proteins rates vary from 22 to 30% of the dry weight of grains and leaves from 13 to 17% in the haulms. In Africa, the leaves are consumed fresh or dried vegetables (grains and leaves), the immatures pods and/or seeds are also eaten as vegetables in the rainy season. Cowpea is often consumed in occidental and central Africa in the form of steamed dough cake called Koki and donuts called Kosai or Akara (Mbofung *et al.*, 1999a, b). Its worldwide annual production varies between 3.3 and 5.5 billion ton of dry seeds (Makunur *et al.*, 2013; Shanko *et al.*, 2014), which more than 64 % are produced in Africa (Nkouannessi, 2005).

In Cameroon, the production of Cowpea is estimated at 31.000-ton of dry seeds and harvests are intended mainly for family needs (Langyintuo *et al.,* 2003). Cultivation remains artisanal and limited to village plantations. This culture represents 1 % of African production and is practiced in almost all regions of the country, with Far-North (59%), North (37 %), Center (1.85 %), South (0.38%), Littoral (0.36%), North-West (0.18%), Adamawa (0.11 %) West (0.02 %) in seeds (MINADER, 2017). In Adamawa, according to the Cameroon National Institute of Statistic the production Cowpea fell from 355.22 ton in 2014 to 170 ton in 2015 with a decrease of 185.22 ton (MINADER, 2017). However, a real need to increase Cowpea is important for the production. Many studies have already focused on the behavior of Cowpea cultivars, in particular the works of Mutamba *et al.* (2017) on varietal evaluation of some Cowpea genotypes under agro-ecological conditions in Kabinda, Lomani province, Democratic Republic of Congo,

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Nadjam *et al.* (2015) on agro-morphological variability of forty five local Cowpea cultivars from the Sudano zone of Chad and Noubissié *et al.* (2011a) on the genetic analysis of the physico-chemical parameters of seed of *Vigna unguiculata* in the Sudano-Guinean zone of Cameroon. All this with a view to developing cultivars for their different agronomic and/or nutritional qualities. Unfortunately, the work carried out in Ngaoundere to boost agricultural yields of Cowpea seems insufficient. Therefore, the introduction of the new varieties would contribute to increases the Cowpea production in the high Guinean Savannah zone? The main objective of this research is to assess the level of adaptability of eight Cowpea cultivars (*Vigna unguiculata*) on plants growth and productivity in a pedoclimatic conditions in the Guinean Savannah zone of Cameroon.

2. MATERIALS AND METHODS

2.1 The study site

The study was realized from July to October 2022 in Bini-Dang, Ngaoundere District and Adamawa Region in Cameroon. The Adamawa is a region that covers approximately around 62.000 km^2 and belongs to the agro-ecological zone of High Guinean Savannah (Djoufack-Menetsa, 2011). This region presents a mountainous arc separating the Northern and Southern part of the country and located between 6th and 8th degrees North latitude and between 11th and 15th degrees East longitude. The experimental site is located near to the University of Ngaoundere with geographic coordinates point of 7°24’43’’ latitude North and of 13°31’47’’ longitude East.

2.2 The climate, sols and vegetation

The climate area is covered by the Sudano-guinean type mild and cool characterized by 2 seasons: arainy season from April to October and May to September and a dry season from to November to March. The average annual rainfall is 2037.2 mm with a relatively low average annual temperature of around 21°C and amplitude of2.5°C (Djoufack-Menatsa, 2011).The soils are permeable with medium water retention capacity. Most of the Adamawa soils belong to the large groups of ferralitic soils. The ground is covered with basalt rocks in certain places with a brown or reddish color and a clay texture (Megueni *et al.*, 2011).The is characterized by a shrub or tree savannah with *Daniella oliveri* and *Lophira lanceolata*. It is constantly undergoing pressure due to anthropic and zoo-anthropic factors such as bush fires and grazing (Letouzey, 1968).

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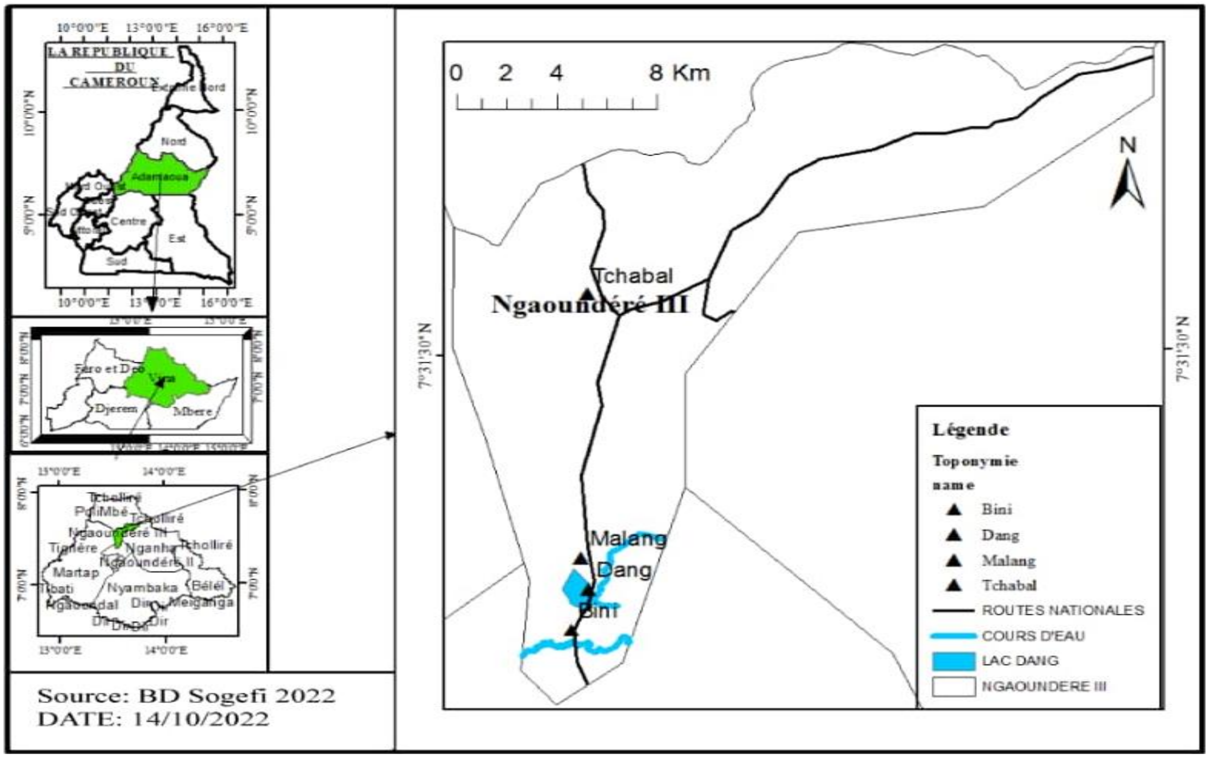

Figure 1: Localization of the study area.

2.3 Vegetal materials

The plant material consists of eight cultivars which are varieties provided by research centers such as IITA, INERA, INRAN, ISRA (**Figure 2**).

a) **VKX30-30966** b) **TN5-78** c) **Vita5**

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d) **IT81D994**

e) **Melackh**

f)**TN-985-61399**

g) **TN-27-80**

h) **IT99K573-1-2**

Figure 2: Different varieties cultivated.

Table 1: The characteristic and provenance of the different seed varieties

Varieties	Origin	Plant habit	Color	Flowering	Cycle semi-maturity
KVX3030966	INERA (Burkina-faso)	Semi-creeping	White	Spread	75 days
TN5- 78	INRAN	Semi-creeping	White	Spread	75 days
Vita5	IITA (R.C.A)	Semi-erected	White	Spread	75 to 80 days
IT81D994	IITA (Nigeria)	Semi-creeping	White	Spread	85 days
Melack	ISRA	Semi-creeping	White	Spread	80 days
TN985-61399	INRAN	Crawling	White	Spread	70 days
TN-27-80	INRAN	Semi-creeping	White spottedwithbrown	Spread	75 to 80 days
IT99K573-1-2	IITA (Nigeria)	Semi-creeping	White	Spread	70 days

2.4 Mechanic materials

For the realization of plot on the field, some materials were used as:

- Machetes for preparing experimental plot on field;
- Hoes for the labor of soil, sowing and weeding the plot;
- Sprayer for apply insecticide to control insect pests;
- Balance for the weight of seeds after harvest and drying procedure;
- Meter for the measuring the height of plants on field;
- Decameter for measure of experimental surfaces.

2.5 Experimental design

The experimental design is a block completely randomized with eight treatments and 3 replications. Each variety represents a treatment and the study plot was 21.5 m in length and 6.8m in wide, with a spacing of 1 m between the blocks and 0.5 m between the units. This experimental unit is represented in the form of ridge of 0.3 m in high measuring 2m in length and 0.7m in wide with the formation of two lines in areas on of five pockets per lines.

2.6 Preparation, sowing and maintenance of plots on field.

The plots were prepared by clearing and plowing the different experimental plots. The sowing was carried out on July 2022 for all the varieties in a reason of three seeds per pockets at the depth of 2.5 cm. Two weeks after germination on field, the weeding procedure of different plots was done manually after every three weeks. The use of pesticides (Optimal and Cypercot) was applied at one month after sowing to fight against harmful insects that perforate the leaves during the development of plants.

2.7 Harvest process

The harvest of pods was done successively in following the end of maturation of the majority of pods of each experimental unit in order to avoid the effect of rain on rotting of the pods in plots. The first harvest was started at 90^{th} days after sowing in all the unit and then the pods were dried for four days and shelled to separate the haulms from the seeds.

2.8 Parameters assessment

2.8.1 Phenological aspect

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The emergence rate, the data of 50 % of flowering and 50 % of maturation were collected on each variety respectively by counting plants at the steps of the germination, during the development and flowering process.

2.8.2 Growth of plants

Data of the number of leaves, plants height and number of nodes were collected on every variety by counting the plants during the development and flowering process.

2.8.3 Productivity of plants

The yield of plants was evaluated at the end of the cropping season. The number of pods per plant, the length of pods, the number of seeds per pods, the weight of 100 seeds and the yields of seeds (kg/ha)for each treatment was evaluated. For each treatment, 100 seeds in total were weighed with an electronic scale (2000*0.1g).The yields (in kg/ha) are estimated by using the population density per hectare, which was 120.000 plants per hectare and the seeds weight per plant according to this formula:

YSd = AWSPs x120.000

where:

YSd = yield of seed;

AWSPs = Average weight of seeds per plants in kg.

2.9 Data Analysis

2.9.1 Genetic and statistical analysis

The Microsoft excel 2016 software was used to ranges data and Statgraphic version 16.1.18 were used for the analysis of variance (ANOVA). Duncan's multiple comparison test were performed in order to determine the difference among average and when genotypes are significantly different ($P \leq 0.05$).

2.9.2 Estimation of genetic variability, heritability and selection gain

The total variation (phenotypic variation) present in a population increases as genotype and environmental effect. The variability between several different varieties results from genetic breeding and environmental conditions. When we studying several representative varieties of a species the inter-varietal variance is assimilated to the phenotypic variance (**$\sigma^2 p$**) (Noubissié, 2019). Genetic variance (**$\sigma^2 g$**) is hereditary, while environmental variance (**$\sigma^2 E$**) is not

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transmitted to the next generation and therefore cannot be isolated during the selection (Noubissié, 2019). In absence of genotype x environment interactions (**GxE**), and when we have several genotypes with extended intra-population genetic variability, the heritability can be accessed from the intra-population variance and the inter-population variance (Noubissié, 2019).The heritability (**h^2**) is the proportion of genetic in total variability or phenotypic variability of a trait under consideration. The heritability is used to indicate the relative degree to which a trait is expressed. It varies from 0 (when all the variation comes from environmental origin) to 1, when the variation is totally provides of genetic origin. The heritability therefore makes to know whether the differences between individuals come from their genetic constitution or from environmental factors. The heritability, which measures the degree of transmission of a quantitative trait, is the proportion of genetic variability in total or phenotypic variability (Noubissié, 2019). According to Noubissié (2019), the heritability on a broad sense is estimated by the formula:

$$h^2 = \sigma_g^2 / \sigma_p^2 = (\sigma_p^2 - \sigma_E^2) / \sigma_p^2 = (\sigma_I^2 - \sigma_i^2) / \sigma_I^2$$

- **σ_I^2**: inter-varietal variance, **σ_p^2**: phenotypic variance;
- **σ_i^2**: intra-varietal variance,**σ_E^2**: environnemental variance.

The inter-varietale variance is calculated by this formula:

$$\sigma_I^2 = \Sigma\ [(X_m - X_i)^2] / n-1$$

- **X_m**: Average value of all pure line;
- **X_i**: Average of each variety;
- **n**: Numberof variety (**n=8**).

The intra-varietal variance is measured for each variety by this formula:

$$\sigma_i^2 = \Sigma\ [(r_m - r_i)^2] / r-1$$

- **r_m**: Average value of all repetition;
- **r_i**: Value of each repetition;
- **r**: Numberof repetition (**r= 3**).

The heritability values are estimated for each parameter at the level of each variety and at the level of all population.

In convention:

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- When $h^2 \geq 0.8$ the heritability is said very high.
- When $0.6 \leq h^2 < 0.8$ it is said to be high.
- When $0.5 \leq h^2 < 0.6$ it is said to be moderate or moderately high.
- When $0.4 \leq h^2 < 0.5$ it is said to be average.
- When $0.2 \leq h^2 < 0.4$ it is said to be low.
- When $h^2 < 0.2$ it is said to be very low.

2.9.3 Gain de selection

The selection gain can be estimated from the heritability value and the phenotypic variance using the formula proposed by Noubissié (2019):

$$G = K \times (\sigma^2 p)^{1/2} \times h^2$$

With **G** = Expected gain of selection **K**= Standardized selection differential or whose value depends of the selection percentage (**K**= 1.75)for a selection differential intensity in standard deviation units (10 %), $\sigma^2 p$= Phenotypic variance in the initial population, h^2= The heritability on a broad sense.

In percentage:

$$G\% = \frac{G}{M} \times 100$$

- **G%:** Expected gain of selection in percentage;
- **G:** Selection gain;
- **M:** Total average of genotypes.

2.9.4 Correlation assessment

The correlation coefficient is an index that measures the existence, direction and strength of the links between two quantitative characters. It is used mainly to designate the link (relation/association) between any two variables (**X, Y**). The formula of Bravais-Pearson (**r**) of correlation coefficient was adopted to determine the different relationships that exist between the parameters. The formula used is:

$$r = \Sigma [(X_i - X_m) \times (Y_i - Y_m)] / [\Sigma (X_i - X_m)^2 \times \Sigma (Y_i - Y_m)^2]^{1/2}$$

- **r** : Correlation coefficient of Bravais Pearson, $-1 \leq r \leq 1$;
- X_i: Average value of parameter X for the variety i;

- **X_m**: Average of Xi for all the variety studied;
- **Y_i**: Average value of parameter Y for the variety i;
- **Y_m**: Average of Yi for the variety studied.

The value of **r** in absolute value was compared with a value read on a correlation coefficient table to assess the significance threshold of 5 % and 1 %.

3. RESULTS AND DISCUSSIONS

3.1 Genetic analysis of the variability, heritability of phenological parameters

3.1.2 Selection gain of emergence rate, start of flowering and start of maturation

The germination rates are recorded on the **Table 2** below for all the varieties studied with overall average of 85.52 %. The variety 5 (Melackh) is that present the lowest emergence rate with 73.16 % and significant difference ($P \leq 0.05$) were recorded by the variety 8 (IT99K-573-1-2) and 3 (Vita 5) with the highest germination rate respectively to 90.67 % and 94.41 %. These germination rate obtained corroborate with those works of Nkanza *et al.* (2021) who obtained the results of germination rate from 65.5 % (HM21-7) to 95.5 % (K131) on *Phaseolus vulgaris*. Overall, the variability of results obtained on the emergence rates showed high values for the experiment and this is due to the quality of seeds and the environmental conditions which favored a rapid recovery of seeds. All the varieties showed the rate above threshold of 70 % required for the quality of seeds. The heritability of this trait of germinative power is 0.63 and is said to be moderate. We can suggest that breeding for this trait might be efficient.

The average date of 50 % of flowering or semi-flowering of different varieties ranges between 55.66 DAS and 63 DAS, with an overall average of 57.79 DAS (**Table 2** below). The difference on flowering date at 50 %was noted between varieties ($P \leq 0.05$). The variety 7 (TN-27-80) present an early flowering compared to the variety 4 (IT81D994), which has late flowering (**Table 2**). Our results of the number of flowering days after sowing obtained are superior to those of Mutamba *et al.* (2017) obtained in Democratic Republic of Congo, who noted a flowering time at 50 % among 45 DAS and 54 DAS. This difference may be due to the pedoclimatic conditions of the locality and the genomic constitution of every variety. The heritability of the character start of flowering is very high (0.94).This heritability rate which is 94 % attest that the genetic variance is clearly considerable and that the start of flowering is little affected by environmental conditions, breeding for this trait could be efficient and will allow breeders to consider breeding with a gain of 6.51.

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The **Table 2** below show the different days of pod maturation after sowing. The average values obtained are between 82.33 DAS and 96 DAS, with an overall average of 86.08 DAS. A difference was noted among the variety concerning the days on pod maturation ($P \leq 0.05$). The variety 6 (TN985-61399) and 8 (IT99K573-1-2) shows a number day of 82.33 DAS and are considered like earlier maturation varieties and the variety 4 as late maturation variety. The results obtained are the same of those of Mutamba *et al.* (2017), who obtained a maturation time between 73.6 DAS for the variety Diamant to 91 DAS for the variety IT94K-205-8. The performances observed on all the varieties concerning the number of days of semi-maturation reveal an adaptative aptitude to the study of environment. The heritability of this character is 0.95. This very high heritability attest to the superiority of genetic variance over environmental variance and show us that the selection of this trait could be efficient with a selection gain of 12.75.

Table 2: Variability, heritability and selection gain of phenological parameters.

Genotypes	Emergence rate (%)	SF(50%)	SM(50%)
KVX30-30966	88.8±0^{bc}	56.33±0.57^{a}	84.66±1.15^{ab}
TN5-78	87.90±1.55^{bc}	57±0^{ab}	86.66±1.52^{b}
Vita 5	94.41±4.86^{c}	58±1^{b}	85±1^{ab}
IT81994	87±1.55^{bc}	63±1^{c}	96.33±1.52^{c}
Melackh	73.14±12.52^{a}	58±1^{b}	85.33±1.15^{b}
TN985-61399	76.85±8.01^{ab}	58±1^{b}	82.33±1.52^{a}
TN-27-80	85.44±12.56^{abc}	55.66±1.52^{a}	86±2.64^{b}
IT99K573-1-2	90.67±5.73^{c}	56.33±0.75^{a}	82.33±1.15^{a}
Moyenne	85.52±9.1	57.79±2.32	86.08±4.42
P(0.05)	**0.0447**	**0.0001**	**0.0001**
PPSD	**12.48**	**1.61**	**2.66**
σ_I^2	**151.10**	**15.70**	**58.83**
σ_i^2	**55.04**	**0.87**	**2.37**
h^2	**0.63**	**0.94**	**0.95**
G	**13.55**	**6.51**	**12.75**
G%	**15.84**	**11.26**	**15.48**

*Values followed by the same letter (a or b) are not significantly different at the level of probability considered ($P \leq 0.05$).**SF**: Start of flowering at 50 %; **SM**: Start of maturation 50 %; **PPDS**: Last significant difference; **P**: Percentage at 5%;**σ_I^2:** Inter-varietal variance; **σ_i^2:** Intra-varietal variance; **h^2**: Heritability ona broad-sense; **G**: Selection gain; **G(%)**: Selection gain in percentage.*

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3.2 Growth parameters of plants

3.2.1 Number of leaves, height of plants and number of nodes

The growth parameters as the number of leaves, the height of plants and the number of nodes per plant were taken eight weeks after sowing on five plant per experimental unit (**Table 3**). A difference was noted among the different varieties (P≤0.05). The average variation of the number of leaves is located between 19.86 and 34.58 with an overall average of 25.98. The variety 6 (TN985-61399) is the one with the highest number of leaves on average of 34.38 and the variety 3 (Vita 5) and 8 (IT99K573-1-2) have the lowest number of leaves with an average of 19.86 (**Table 3**). This variability on the number of leaves obtained in this study is could due to the actions of genes that govern this character without ignoring the influence of the environmental factors. Therefore, we can suggest that the variety 6 (TN985-61399) is the variety that has a good adaptability for the development of the number of leaves and the less suitable, followed by the variety 3 (Vita 5) and 8 (IT99K573-1-2). Ours results are lower of those of Noubissié *et al.* (2011b), who found the number of leaves varying from 25.5 (HMO) to 74.8 (IT573) carried out in an experimental field at the University of Ngaoundere Bini-Dang in Adamawa-Cameroon and superior than those of Mutamba *et al.* (2017) in Democratic Republic of Congo which revealed a number ranging from 6 (IT94K-205) to 12.6 (Diamant). The heritability in the broad-sense of character according to the number of leaves is 0.96.This value confirms the predominance of genetic variance compared with environmental variance. This very high heritability shows us that the selection of this trait could be efficient with a gain of 14.22.

The height of plants of the different varieties on average are among 32.38 cm and 43.78 cm with an overall average of 36.01 cm (**Table 3**). A difference on the height was noted among the different varieties (P≤0.05). The variety 8 (IT99K573-1-2) has the highest significant height of plants with 43.78 cm, while the variety 1 (VKX30-30966) appear with the smallest height with an average of 32.38 cm (**Table 3**). Our results obtained are higher than those of Mutamba *et al.* (2017) who found a variability of the height of plants between 8.2 cm (IT98K-131-2) to 13.4 cm and lower than those of Nkanza *et al.* (2021) on the plants of *Phaseolus vulgaris* which found the height between 36 cm (dwarf lola) to 121 cm (CODMLDB001) in Democratic Republic of Congo. This variability on the height of plants could be explained by the genomic contributions of each variety and the behavior of the genotypes in different areas. The heritability of plant height is 0.94. This heritability is very high and show us the superiority of genetic variance over all environmental variance and therefore breeding for this character could be very efficient (Noubissié, 2019) with the gain of 11.15.

The number of nodes varies from one variety to another. A significant difference was noted among the different varieties (P≤0.05). The averages vary between 15.8 to 24.93 with overall average of 18.87 (**Table 3**). The variety 4 (IT81D994) is one of that has fewer nodes with an average of 15.8 and the variety 6 (TN985-61399) has most nodes with an average of 24.93 (**Table 3**). This variability could be explained by a high adaptability during the development of the number of nodes of the variety 6, compared to the variety 4. The heritability of the character number of fruiting nodes is 0.92. This very high heritability value shows the predominance of genomic variance over environmental variance and the selection of this character could be very efficient with a selection gain of 9.27.

Table 3: Genetic variability of three growth agronomic parameters and development of Cowpea.

Genotypes	NLP	HP	NFN
VKX30-30966	286±0.50^{d}	32.38±1.62^{a}	19.13±1.02^{c}
TN5-78	24.06±1.85^{b}	32.77±0.94^{a}	15.33±2.50^{a}
Vita5	19.86±0.61^{a}	34.16±0.39^{ab}	16.13±2.02^{ab}
IT81D994	26.2±1.70^{bc}	39.01±1.73^{cd}	15.8±1.90^{a}
Melackh	25.86±1.44^{b}	40.78±1.33^{d}	18.6±1.8^{bc}
TN985-61399	34.58±1.57^{e}	36.68±2.36^{bc}	24.93±0.46^{e}
TN-27-80	28.53±0.94^{cd}	34.11±1.65^{ab}	22.2±0.91^{d}
IT99K573-1-2	19.86±2.27^{a}	43.78±12.36^{e}	18.86±0.80^{bc}
MOYENNE	**25.98±4.83**	**36.71±5.39**	**18.87±3.44**
P(0.05)	**0.0001**	**0.0001**	**0.0001**
PPSD	**2.57**	**2.95**	**2.73**
σ_I^2	**71.71**	**51.10**	**33.17**
σ_i^2	**2.20**	**2.92**	**2.49**
h^2	**0.96**	**0.94**	**0.92**
G	**14.22**	**11.15**	**9.27**
G%	**54.73**	**32.62**	**49.12**

Values followed by the same letter (a or b) are not significantly different at the level of probability considered (P ≤ 0.05). ***NLP****: number of leaves per plant;* ***HP****: height of plant;* ***NFN****: number fruiting nodes.*

3.3 Variability, heritability and selection gain of productivity

3.3.1 Number of pods per plant, length of pods, number of seeds per pods, weight of 100 seeds and yields of seeds (kg/ha)

According to the **Table 4**, the number of pods vary on average from 12.86 to 24.66 with overall average of 17.76. A significant difference was noted among the different varieties (P≤0.05). The variety 2 (TN5-78) is one that has lowest number of pods with an average of 12.86 and the

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variety 6 (TN985-61399) with the highest number of pods on average of 24.66 (**Table 4** below).Our results obtained are inferior than those of Gbaguidi *et al.* (2015), who found the number of pod values between 14.33 (N74) and 70.66 (N113) in Benin. But these results are highest than Mutamba *et al.* (2017) who found the number between 8 (IT98K-131-2) and 13.3 (IT97K-499-33) on Cowpea and the works of Nkanza *et al.* (2021) with the number of pods varying from 4.3 (NUA 99) to 12.6 (K131) on the plants of *Phaseolus vulgaris* in Democratic Republic of Congo. This variability of pods number between the different variety could be due to genomic contribution of each variety and to the agro-ecological conditions of the environment. The heritability in a broad-sense of character of pods number per plant shows a value of 0.96 which is very high and therefore suggest to us that, the selection of this trait could be solicited with a selection gain of 12.14.

The length of pod data is contained in the **Table 4**. A difference was noted among the different varieties ($P \leq 0.05$). It shows that the length of pods ranges from 9.08 cm to 19.17 cm. The variety 2 (TN5-78) and 4 (IT81D994) have on average the same length which is 12 cm, in the other hand the varieties 3 (Vita 5), 5 (Melackh) and 7 (TN-27-80) present also almost the same length of pods which is 14 cm. The variety 8 (IT99K573-1-2) is the one with the highest length with 19.17 cm (**Table 4**). The overall average of the length pods is 13.56 cm. Our results are similar to those of Gbaguidi *et al.* (2015) who obtained a length varying from 12 (N73) to 21.33 (N102) in Benin. Also, Mutamba *et al.* (2017) found the pods length values between 13.3 (IT94K-205-8) and 18.4 (IT99K-573-1-1)in Democratic Republic of Congo. We can therefore suggest that these varieties studied present a variability of the adaptability which depends on the genomic contribution and the influence of environmental conditions on each varieties studied. The heritability in the broad sense of this character is 0.98 and is said to be very high. The selection for this trait could be very efficient with a selection gain of 8.36.

The data of the number of seeds per pods are recorded in the **Table 4** below. A difference was noted among the different varieties ($P \leq 0.05$).The average number of seeds varies very little according to the varieties. They are between the values of 10.3 and 11.76 with an overall average of 10.78 (**Table 4**). The variety 5 (Melackh) and 7 (TN-27-80) have roughly equal and with the highest averages of 11.7 and the variety 2 (TN5-78) and 6 (TN985-61399) have the smallest average with 10.2 and 10.3. Our results obtained are lower to those of Mutamba *et al.* (2017), who found the number of seeds per pods varying from 11.6 (IT94K-205-8 and IT99K-494-6) to 17.3 (Mujilanga). These results corroborate with the works of N'gbesso *et al.* (2013), who found the values between 10 (IT83S-889) and 13 (IT86F-2014-1 and IT96D-666).The variability of adaptability of the different varieties observed could be the result of the genomic contribution and the influence of environmental conditions. The heritability in a broad sense of the character number of seeds per pods is 0.74. This value is considered to be high with an influence of

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environmental variance compared to the heritabilities calculated above, which were very high. However, the selection for this character remains possible, with a selection gain of 4.47.

The **Table 4** below show the results of the weight of 100 seeds of different variety in gram (g). It shows the values on average between 8.66 g and 17 g, with average of 12.54g. The variety 8 (IT99K573-1-2) is the one that has significant highest seeds weight with 17g, followed by the variety 5 (Melackh) with 14 g($p<0.05$). Our results corroborate to works of Gbaguibi *et al.* (2015), who obtained values around 14 g (N73) and 23.75 g (N120) on Cowpea in Benin and works of Mutamba *et al.* (2017), which the weight varying from 13g (Mukumari) to 17g (IT99K-573-1-1). The works of Noubissié *et al.* (2011) showed that the weight of 100 seeds varied from 39.45 g(55-437) to 90.50g (local variety) on 12 varieties of peanuts growth cultivated in Ngaoundere. The variability of weight of 100 seeds of different variety is the behavioral result that each variety that could be due to genomic and environmental origin. The heritability in a broad sense of this character is 0.96. This value shows the superiority of genetic variance of environmental variance. The heritability of weight of 100 seeds is said to be very high and suggest that the selection of trait can be efficient with a gain of 7.08.

Yield data in kg/ha are recorded in the **Table 4**. The results obtained vary on average between 2054 kg/ha to 3576 kg/ha. A significant difference was noted among the different varieties ($P\leq0.05$). The variety 7 (TN-27-80) has a highest yield with an average of 3576 kg/ha. Our results not corroborate to the works of Mutamba *et al.* (2017), which show the values varying between 590 kg/ha (IT94K-205-8) to 666.6 kg/ha (Diamant) in Democratic Republic of Congo. However, these results close to the works of Nkanza *et al.* (2021) on the plant of *Phaseolus vulgaris*, with an average ranging from 1025 kg/ha (NUA 99) to 1854 kg/ha (K131) and works of Gbaguidi *et al.* (2015) with the values between 517.6 kg/ha (N73) and 2696.5 kg/ha (N120) in Benin. This variability in seeds production is due to the genomic contribution and the adaptation of different varieties to agro-ecological conditions. The heritability of yield is 0.67. This heritability value is said to be moderate and show a considerable influence of environmental conditions compared to other parameters, but we suggest that the selection of this trait can be consider with a gain of 2.58.

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Table 4: Genetic variability of 05 agronomic parameters of production.

Genotypes	NPP	LP	NSP	WS	YS
VKX30-30966	20.13±0.50^{de}	13.16±0.41^{bc}	9.63±0.35^{a}	12.33±1.52^{bc}	2869±106.6^{bc}
TN5-78	12.86±1.84^{a}	12.19±0.51^{b}	10.23±0.23^{ab}	13±0^{cd}	2054±342.2^{a}
Vita5	14.67±0.75^{ab}	14.17±0.12^{c}	11.36±0.35^{cd}	12.33±0.57^{bc}	2464±89.87^{ab}
IT81D994	18.26±0.83^{cd}	12.55±1.18^{b}	10.63±0.25^{bc}	11±1^{b}	2561.6±64.1^{ab}
Melackh	16.06±1.72^{bc}	14.06±0.96^{c}	11.66±0.32^{d}	14.33±0.57^{d}	3269±483.8^{cd}
TN985-61399	24.66±1.85^{f}	9.08±0.12^{a}	10.3±0.43^{ab}	8.66±0.57^{a}	2645.2±315.2^{b}
TN-27-80	21.73±1.47^{e}	14.12±0.79^{c}	11.76±0.65^{d}	11.66±0.57^{bc}	3576±403^{d}
IT99K573-1-2	13.73±1.36^{ab}	19.17±0.46^{d}	10.66±0.65^{bc}	17±1^{e}	3000±379.6^{bc}
MOYENNE	**17.76±4.15**	**13.56±2.75**	**10.78±0.80**	**12.54±2.43**	**2805.08±528.2**
P(0.05)	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0006**
PPDS	**2.4**	**1.16**	**0.75**	**1.45**	**540.76**
σ_I^2	**52.37**	**23.81**	**1.70**	**17.80**	**4.855**
σ_i^2	**1.92**	**0.45**	**0.17**	**0.70**	**1.56**
h^2	**0.96**	**0.98**	**0.74**	**0.96**	**0.67**
G	**12.14**	**8.36**	**4.47**	**7.08**	**2.58**
G%	**68.35**	**61.65**	**41.46**	**56.45**	**0.09**

*Values followed by the same letter (a or b) are not significantly different at the level of probability considered ($P \leq 0.05$).**NPP**: Number of pods per plant; **LP**: Length of pods; **NSP**: Number of seeds per pods; **WS**: Weight of 100 seeds; **YS**: Yield of seeds.*

3.4 Correlation between the parameters evaluated

The **Table 5** below shows the correlation among parameters evaluated. The correlation coefficient obtained between the number of leaves and the height of plant gives a negative value **r= - 0.801*** which is significant. This makes it possible to note the existence of a negative correlation between the height and the number of leaves. More plant is erect, more she is higher and has less ramification and plant recover (Dugjé *et al.,* 2009).The correlation coefficient obtained between the number of fruiting nodes and the number of leaves per plant gives a positive correlation with **r= 0.732*** (**Table 5**). This value suggests a positive link between these two parameters and more we have a leaves formation, more we will have the formation of fruiting nodes. The yield variable in kg/ha is correlated with the number of pods per plant equal to **r= 0.889*** (**Table 5**). This value shows a positive and significant correlation coefficient. More we have pods production by Cowpea plant, more the seed yield is higher and therefore the weight of seeds will be consistent. The seed yield therefore depends on the number of pods formed. The yield variable is also correlated with the number of seeds per pod with a correlation coefficient **r= 0.905*** (**Table 5**). This value is positive and significant indicating a dependence of the yield on the number of seeds per pod. More we have the seeds per pod, greater the possibility of high yield. Our results are similar to works of N'gbesso *et al.* (2013), which found a positive and significant correlation coefficient **r= 0.751*** between the yield and the number of seeds per pod. We also noted a correlation between the length of pods and the weight of 100 seeds with a correlation coefficient **r= 0.751*** which is positive and significant (**Table 5**). This could be explained by the fact that more the pods are longer, more they have the large seeds and leads a high weight of 100 seeds.

Table 5: Correlation matrix of parameters evaluated.

Variables	NLP	HP	NFN	NPP	LP	NSP	WS	YS (Kg/ha)
NLP	1							
HP	**-0.801***	1						
NFN	**0.732***	-0.232	1					
NPP	-0.371	0.051	0.325	1				
LP	0.571	-0.252	0.603	-0.31	1			
NSP	0.629	0.511	0.173	0.373	0.276	1		
WS	0.423	0.02	0.212	0.576	**0.751***	0.262	1	
YS (Kg/ha)	0.388	-0.01	0.251	**0.889***	0.217	**0.905***	0.535	1

NB: **significative (5%);* ***NLP****: number of leaves per plant;* ***HP:*** *height of plant;* ***NFN:*** *number fruiting nodes.* ***NPP:*** *Number of pods per plant;* ***LP:*** *Length of pods;* ***NSP:*** *Number of seeds per pods;* ***WS:*** *Weight of 100 seeds;* ***YS:*** *Yield of seeds.*

4. CONCLUSION

Results of this study showed that, the eight Cowpea varieties tested in Adamawa region shows a significant difference in their performance. The variety TN-27-80 and IT99K573-1-2 have an early flowering compared to the variety IT81D994 which is late. Early maturation was noted for the varieties TN985-1399; IT99K573-1-2 and the late maturation for the variety IT81D994. The variety TN985-61399 shows a good adaptability on the number of leaves emitted followed by the varietyVKX30-30366 and TN-27-80. The variety IT99K573-1-2has a good performance and adaptability, followed by the variety VKX30-30966. The development of fruit was suitable for the variety TN985-61399. The number of pods per plant was significantly highest for the variety TN985-61399. Concerning the length of pods, the variety IT99K573-1-2 has relatively a long pod. The number of seeds per pods, the variability of this aspect remains very low despite the length of pods which is varied. This is justified by the length, the width and thickness of seeds of each variety. The weight of 100 seeds is higher for the variety IT99K573-1-2 and the seeds yield (in kg/ha) was highest for the variety TN-27-78. The heritability of all the parameters evaluated is globally between 0.63 and 0.98 which attesting that to a strong involvement of genetic factors compared to the environmental factors. That suggests the selection of these traits could be efficient. With the exception of plant height which is negatively related with the number of leaves; the number of leaves and number of fruiting nodes; the length of pods and the weight of 100 seeds, the yield; the number of seeds per pods and the number of pods per plant are positively related. The strength of these bonds can be used in selection to make selection character easier and more efficient.

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