Original Research Article

Agromorphological characterization of a collection of *Senna obtusifolia* (L.) in Burkina Faso

Abstract

Aims: *Senna obtusifolia* (L.) is an important wild herbaceous species for subsaharian Africa population. It is used in human food and traditional medicine to treat several deseases. In Burkina Faso, this species despite its potentialities, is a little interest to scientific research. The aim of this study is to provide a good knowledge of the genetic diversity of this species.

Study design: The experimental design used was a randomized Fischer block type with three replications.

Place and Duration of Study: The study was carried out at Gampéla during 2018 rainy season.

Methodology: Seventy (70) accessions of *Senna obtusifolia* were used for the evaluation of agromorphological variability. A total of twenty-seven (27) quantitative traits were studied.

Results: The study revealed the existence of a great variability within the studied collection. Among the twenty-on (21) traits used for the analysis of variance

UNDER PEER REVIEW

(ANOVA), seventeen (17) variables significantly discriminate the accessions. A high heterogeneity was observed for the number of leaflets of the three first leaves and the number of floral pieces. Also, significant correlations were observed between several variables. Indeed, the number of primary branches was positively correlated with number of fruits per plant (r = 0.483), number of grains per plant (r = 0.352) and leaves biomass (r = 0.279). However, the number of days at flowering (NJF) is negatively correlated with number of primary branches (r = -0.281). The variability obtained was structured in three groups. Group 3 is composed of accessions with best agronomic performance that could be used in future breeding program.

Conclusion: A high agromorphological diversity of *Senna obtusifolia* was observed and could be used in a breeding program.

Key words : *Senna obtusifolia, sicklepod, agromorphological variability, interest traits, Burkina Faso.*

1. Introduction

Senna obtusifolia (L.) commonly known as sicklepod or « pistache marron ou casse fétide » in French, is a herbaceous plant with food, nutritional, medicinal and economic potential. Indeed, its leaves are used as vegetable in Africa and Asia as well [1, 2]. Moreover, according to the chemical composition given by [3], this species contains more iron, calcium, phosphorus, vitamin C and protein than *Amaranthus hybridus* and *Hibiscus sabdariffa*. Its leaves, seeds and roots are used to treat diseases such as night blindness, hepatitis, ulcers, stomachaches, venomous insect bites, etc. [4]. "*Kawal*" made from the leaves of *Senna obtusifolia*, generates important income to women and thus contributes to the valorization of plant resources and food security of the population of Tchad [5]. Moreover, it is well adapted to local climatic conditions. Despite its socioeconomical importance, very few studies have been carried out on *Senna obtusifolia* in Burkina Faso. No collection at national level has yet been carried out on this species. According to [6], the lack of knowledge about the species is one of the factors that dangerously threaten their existence. It is therefore necessary to study the genetic diversity of

Senna obtusifolia in order to provide a better knowledge for its promotion, valorization, and conservation.

It is on the view of answering this concern that occurs this study, the main objective of which is to contribute to the knowledge of the agromorphological variability of the species. Specifically, this study aims at : i) identifying the quantitative characters that discriminate the accessions ; ii) identifying the different correlations between the studied characters ; iii) establishing the level of agromorphological variability and iv) establishing the structure of the agromorphological variability.

2. Material and methods

2.1. Plant material

The plant material consists of seventy (70) accessions of *Senna obtusifolia* (L.) collected in 5 provinces of the 3 agroclimatic zones of Burkina Faso in 2017 by genetics and plant breeding team of the university Joseph KI-ZERBO.

2.2. Experimental site

The agromorphological characterization was conducted at the experimental station of Institut de Développement Rural (IDR) at Gampèla at 12°15' North latitude and 1°12' West longitude. The site is located in the North Sudanian domain and is characterized by an annual rainfall ranged between 600 and 900 mm [7]. This site received 854.3 mm of water during 2018 rainy season between July to October.

The soil texture is predominantly sandy loam with 32.5% fine silt, 23.98% coarse silt, 21.32% fine sand and 3.2% coarse sand. The organic matter content was 0.741% and the total carbon and total nitrogen content was 0.430% and 0.034% respectively, with a C/N ratio of 13%. The exchange capacity was 6.4 with a saturation rate of 63%. The pH of the soil was 5.69 [8].

2.3. Experimental design and cultivation practices

The study was carried out in a randomized Ficher block with three replications. Each accession was sown in rows of 4.5 m long with spacing of 0.5 m. The plots was fertilized with organic manure at the rate of five (5) tons per hectare. Weeding was carried out when it's necessary in order to fight against weeds.

2.4. Data collection

UNDER PEER REVIEW

The variables used in this study were selected based on agromorphological characterization studies conducted on leafy vegetable species such as *Solanum aethiopicum* [9], *Corchorus olitorius* [10] and *Cleome gynandra* [11].

A total of twenty-seven (27) quantitative variables were measured. This is the number of days to emergence (**NJL**), number of days to flowering (**NJF**), plant height at maturity (**HPM**), stem diameter (**DTG**), number of primary branches (**NRP**), leaf length (**LOF**), small leaflet length (**LOf1**), large leaflet length **(LOf2),** small leaflet width **(LAf1**), large leaflet width (**LAf2),** number of leaflets per leaf (**NFO**), petiole length (**LPE**) and leaves biomass (**BIO**) mesured on vegetative parts of the plant and by counting. The traits measured on flowers are length of large sepal (**LOS1)**, length of the small sepal (**LOS2)**, number of sepals per flower (**NSE**), number of petals per flower (**NPE**), length of petals (**LOPe**), number of stamens per flower (**NET**), number of pistils per flower (**NPI**), floral peduncle length (**LOPc**) and number of flowers per leaf axil (**NFA**). Among the variables measured on the fruit, there are fruit length (**LOFr**), fruit width (**LAFr**), number of fruits per plant (**NFrP**), number of seeds per fruit (**NGFr**) and number of seeds per plant (**NGP**) assessed on all fruits produced per plant.

2.5. Data analysis

The collected data were entered and then processed with Excel 2016 software before analyses with Xlstat 2016.02.27444 softwares. Thus, an analysis of variance (ANOVA) was performed in order to determine the characters that discriminate the different accessions of *Senna obtusifolia*. A correlation matrix was realised in order to observe the relationships that would exist between the characters. A Principal Component Analysis (PCA) was performed. The projection of all the characters on the planes formed by the principal components also allowed to appreciate the correlations between the different agromorphological characters. A hierarchical ascending classification (HAC) according to Ward's aggregation method using the Euclidean distance allowed the grouping of accessions. The morphological groups obtained were characterized by a discriminant factor analysis (DFA) and the Newman-Keuls test of separation of means at 5% threshold was performed in order to compare the morphological performance of these groups.

UNDER PEER REVIEW

3. Results

3.1. Agromorphological performance of the studied accessions

The analysis of variance (ANOVA) showed that among the 21 characters used, only four (4) such as small leaflet length (LOf1), small leaflet width (LAf1), length of large sepal (LOS1) and fruit width (LAFr) didn't allow to dricriminate the accessions at 5% threshold (table 1). However, the characters plant height at maturity (HPM), length of large leaflet (LOf2), length of petals (LOPe), number of seeds per fruit (NGFr) highly discriminate the accessions at 1% threshold.

Moreover, the high values of the coefficient of variation (CVs) and coefficient of determination (R^2) (above 30%) for most of the characters indicate a very high heterogeneity within the studied material. Indeed, the values of the coefficient of determination (R^2) are high (higher or equal to 30) for all the characters. The coefficient of determination (R^2) varied from 31.80% for fruit width (LAFr) to 82% for leaves biomass (BIO).

Coefficients of variation (CVs) ranged from 6.80% for fruit length (LOFr) to 48.90% for small sepal length (LOS2). CVs were high (CVs higher than 30%) for the characters number of days to emergence (NJL) (46.20), leaves biomass (BIO) (33.90%), large sepal length (LOS1) (38.30%), small sepal length (LOS2) (48.90%), number of fruits per plant (NFrP) (32.2%) and number of seeds per plant (NGP) (32.3%).

Variability was observed in the number of the leaflets on the three first leaves. Thus, for the number of the leaflets of the first three (03) leaves, the majority of accessions (92.85%) had the first leaf with two pairs of leaflets and the following leaves with three pairs of leaflets or five leaftlets (figure 1).

According to the reproductive organs, 75.71% of the accessions have solitary flower in the leaf axils (figure 2A). Some accessions (15.71%) presente a pair of solitary flowers in the same leaf axil (figure 2B). However, there are accessions with three (8.57%) (figure 2C), four and five solitary flowers in the same leaf axil (figure 2D). Sometimes, all of the variant of these arrangement are observed in the same plant. The flowers have five sepals of unequal size (3 large and 2 small), five petals and ten stamens of which four are long, three short and three reduced. Most flowers have

UNDER PEER REVIEW

one recurved pistil (98%) (figure 3A). However, some accessions have flowers with 2 or 3 pistils (figure 3B).

Table 1 : Average performance of the studied accessions for 21 quantitative traits

Variable	Minimum	Maximum	Average	CV (%)	R^2 (%)	F	Pr > F
NJL	3.000	16.000	4.952	46.200	74.100	5.794	< 0.0001
NJF	39.000	72.000	53.138	12.900	80.000	8.116	< 0.0001
HPM	50.000	140.667	102.474	18.000	45.500	1.695	0.004
DTG	9.417	21.010	14.254	15.300	75.800	6.343	< 0.0001
NRP	10.000	23.000	16.024	15.200	63.500	3.524	< 0.0001
LOF	9.000	14.600	12.291	09.200	64.500	3.689	< 0.0001
LOf1	2.033	4.333	3.355	11.600	40.200	1.363	0.063
LOf2	3.467	5.833	4.706	10.700	47.000	1.802	0.002
LAf1	1.633	3.433	2.640	12.500	37.400	1.211	0.171
LAf2	2.300	5.067	3.117	11.700	43.100	1.537	0.017
LPE	3.367	7.067	5.176	15.700	56.400	2.624	< 0.0001
BIO	22.630	217.300	84.250	33.900	82.000	9.225	< 0.0001
LOS1	0.567	4.900	0.766	38.300	34.600	1.075	0.355
LOS2	0.267	2.433	0.431	48.900	41.900	1.461	0.030

LOPe	0.967	1.833	1.200	08.000	44.400	1.621	0.008
LOPc	1.567	3.533	2.482	15.200	49.200	1.965	0.000
LOFr	12.333	19.600	15.784	06.800	52.700	2.257	< 0.0001
LAFr	0.233	0.400	0.340	21.200	31.800	0.948	0.593
NFrP	53.000	305.000	141.029	32.200	75.300	6.174	< 0.0001
NGFr	18.000	32.000	26.348	09.600	47.100	1.806	0.002
NGP	698.000	7379.000	3651.140	32.300	69.500	4.624	< 0.0001

Legend: NJL: *number of days to emerge;* **NJF***: number of days to flowering;* **HPM:** *height of plant at maturity;* **DTG:** *stem diameter;* **NRP:** *number of primary branches;* **LOF***:length of the leaf;* **LOf1***: small leaflet length;* **LOf2***: large leaflet length;* **LAf1***: small leaflet width;* **LAf2***: large leaflet width;* **LPE:** *petiole length;* **BIO:** *Leaves biomass;* **LOS1***: length large sepal;* **LOS2***: length of the small sepal;* **LOPe:** *length of the petal;* **LOPc***: length of the floral peduncle;* **LOFr***: length of fruit;* **LAFr***: width of fruit;* **NFrP***: number of fruits per plant;* **NGFr***: number of seeds per fruit;* **NGP***: number of seeds per plant;* **CV:** *coefficient of variation;* **R^2:** *coefficient of determination*

A **B** **C**

Figure 1 : Number of leaflets of the three first leaves (**A** *: First leaf with two pairs of leaflets ;* **B** *: Two first leaves with two pairs of leaflets ;* **C***: Presence of two pairs, three pairs and five leaflets on the same plant*)

A B C D

Figure 2 : Number of flowers per leaf axil (**A** *: One flower per axil ;* **B** *: Two flowers per axil ;* **C** *: Three flowers per axil ;* **D** *: Five flowers per axil*)

A B C

Figure 3 : Number of pistils per flower (*A : one pistil ; B : two pistils ; C : three pistils*)

3.2. Correlation between quantitative traits

Pearson correlation matrix (Table 2) shows several significant correlations between the studied characters at 5% threshold. Thus, the number of days at flowering (NJF) is negatively correlated with the number of primary branches (PRN) (r = -0.281), fruit length (LOFr) (r = -0.244), number of fruits per plant (NFrP) (r = -0.361) and number of grains per plant (GPN) (r = -0.323). However, the number of primary branches (NRP) is positively correlated with the number of fruits per plant (NFrP) (r = 0.483), the number of grains per plant (NGP) (r = 0.352) and leaves biomass (BIO) (r = 0.279).

Table 2 : Pearson correlation matrix between the studied characters

Variables	NJL	NJF	HPM	DTG	NRP	LOF	LOf1	LOf2	LAf1	LAf2	LPE	BIO	LOS1	LOS2	LOPe	LOPc	LOFr	LAFr	NFrP	NGFr	NG P
NJL	**1**																				
NJF	0.218	**1**																			
HPM	-0.070	0.197	**1**																		
DTG	-0.212	0.127	**0.414**	**1**																	
NRP	-0.104	**-0.293**	0.029	**0.349**	**1**																
LOF	0.006	-0.127	**0.257**	0.170	0.211	**1**															
LOf1	-0.053	**-0.258**	**0.334**	0.190	0.072	**0.729**	**1**														
LOf2	-0.191	-0.229	**0.242**	**0.237**	0.032	**0.683**	**0.917**	**1**													
LAf1	-0.028	-0.190	**0.386**	**0.309**	0.095	**0.688**	**0.859**	**0.836**	**1**												
LAf2	-0.139	-0.161	**0.370**	**0.236**	0.043	**0.612**	**0.809**	**0.818**	**0.814**	**1**											
LPE	0.048	0.074	0.216	0.000	0.008	**0.772**	**0.512**	**0.408**	**0.427**	**0.357**	**1**										
BIO	**-0.339**	-0.198	0.157	**0.312**	**0.279**	**0.342**	**0.433**	**0.473**	**0.383**	**0.321**	0.159	**1**									
LOS1	-0.054	-0.123	-0.070	-0.049	0.127	0.104	0.136	0118	0.079	0.108	0.035	0.010	**1**								
LOS2	-0.088	**-0.281**	0.022	-0.073	-0.126	0.033	0.147	0.170	0.106	0.130	-0.036	-0.078	**0.605**	**1**							
LOPe	-0.228	**-0.381**	-0.134	0.175	0.025	0.086	0.190	**0.279**	0.190	0.180	-0.157	**0.257**	0.077	0.077	**1**						
LOPc	-0.083	**-0.519**	0.166	**0.249**	**0.282**	**0.363**	**0.270**	0.232	**0.306**	0.189	0.168	**0.307**	0.166	0.158	**0.406**	**1**					
LOFr	**-0.316**	**-0.244**	0.027	**0.274**	-0.012	0.114	0.200	**0.253**	0.135	0.147	-0.053	**0.376**	-0.019	-0.056	**0.388**	**0.332**	**1**				
LAFr	-0.067	-0.040	-0.037	**-0.338**	-0.071	0.160	0.008	-0.089	-0.092	-0.062	**0.279**	-0.171	0.041	0.084	-0.195	-0.129	-0.184	**1**			
NFrP	-0.231	**-0.361**	0.024	**0.529**	**0.483**	0.140	**0.280**	**0.356**	**0.282**	**0.276**	-0.080	**0.296**	0.050	-0.020	**0.331**	**0.339**	**0.344**	**-0.246**	**1**		
NGFr	**-0.279**	-0.065	-0.009	-0.021	-0.121	0.115	0.164	0.184	0.107	0.140	0.077	0.098	0.064	-0.118	0.182	0.012	**0589**	0.008	0.119	**1**	
NGP	**-0.240**	**-0.323**	-0.024	**0.461**	**0.352**	0.169	**0.380**	**0.461**	**0.360**	**0.321**	-0.052	**0.328**	0.063	-0.014	**0.291**	0.235	**0.403**	-0.196	**0.881**	**0.361**	**1**

Legend: *in bold: significant correlations;* ***NJL****: number of days to emergence;* ***NJF:*** *number of days to flowering;* ***HPM:*** *plant height at maturity;* ***DTG:*** *stem diameter;* ***NRP:*** *number of primary branches;* ***LOF:*** *leaf length;* ***LOf1****: small leaflet length;* ***LOf2:*** *large leaflet length;* ***LAf1:*** *small leaflet width;* ***LAf2****: large leaflet width;* ***LPE****: petiole length;* ***BIO****: leaves biomass;* ***LOS1****: large sepal length;*

LOS2: *small sepal length;* ***LOPe****: petal length;* ***LOPc:*** *length of the floral peduncle;* ***LOFr:*** *fruit length;* ***LAFr:*** *fruit width;* ***NFrP****: number of fruits per plant;* ***NGFr****: number of seeds per fruit;* ***NGP:*** *number of seeds per plant*.

3.3. Structuring of the diversity

3.3.1. Agromorphological diversity

The results of the Principal Component Analysis (ACP) revealed that the first four axes explain 73.884% of the total variability (figure 4). Indeed, axis 1 with 30.615% of the total inertia, is positively associated with the characters stem diameter (DTG) (r = 0.598), number of primary branches (NRP) (r = 0.586), leaf length (LOF) (r =0.505), leaves biomass (BIO) (r =0.648), floral peduncle length (LOPc) (r = 0.703), fruit length (LOFr) (r = 0.537), and number of fruits per plant (NFrP) (r = 0.735). But, this axis is negatively associate to the character number of days to flowering (NJF) (r = -0.496). Axis 2 with 19.345% of inertia, is positively associated with leaf length (LOF) (r=0.767), petiole length (LPE) (r = 0.880) and fruit width (LAFr) (r = 0.585).

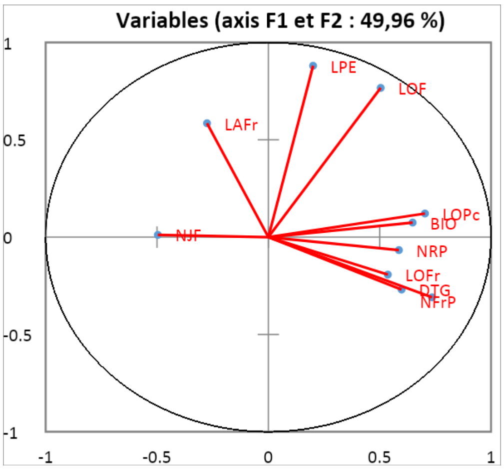

Figure 4 : Projection of the measured variables in the plan 1/2 of the analysis of principal components (APC)

3.3.2. Structuring of the accessions

The hierarchical ascending classification (HAC) gives a structuring of the 70 accessions of *Senna obtusifolia* (L.) in three groups (figure 5) without taking into account their geographical origin, with an inter-class variance of 77.22% and an intra-class variance of 22.78%.

UNDER PEER REVIEW

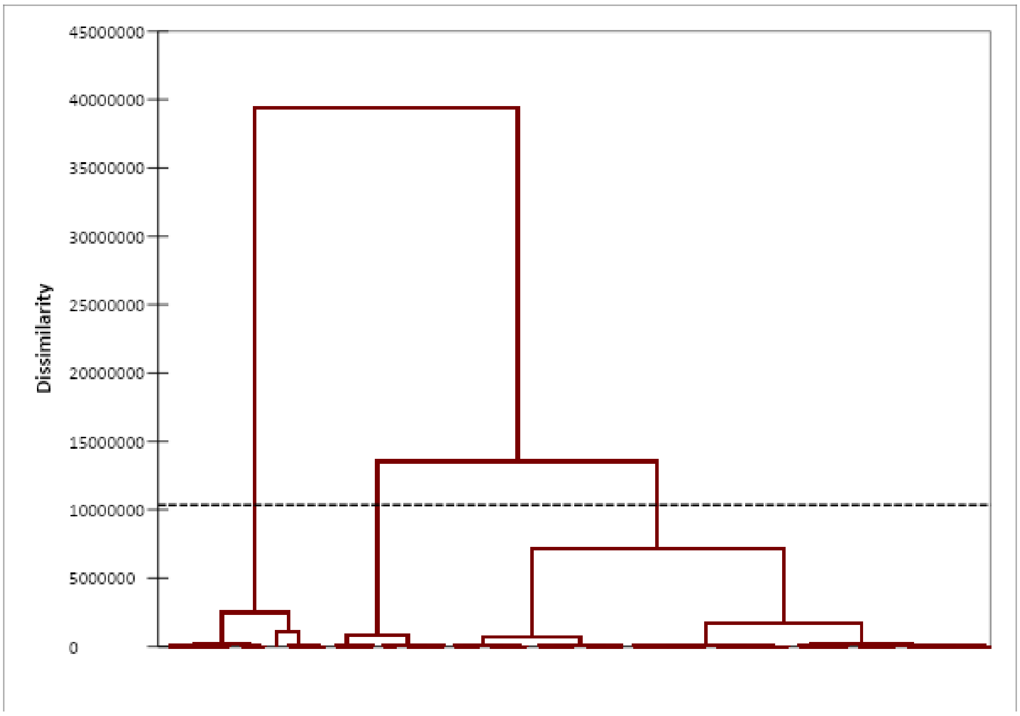

Figure 5 : Dendrogram from the hierarchical ascending classification (HAC) of the collection of *Senna obtusifolia* (L.)

3.3.3. Groups characteristics

The Wilkin's Lambda test indicate that the 3 groups are quite distinct entities at 5% threshold. The results of the analysis of variance, and the Newman-Keuls test at 1% threshold indicate that the characters fruit length (LOFr) (P-value = 0.000), number of fruits per plant (NFrP) (P-value < 0. 0001), number of seeds per plant (NGP) (P-value < 0.0001), stem diameter (DTG) (P-value = 0.001) and length of large leaflet (LOf2) (P-value = 0.008) significantly discriminate the groups. Furthermore, the relationship of the groups with the axes of Discriminat Factor analysis (Figure 6) shows that group 1 and 3 are opposite and correlated to the axis 1. As for group 2, it is located between group 1 and 3 and correlated to axis 2.

The group 1 is formed by accessions with low agronomic performance. These accessions have a reduced number of primary branches and low leaves biomass. They produce few fruits that are shorter but wider, few seeds and flower late. The group 2 is composed of accessions with average agronomic performance. These accessions have an average number of primary branches and leaf biomass. They have an average fruit length, number of fruits per plant and number of seeds per plant. The group 3 includes accessions with better agronomic performances. Thus, the accessions of this group have high number of primary branches and high leaves biomass. They produce many long but thin fruits with many seeds. They flower earlier.

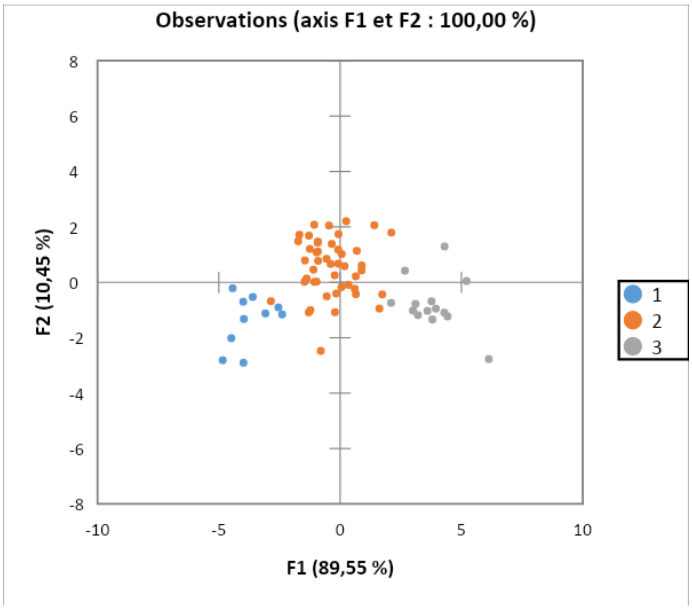

Figure 6 : Representation in the plan 1/2 of DFA of the groups formed by HAC

4. Discussion

The analysis of variance reveals the existence of an agromorphological variability within the studied collection of *Senna obtusifolia* in Burkina Faso. Indeed, the high values of the coefficient of determination and the coefficient of variation recorded for most of the studied characters show the existence of heterogeneity within the collection that could be attributed to the genotypic expression of the different accessions. Moreover, since the species is still wild, it has not been subjected to pressures of selection. According to [12, 13], management practices though empirical selection are widely known to have consequences on the level of genetic diversity and the evolution of the plant species by reducing their variability.

The variability observed in the number of the leaflets on the three first leaves corroborate those of [14, 15] who found two pairs of leaflets for the first leaf and three pairs for the others or alternated leaves with two to three pairs of leaflets. These criteria could be used to range the accessions in several morphotypes. Indeed, according to the number of leaflets three morphotypes could be identified in the

UNDER PEER REVIEW

studies accessions. The first morphotype has first leaf with two pairs of leaflets and the other leaves with three pairs of leaflets. The second morphotype has the two first leaves with two pairs of leaflets, the others with three pairs of leaflets. The third morphotype has the first leaf with two pairs of leaflets, the second with three pairs of leaflets, the third leaf with two pairs of leaflets, the other leaves formed by an alternation of two pairs, three pairs and five leaflets.

According to the number of flowers in the leaf axils, three morphotypes have been also identified. A first morphotype with solitary flowers in the leaf axils, a second morphotype with solitary or paired flowers in the leaf axils and a third morphotype with solitary, paired, triple, quadruple or quintuple flowers in the leaf axils of the same plant. The two first morphotypes agree with the results of [16] according to which the flowers are arranged solitary or in pairs in the axils of the leaves. However, the third morphotype differs from these results by the presence of flowers arranged by triple, quadruple, quintuple in the leaf axils. This difference could be justified by the genotypic difference between accessions of *Senna obtusifolia* from Burkina Faso and elsewhere.

The results of this study concerning flowers that have ten stamens of which three reduced, four short and three large and have also a recurved pistil are in accordance with those of [17, 18]. However, the presence of morphotypes with some flowers with two (02) or three (03) pistils differ from the results of previous studies. This difference could be explained by the nature of the material studied. Indeed, according to [19, 20], accessions from spontaneous populations keep their wild characters, while those from cultivated populations tend to acquire other characteristics that differentiate them from spontaneous populations. Moreover, all of our accessions were collected from the wild, so this would indicate the existence of high variability within the spontaneous population of *Senna obtusifolia*.

The negative correlation between the number of days to flowering (NJF) and the variables number of primary branches (NRP), length of fruit (LOFr), number of fruits per plant (NFrP) and number of seeds per plant (NGP) observed, show that morphotypes with short reproduction cycle have high number of primary branches and high yields of leaves, fruits and seeds. This suggests that selection should be oriented towards earlier flowering accessions that produce more leaves as well as

UNDER PEER REVIEW

seeds. This low performance of the long-cycle accessions of *Senna obtusifolia* would be due, on the one hand, to the port of the plant, which bears less branching, and on the other hand, to rainfall deficiencies observed during the trial which therefore, didn't allow a full expression of their potentialities. Similar results were observed by [21] on *Solanum aethiopicum* (L.) in Burkina Faso.

The structuring of the studied accessions into three agromorphological groups independently of their origin could be justified by the existence of significant intra-accession variability in the collection areas. These results corroborate those of [22, 23] on *Corchorus olitorius* and [20] on *Cleome Gynandra* (L.). The existence of variability is essential for varietal improvement. Thus, the variability observed within the studied accessions shows that it's possible to use them in a selection program. Moreover, the different correlations observed contribute to guide genetic improvement of this species. Finally, the accessions of the group 3 which have the best agronomic performances could be used in future breeding program.

5. Conclusion

The agromorphological characterization revealed the existence of several discriminating characters reflecting the existence of high variability within the collection of *Senna obtusifolia* studied. This variability was structured in three morphological groups independently of the areas of collection. Numerous significant and interesting correlations were noted between several characters, notably the number of primary branches, leaves biomass and the number of seeds per plant. The study also shows the existence of a significant gene control on the expression of the traits, expressed by a high coefficient of determination. A particular interest could be focused on the accessions of group 3, due to their high agronomic performance. The agromorphological parameters being under the influence of the environment, it is therefore necessary to refine the variability obtained at the end of this study by using molecular markers.

UNDER PEER REVIEW

BIBLIOGRAPHIC REFERENCES

[1] Pasternak D.L., Woltering A., Nikiema D., Senbeto D., Fatondji J. and Ndjeunga J., 2007. Domestication of *Senna obtusifolia*, an important leafy vegetable for the Sahel. ISHS *Acta Horticulturae* 752 : International Conference on Indigenous Vegetables and Legumes. Prospectus for Fighting Poverty, Hunger and Malnutrition. https://doi.org/10.17660/Acta-Hortic.2007.752.

[2] Shailesh M.K., 2012. Pharmacognostical studies on the leaves of *Cassia obtusifolia* Linn. *Asian J. Plant Sci. Res* ; 4 : pp 421-427.

[3] Toury J., Giorgi R., Favier J.C. and Savina J. F., 1967. Aliments de l'ouest africain : tables de composition. *Annales de la nutrition et de l'alimentation* ; Vol. 21, pp. 73-127.

[4] Eklu-Natey R.D. et Balet A., 2012. *Pharmacopée Africaine Dictionnaire et Monographies multilingues du potentiel Médical des plantes africaines*. Afrique de l'Ouest. Vol 2. Édition d'en bas-Traditions et Médecines. ISBN, 978-2-8290-0433-9.

[5] Abakar I.L., Guira F., Tapsoba F., Zongo C., Abdoullahi Hissein O., Tidjani A. et Savadogo A., 2019. Le kawal, un condiment à base de feuilles fermentées de *Senna obtusifolia*: technologies et valeurs nutritionnelles. *Af. J. Food Agric. Nutri. Dev. ;* 19(2) pp 14244-14260.

[6] Dansi A., Adjatin A., H. Adoukonou-Sagbadja H., Faladé V., Yédomonhan P., Vodouhè R., Agbangla C., Sanni A., Akouegninou A. et Akpagana K., 2008. *Biodiversité des Legumes feuilles Traditionnels consommés au Bénin*. 157 p. ISBN : 978 -99919 -68 -63 -6.

[7] Thiombiano A. et Kampmann D., 2010. Atlas de la biodiversité de l'Afrique de l'Ouest, Tome II : Burkina Faso, Ouagadougou et Frankfurt/Main.

[8] BUNASOLS, 2019. Resultats d'analyse du sol.

[9] Sawadogo B., Bationo-Kando P., Sawadogo N., Kiebre Z., Kiebre M., Nanema K.R., Traore R.E, Sawadogo M. and Zongo J.D., 2015. Variation, correlation and heritability of interest characters for selection of african eggplant. *African Crop Science Journal*, Vol. 24, No. 2, pp. 213 – 221.

[10] Kiebre M., Bationo/Kando P., Kiebre Z., Sawadogo M., Sawadogo N., Sawadogo B., Nanema R.K. et Traore R.E., 2016. Evaluation agromorphologique d’accessions de corète potagère *(Corchorus olitorius.* L*)* du Burkina Faso. *International Journal of Innovation and Applied Studies,* Vol. 14 (1), pp. 198-209.

[11] Kiebre Z., Bationo/Kando P., Sawadogo N., Kiebre M., Sawadogo B., Traore R.E., Sawadogo M. et Zongo J.D., 2017. Évaluation de la diversité agromorphologique d'une collection de *Cleome gynandra* L. du Burkina Faso. *Journal of Applied Biosciences* ; 118 : pp 11768-11780

[12] Missihoun A.A., Agbangla C., Adoukonou-Sagbadja H., Ahanhanzo C. et Vodouhè R., 2012. Gestion traditionnelle et statut des ressources génétiques du sorgho (*Sorghum bicolor* (L.) Moench) au Nord-Ouest du Bénin. *Int. J. Biol. Chem. Sci*. 6(3) : pp 1003-1018.

[13] Vom Brocke K., Christinck A., Weltzien E.R., Presterl T. and Geiger H.H., 2003. Farmer’s seed systems and management practices determine pearl millet genetic diversity patterns in semiarid regions of India. *Crop Sci*., 43 : pp 1680-1689.

[14] Johnson D.E., 1997. *Les adventices en riziculture en Afrique de l’ouest*. 312 p.

[15] Mackey A.P., Miller E.N. and Palmer W.A., 1997. *Sicklepod in Sicklepod* (Senna
obtusifolia). Department of Natural Resources and Mines, Queensland. ISBN : 0724272585.

[16] Merlier H. et Montégut J., 1982. Adventices tropicales. 490 p.

[17] Gottsberger G. and Silberbauer-Gottsberger I., 1988. Evolution of flower structures and pollination in neotropical *Cassiinae Caesalpiniaceae* species. P*hyton* (*Horn*) ; 28 : pp 293-320.

[18] Irwin H.S. and Barneby R.C., 1982. The American *Cassinae*. A synoptical revision of *Leguminosae* tribe *Cassieae* subtribe *Cassiinae* in the New World. *Memoirs of the New York Botanical Garden* ; 35 : pp 252-255.

[19] Ghosh K.R., Wongkaew A., Sreewongchai T., Nakasathien S. and Phumichai C., 2014. Assessment of Genetic Diversity and Population Structure in Jute (*Corchorus spp*.) using Simple Sequence Repeat (SSR). *Kasetsart J.* (*Nat. Sci*.) ; 48 (1) : pp 83 – 94.

[20] Kiebré Z., Bationo/Kando P., Sawadogo N., Sawadogo M. and Zongo J.D., 2015. Selection of phenotypic interest for the cultivation of the plant *Cleome*

UNDER PEER REVIEW

gynandra L. in vegetable gardens in Burkina Faso. *Journal of Experimental Biology and Agricultural Sciences*, 3(3) : pp 288-297.

[21] Sawadogo B., 2018. *Diversité génétique de l'aubergine africaine* (Solanum aethiopicum (L.) subsp kumba) *du Burkina Faso*. Thèse de Doctorat Unique, Université de Ouagadougou (Burkina Faso), 128 p.

[22] Benor S., Blattner F.R., Demissew S. and Hammer K., 2009. Collection and ethnobotanical investigation of *Corchorus* species in Ethiopia : potential leafy vegetables for dry regions. *Genet. Resour. Crop ; vol. 57(2),* pp 293–306.

[23] Adebo H.O., Ahoton L.E., Quenum F. and Ezin V., 2015. Agro-morphological Characterization of *Corchorus olitorius* Cultivars of Benin. *Annual Research & Review in Biology ;* 7(4) : pp 229-240.