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Research Article

Agromorphological evaluation of six varieties of Cowpea [*Vigna unguiculata* (L.) Walp.] in the Zinder region (Niger)

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Abstract
Cowpea is the main food leguminous plant grown in Niger. It is mainly cultivated for its protein-rich haulms and seeds and for its ability to improve soil fertility through its symbiosis with atmospheric nitrogen-fixing bacteria. The present study evaluated genetic variability among six cowpea varieties for yield, yield related and phenology traits in the Zinder region. The experiment was conducted at the experimental area of André Salifou University in Zinder. An experimental device composed of three completely random blocks was used. The six varieties (four local and two improved) of cowpea were evaluated based on 24 quantitative agronomic and morphological characters according to IBPGR descriptors. The comparison of the means and the PCA revealed significant differences between the varieties in almost all the traits tested, with substantial phenotypic variations. IT98 was the most productive variety, with an average yield of 385.50 kg/ha. It also recorded the earliest flowering (38.41 days after sowing) and maturity (55 days after sowing) dates. BlAr gave the highest 100-Seed weight with an average value of 29.21g. CDSb and BTAr were the tallest plants at 40.44 and 40.26 cm respectively. The completed PCA indicates that the first two axes expressed 78,7% of the total variability whereby PC1 and PC2 highly contributed to the total variation at 54.76% and 23.94, respectively. Thus, IT98 may be a good candidate to be considered in Niger struggle to fight food shortage and face nutrition challenges, especially for the Zinder region due to abiotic constraints.

Keywords: Agronomic, Evaluation, Morphological, *Vigna unguiculata*, Zinder

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp.] is one of the main grain legume species which plays a major role in cropping systems by restoring soil fertility through atmospheric nitrogen fixation (Taffouo *et al.,* 2008). It is grown and consumed in Asia, South and Central America, the Caribbean, the United States, the Middle East and Southern Europe (Food and Agriculture Organization, FAO 2020). The annual dry seed production in the world is about 27.54 million tons from an area of about 34.80 million hectares (Food and Agriculture Organization, FAO 2020). In Africa, this production is about 7.07 million tonnes with an average yield of 835.9 kg ha-1 from about 8.46 million hectares (Food and Agriculture Organization, FAO 2020). In Niger, cowpea is grown over an area of 5,819,043 ha for a production of around 1,656,054 tonnes, i.e. a yield of 285 kg ha-1 (Ministry of Agriculture, 2021). According to National Network of Chamber of Agriculture (2022), Niger is one of the major cowpea producers in West Africa just below Nigeria, which produces 75% of West Africa's total production.

Cowpea is mainly grown in Niger for its seeds and leaves, serving as human food and excellent animal fodder. The dry seeds cooked in various forms and its young immature pods whose protein value reaches 21% are consumed (Pasquet *et al.,* 1997), for the development of the human organism and for their health benefits. It is cultivated throughout the southern agricultural belt of Niger.

Over the past ten years, national and regional research structures have offered several new cowpea varieties to producers. Thus, fourteen varieties appear in the national catalog of plant species and varieties published in Niger (Ministry of Agriculture, 2021).

In the Zinder region, cowpea cultivation is practiced on 2 to 5 ha per family, with a yield of less than 350 kg per hectare and an income of around 25,000 FCFA per hectare (Harouna *et al.,* 2020). Today, the shortening of rainy periods pushes people to abandon several local varieties with a long cycle, consequently creating a genetic erosion of resistant and productive varieties (Dagnon *et al.,* 2017). This problem, combined with the increase in population, worsens food insecurity in the region.

To face this nutritional problem, the collection and characterization of local cowpea ecotypes and cultivars held by both producers and researchers appear essential in the strategy for the conservation of the agricultural diversity of this species (Ouedraogo *et al.,* 2010). In addition, several studies have focused on the production and cowpea sector in Niger (Rabé *et al.,* 2017; Abdou *et al.* (2015) and Moussa *et al.* (2019) have found that variability for many collections has been highlighted in many species. However, the literature shows that the existing data reveal themselves sketchy regarding the agronomic and morphological evaluation of local varieties and their performance in the face of climate change. The study aimed to address this lacuna found in the literature and would provide researchers and producers with sound data to facilitate the selection of high-performance varieties in a climate change context, contributing to the fight against malnutrition and food shortage in the region. The present study aimed to characterize six cowpea varieties based on their agro-morphological traits for providing valuable information for improving the cowpea crop, particularly in Zinder cowpea production.

MATERIALS AND METHODS

Plant materials

This study was carried out on six varieties of cowpea [*Vigna unguiculata* (L.) Walp.], two of which were local varieties of Arewa (a and b), two were local varieties of Soubdou (c and d) purchased from producers in the region of Zinder (Niger Republic) and two improved varieties (IT90 and IT98) provided by the seed bank of the School of Sciences and Technology at Université André Salifou de Zinder (Niger Republic) (Table 1 and Fig. 1).

Experimental design and data collection

The experiment was laid out in a randomized complete block design with three replications at the Department of Biology, School of Sciences and Techniques research farm, Université André Salifou de Zinder . A block consisted of 6 plots, each of them has an area of 20.25 m^2 containing 16 plants per plot. Blocks, plots, lines, and spacing of 1.5 m separate plants. In sum, 3 blocks were used, i.e. 3 repetitions. The number of plots is 6×3=18, with a total area of 364.5 m^2. The local soil is classified as sandy clay (Mamadou, 2014). Weeds were removed manually every two weeks, start-

Table 1. Morphological characteristics of the seeds tested

Types of varieties	Codes	Morphological characteristics of seeds			
		Provenances	seed color	Aspects	P100 (g)
Local variety (a)	BTAr	Gagawa	white orange	Wrinkled	28.17
Local variety (b)	BLAr	Gagawa	White	Wrinkled	16.26
Local variety (c)	CDSB	Subdu	Ash	Wrinkled	18.15
Local variety (d)	BLSB	Subdu	White	Wrinkled	14.33
Improved variety (e)	IT98	UAS	White	Wrinkled	16.73
Improved variety (f)	IT90	UAS	White	Wrinkled	15.12

BLAr : Blanc Arewa (local variety); BLSB: Blanc de Soubdou (local variety); BTAr: Blanc tache Arewa (local variety); CDSB : Cendre de Soubdou (local variety); IT90: improved variety; IT98 : improved variety

Fig. 1. *Seeds of six Vigna unguiculata varieties (a-f as defined in Table 1) from the Zinder Region taken for evaluation*

ing one month after sowing.

The data recorded on 38 plants randomly selected plants from each variety were used for analysis by adapting the procedure of IBPGR (1983), Thus, the agronomic and morphological data were collected on 288 plants based on 24 variables including 8 quantitative agronomic variables, 16 quantitative morphological variables taken according to the recommendations listed in the cowpea descriptors (IBPGR, 1983), also used by Gbaguidi *et al.*(2015); Nadjiam *et al.* (2015); and Kouassi *et al.* (2017).

Statistical analysis

Descriptive statistics, including mean and standard deviation, were calculated using MS Excel 2013. Data collected were subjected to analysis of variance (ANOVA) using XlStat version 7.1, and the means were separated by using Turkey's Method at 0.05 level of significance if differences were found significant. A principal component analysis (PCA) was carried out with the R 4.1.0 software to simplify the data and represent the varieties studied in a plan according to their characteristics.

RESULTS

Quantitative agronomic and morphological characteristics of cowpea varieties

The ANOVA of the agronomic variables of six varieties of cowpea showed a significant difference (P<0.05) between the varieties (Table 2). The variety ash of Soubdou (CDSB) started tillering in 28.62 days on average after sowing, while the variety IT98 did it in 32.02 days after sowing. Flowering of the IT98 variety began at an average of 38.41 days after sowing, followed by IT90 at an average of 45.74 days, while the varieties Arewa white (BLAr), Soubdou white (BLSB), white spotted Arewa (BTAr), ash of Soubdou (CDSB) recorded their first flowers respectively at 74.82, 73.51, 72.40 and 86.75 days on average after sowing. Four groups were observed regarding the average time to maturity. The first consisted of the CDSB variety, which recorded the highest average number of days of 107.78 days, followed by BLAr, BTAr and BLSB with 95.60, 94.17 and 93.82 days, respectively, for the second group; the third group consisted of IT90, which completed the cycle at 66.54 days and finally the variety IT98 which recorded its beginning of maturity at 55 days after sowing (Table 2).

Improved varieties produced a higher number of flower buds than local varieties. On the other hand, variety IT98 produced 4.17 flowers and pods per flower bud, followed by variety IT90 2.74 flowers and pods per flower bud. The highest average number of pods was recorded in variety IT98 with 41.07 pods followed by variety IT90 with 26.07 pods and at the end CDSB, BLAr, BLSB and BTAr with respective pod numbers of 14.56, 13.17, 11.38 and 11.09 pods on average per pocket. In addition, the IT98 variety was more productive with a yield of 385.5 kg.ha $^{-1}$ followed by the IT90 variety with 153.48 against the CDSB, BTAr, BLAr and BLSB varieties, which obtained relatively very low yields with respectively 101.81 kg ha $^{-1}$, 92.32 kg ha $^{-1}$, 83.10 kg ha $^{-1}$, 73.08 kg ha $^{-1}$ (Table 2). Thus, the highest average pod length, average pod weight and average number of seeds per pod were observed in variety IT98 with respectively 17.34 cm, 3.46 g and 14.78 seeds per pod, while the smallest measurement of pod length was observed in the BTAr variety, the lowest pod and seed weight per pod was observed in the BLSB variety with 2.12 g and 1.73 g respectively.The IT98 variety produced the highest number of seeds per pod, with 14.78 seeds and the lowest number was observed in the BTAr variety, with 9.18 seeds per pod (Table 3).

The BTAr variety showed higher average seed length, average seed width, average seed thickness, and average 100-seed weight than other varieties. Thus, the highest plant height was observed in the CDSB and BTAr varieties. However, the lowest plant height was obtained in varieties IT98, IT90, BLSB and BLAr. The CDSB variety exhibited the longest petiole length, leaflet length, and width, while the BLSB variety exhibited the lowest measure of these characteristics.

The IT98 variety produces the longest peduncle (31.66 cm), while the BLSB variety has the shortest peduncle, which averages about 10.58 cm. The highest branch number was produced by the BTAr variety, with 13.23 branches, while the IT98 variety gave the lowest number, with 4.26 branches. Regarding the branch length

Table 2. Quantitative agronomic and morphological characteristics of six cowpea varieties

	EMD	BRD	FLD	MTD	NBPD	NBPP	YIELD
Varieties	**Mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**
BLAr	4.16±0.31c	28.94±2.48bc	74.82±4.93b	95.60±5.7b	16.63±3.87c	13.17±3.58cd	83.10±26.6c
BLSB	4.49±0.44ab	30.62±2.74ab	73.51±3.81bc	93.82±3.58b	14.00±2.27c	11.38±3.08cd	73.08±25.6c
BTAr	4.56±0.47a	29.38±2.85bc	72.40±4.11c	94.17±3.99b	14.42 ± 3.32c	11.09±3.31d	92.32 ± 39.2c
CDSB	4.29 ± 0.36bc	28.62 ± 2.32c	86.75 ± 4.83a	107.78± 4.87a	17.40 ± 4.31c	14.56±4.48c	101.81±32.5c
IT90	4.10±0.27c	29.95±3.39bc	45.74±3.35d	66.54±3.43c	29.60±12.47a	26.07±9.32b	153.48±54.2b
IT98	4.07±0.57c	32.02±3.06a	38.41±1.13e	55.00±1.37d	22.39±8.16b	41.07±7.82a	385.50±115a
F	11.47	9.01	1048.49	1121.3	35.51	196.94	195.85
P	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Meaning	***	***	***	***	***	***	***
	LOGS	**WPD**	**GRW**	**NBSP**	**SELE**	**SEW**	**W100**
Varieties	Mean± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD
BLAr	12.44±0.89bcd	2.26±0.46d	2.02±0.41bc	10.41±1.14c	6.22±1.00cd	4.10±0.68c	16.79±0.73d
BLSB	11.47±1.13cd	2.12±0.48d	1.73±0.29c	10.68±1.56bc	6.49±0.48c	3.94±0.43cd	14.52±1.38f
BTAr	11.18±1.11d	3.19±0.52b	2.70±0.55a	9.18±1.45d	8.64±0.52a	6.35±0.37a	29.21±1.32a
CDSB	12.71±1.11bc	2.54±0.45c	2.13±0.41b	10.20±1.60c	7.54±0.42b	4.51±0.46b	19.08±1.32b
IT90	13.47±5.68b	2.31±0.36cd	1.92±0.34bc	11.28±1.50b	6.10±0.42d	3.73±0.32d	15.23±0.58e
IT98	17.34±1.10a	3.46±0.41a	2.95±1.07a	14.78±1.02a	6.54±0.47c	3.83±0.23d	17.55±0.83c
F	38.08	67.78	30.86	89.12	128.14	237.19	1154.66
P	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Meaning	***	***	***	***	***	***	***
	PH	**PELE**	**LELE**	**LEW**	**LEPE**	**NBRA**	**DRBI**
Varieties	Mean± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD
BLAr	36.27±6.85b	11.22±2.15ab	11.32±1.61ab	6.40±1.11a	16.90±3.28cd	12.72±7.35ab	652.40±405.10a
BLSB	34.96±4.7b	8.57±1.98c	9.66±1.75c	4.81±1.05c	10.58±1.25e	10.33±4.46b	581.90±241.80a
BTAr	40.36±5.23a	11.00±1.35ab	10.66±1.02b	5.73±0.71b	18.27±4.67c	13.23±4.40a	623.90±226.30a
CDSB	40.44±5.33a	11.75±1.73a	11.96±1.40a	6.52±1.17a	15.21±1.46d	12.20±3.46ab	746.20±371.70a
IT90	35.14±4.45b	10.58±1.92b	11.19±1.46ab	5.60±1.26b	25.65±4.80b	10.12±3.45b	296.50±156.40b
IT98	37.07±9.27ab	10.16±1.96b	11.46±1.38ab	6.19±1.10ab	31.66±4.83a	4.26±2.32c	261.50±166b
F	7.13	16.06	13.55	15.74	191.27	24.38	23.15
P	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Meaning	***	***	***	***	***	***	***

Values with the same letters are statistically equal for each character with Tukey's method. ***: significant at 5%; EMD : Emergence date (Days), BRD : Branching date (days), FLD : Flowering date, MTD : Maturity date (days), NBPD: number of peduncle; NBPP : Number of pods per plant, YIELD : Seed yield per hectare (kg.ha $^{-1}$), PDL: pod length; WPD: Weight of the pod; SWP: seed weight per pod; NBSP: number of seeds per pod; SELE: Seed length, SEW: Seed width, W100: Weight of 100 seeds , GRW: Grain weight, PH: plant height; PELE: petiole length; LELE: leaflet length; LEW: leaflet width; LEPE: length of peduncle; NBRA: number of branches; BRLE: branch length; DRBI: dry biomass._BLAr : Blanc Arewa (local variety), BLSB: Blanc de Soubdou (local variety), BTAr: Blanc tache Arewa (local variety), CDSB : Cendre de Soubdou (local variety), IT90: improved variety, IT98 : improved variety

Table 3. Correlations between variables and axes

	Axis 1	Axis 2
Real values	6.02	2.63
Total variance %	54.76	23.94
Total Cumul. of variance%	54.76	78.70
Contribution of variables		
FLD	**0.89***	-0.26
MTD	**0.91***	-0.26
NBPP	**-0.86***	0.26
YIELD	**-0.80***	0.38
SELE	0.58	**0.71***
SEW	**0.63***	**0.71***
EPGR	**0.68***	**0.61***
W100	0.52	**0.78***
LEPE	**-0.76***	0.42
DRBI	0.55	-0.22

variable, two groups were observed. The first group consisted of the varieties BLAr, BLSB, BTAr, CDSB and IT90 with respective values of 75.17cm, 77.55cm, 82.49cm, 79.19cm and 77.93cm, which were higher than that observed for the second group consisting of the variety IT98. In addition, the dry biomass showed two groups where the first was formed by local varieties (BLAr, BLSB, BTAr, CDSB) with weights greater than the weights presented by the second group, which consisted of improved varieties (IT90 and IT98) (Table 2).

Agro-morphological diversity of cowpea varieties

Principal component analysis (PCA) applied to the agronomic and morphological characteristics of the varieties studied absorbs more than 78% of explained variation at the level of the first two components analysis of the correlations with axis 1 showed that the variables early flowering stage, maturity stage, seed length, seed width, seed thickness, hundred-seed weight and dry biomass had a good positive correlation with axis 1 while the number of pods, seed yield, peduncle length had a good negative correlation with axis 1 .The correlation with axis 2 shows that the variables viz., seed yield, seed length, seed width, seed thickness, hundred -seed weight and peduncle length positively correlated with axis 2 (Table 3).

This PCA reorganized the six initial varieties into five different groups (Fig.2). Thus, group 1 was made up of the variety IT98, group 2 was made up of the variety IT90, group 3 was made up of the white variety of soubdou (BLSB), group 4 was represented by the ash variety of soubdou (CDSB) and finally group 5 which was made up of the white stained arewa (BTAr) variety. It can be seen that the white arewa (BLAr) variety was divided into group 3 and group 4 (Fig. 2). Fig. 3 illustrates the variables that characterize the different groups.

DISCUSSION

The present results of six cowpea varieties phenological and agro-morphological evaluation showed significant differences. Thus, the date of emergence recorded during this experiment was more than 4 days after sowing for each variety. These results were higher than

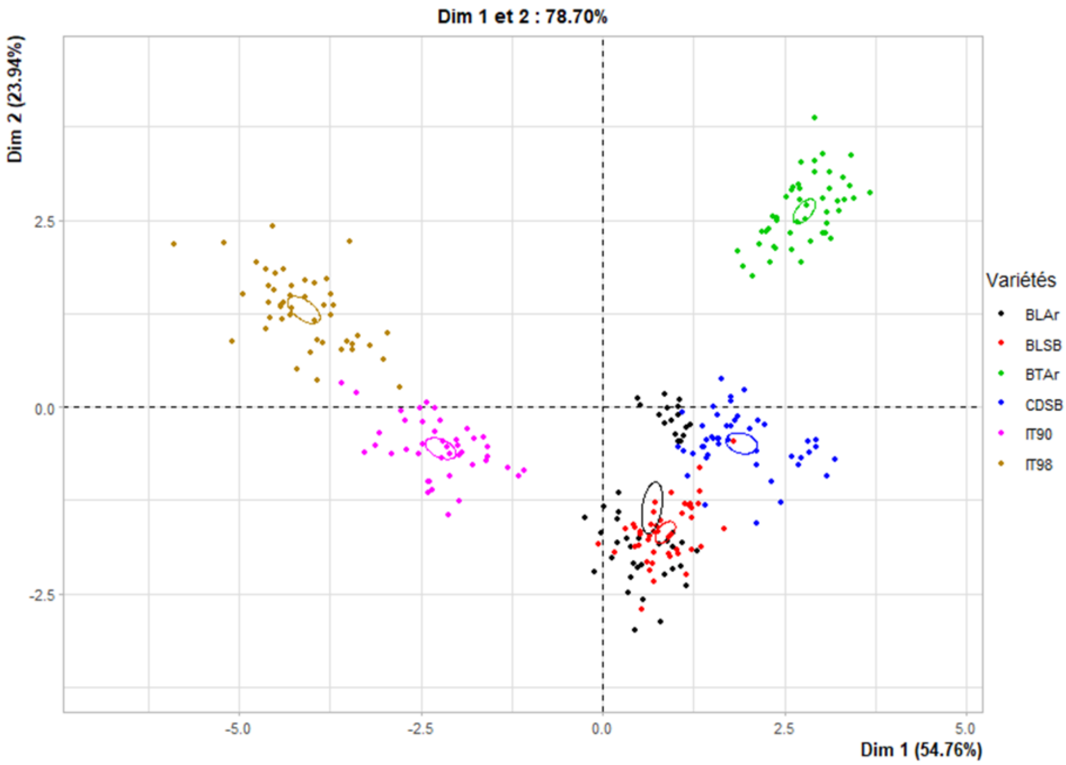

Fig. 2. *Representation of individuals in the PCA plan*

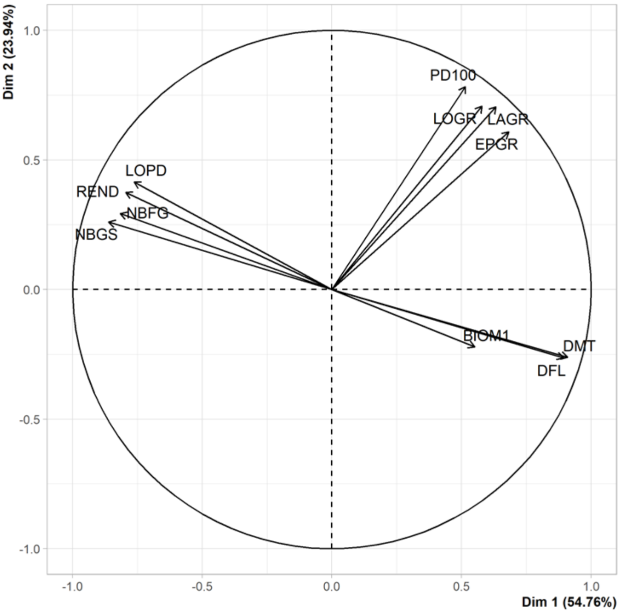

Fig. 3. *Variable correlation circle*

those found by N'gbesso *et al* . (2013), which was 3 days after sowing in Côte d'Ivoire for the 6 improved varieties introduced by IITTA used in the study, and 3.85 days after sowing for all local varieties used (IT86F-2014-1, IT96D-733, IT88DM-363, IT86D-400, IT83S-889 and IT96D-666). These results were also higher than those found on 124 local varieties used by Gbaguidi *et al* . (2015) in Benin. Hower these results were lower than those obtained by Oumarou *et al* ., (2017) with 8 days after sowing for the local variety and 6 days after sowing for the improved varieties in Niger. This could be explained by the higher humidity in Benin and Côte d'Ivoire where it rains heavily, the origin of the variety (local or improved), and the quantity of sand put in during sowing.

In addition, all the local varieties recorded their flowering dates at more than 73 DAS and a maturity time of more than 92 DAS. These recorded values were high compared to those obtained with the 6 improved varieties introduced by IITTA used in the study by N'gbesso *et al*. (2013), on the 124 local varieties assessed in Benin by (Gbaguidi *et al* ., (2015) and on the 70 local varieties assessed in Togo Dagnon *et al* ., (2017). These authors obtained 51; 52.12; 60.27 DAS for the flowering dates and 74; 77; 85.21 DAS for the maturity time, respectively.

In addition, a low yield is observed in these local varieties, which was much lower than that found by Aly *et al* . (2017), with 930 kg ha^{-1} in their studies in Benin with the local variety *Kakanon*. Indeed, the lower yield obtained in the present study can be partly explained by the low spacing taken, which is a very creeping variety compared to the spacing of less than one meter used by Gbaguidi *et al* . (2015) in Benin.

The local varieties are late because they take over three months to complete the cycle. This behavior of these local varieties confirms their local originalities and shows farmers' role in managing agricultural biodiversity. It also indicates that the improved varieties were not widely popularized in the places of origin of the material. IT90 and IT98 were early and had a high yield compared to local varieties. IT98, earlier and more productive, could be popularized in rural areas in the context of climate change with a tendency for the rainy period to shorten during a season.

The quantitative morphological characteristics of the pods showed a significant difference in all varieties. The IT98 variety produced pods of significant average length and a high number of seeds, while the BTAr variety produced pods of a very short length. These results are close to those obtained by N'gbesso *et al* . (2013) for the number of seeds per pod in Côte d'Ivoire for the improved variety IT96D-733 (28 number of seed), lower (25.51) than those obtained by Gbaguidi *et al* ., (2015) in local varieties in Benin, and also lower than 18.4 cm in pod length (improved variety IT99K-573 1-1) and 17.3 seeds per pod (Improved variety Mujilanga) found by Mukendi *et al.*, (2017) in Congo. Seed length, width and thickness showed a significant difference between varieties, but present results were lower than those observed by Mebdoua (2011) on the physico-chemical characterization of local cowpea in Algeria and close to the average found by Dagnon *et al*. (2017) in Togo. In addition, the high 100-seed weight i observed in the BTAr variety was greater than that found by Gbaguidi *et al* ., (2015), 23.75 g, in their study on the agro-morphological characterization of cowpea varieties grown in Benin, and also 20 g obtained by Coulibaly *et al* ., (2020) in Burkina Faso. This difference could be explained by the pedoclimatic conditions or due to the variability of the varieties.

The average length of the petiole, the average length of a leaflet and the average width of the leaflets on our varieties are higher than those obtained by Yoka *et al* . (2014) in Congo. These differences could be explained by the contribution of the amount of organic matter, the differences in precipitation during our experiment, and the temperature. A significant branching is observed with the varieties BLSB, BTAr, CDSB, BLAr and IT90, which was higher than that observed by N'gbesso *et al*. (*2013*) with 4.8 branches per plant, Mukendi *et al* ., (2017) with 2.6 branches per plant. This high number of ramifications can be explained by the secondary ramifications considered during the present data collection.

The low yield observed in local varieties could be linked to the regular loss of leaflets at the flowering stage caused by a rain break. These observations are consistent with that of Dagba (1973) in Dahomey, who found that defoliated plants have lower pod production than non-defoliated plants.

The principal component analysis with 11 quantitative agromorphological characteristics showed a clear reorganization of these six varieties studied in five groups. This explains the difference between the varieties of each group. The improved varieties IT98 forming group 1 and IT90 forming group 2, were characterized by long peduncles, a number of pods, a high yield, and a short cycle. Unlike the improved varieties IT90 and IT98, the varieties forming group 3 and group 4 were characterized by a long cycle (late) and a high biomass yield, while group 5 of the BTAr variety has its own characteristics such as length, width, thickness of the seeds as well as the weight of one hundred seeds. As highlighted by Sulnathi *et al* . (2007), flowering date, maturity date, 100-seed weight, and seed yield are the traits that most contribute to the divergence between cultivars. In the present study, Group 1 and 2 varieties can be very useful in breeding programs because variety IT98 is early, variety IT90 is semi-early, and all have high seed yields.

Conclusion

This study has identified thought-provoking agromorphological characteristics for cowpea cultivation that breeders can use to provide producers with more productive and earlier varieties in the Zinder region (Niger) . In addition, it made it possible to identify the characteristics that contribute to separating these varieties. This is how the improved variety (IT98) proved to be fast and more productive in seeds with other essential components of better yields (number of pods and number of seeds per pod), which constitute key characteristics in predicting yield in cowpea crops. The local varieties (BLAr, BLSB and CDSB) had a slow development with a low seed yield but a high biomass yield. In addition, the local variety (BTAr), having the same behavior as its counterparts mentioned above, displays broader and thicker seeds and a higher weight of 100 seeds. Finally, the IT98 variety could be a good candidate for varietal selection and extension of cowpeas in the context of climate change and food insecurity.

Conflict of interest

The authors declare that they have no conflict of interest.

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