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Morphological Characterization of Genetic Resources of *Corchorus tridens* and *Corchorus fascicularis* Species in Burkina Faso

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Abstract: This study presents an agro-morphological characterization of 40 accessions belonging to two *Corchorus* species, aiming to assess the extant genetic variability within each species. Twenty-six (26) traits, comprising fourteen (14) qualitative and twelve (12) quantitative variables, were evaluated. The experiments were conducted during the 2021 and 2022 rainy seasons at the IDR experimental station in Gampéla, using a randomized complete block design (RCBD) with three replications. The results revealed substantial agro-morphological variability among the accessions of both species, driven by several qualitative and quantitative traits. Notably, while qualitative traits failed to discriminate among *C. tridens* accessions, they revealed significant variability within *C. fascicularis*. Agglomerative Hierarchical Clustering (AHC) using Ward's aggregation method and Euclidean distance partitioned the accessions into three distinct clusters for each species. High broad-sense heritability (H^2) was recorded in both species for the following traits: number of days to 50% flowering (H^2 = 90.78 % in *C. tridens* and 97.27% in *C. fascicularis*), leaf blade length (H^2 = 85.52% in *C. tridens* and 74.02% in *C. fascicularis*), and petiole length (H^2 = 80.43 % in *C. tridens* and 79.49% in *C. fascicularis*). Furthermore, high expected genetic advance as a percentage of the mean (Gax %) was observed in *C. tridens* for leaf blade length (Gax = 41.46 %), leaf blade width (Gax = 47.26 %), and fresh leaf weight (Gax = 53.64 %). Conversely, in *C. fascicularis*, high expected genetic advance was noted for plant height (Gax = 38.72 %), number of primary branches (Gax = 49.47 %), and petiole length (Gax = 49.19 %).

Keywords: *Biodiversity, Intraspecific Diversity, Corchorus tridens, Corchorus fascicularis, Burkina Faso.*

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I. INTRODUCTION

The genus *Corchorus* comprises annual or perennial herbs and shrubs ranging in height from 0.09 m to over 4 m (Benor *et al.*, 2010). In several African, Asian, and European countries, their leaves and fruits are commonly consumed as vegetables (Oyedele, 2006; Furumuto *et al.*, 2002; Velempini, 2003; Grubben and Denton, 2004; Sawadogo *et al.*, 2023). In Burkina Faso, *Corchorus tridens* and *Corchorus fascicularis* are particularly prized, and their organs are traditionally harvested from the wild for various uses. However, this potential is currently threatened. The erosion of plant biodiversity in natural habitats is being exacerbated by climate change and the intensive use of agricultural herbicides. Faced with the progressive depletion of these wild resources, the implementation of integrated sustainable conservation and genetic breeding programs has become imperative. In this context, agro-morphological characterization constitutes a fundamental step, as it enables breeders to identify and select elite genotypes (Adebola and Morakinyo, 2006). Applying such an approach to *C. tridens* and *C. fascicularis* will not only allow for the evaluation of

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their intraspecific diversity but also help identify morphotypes of interest for future breeding programs. The general objective of this study is therefore to evaluate the intraspecific variability of accessions collected in Burkina Faso. Specifically, for each of the two species, the study aims to: (i) identify discriminating morphological traits; (ii) analyze the correlations among the quantitative traits under study; and (iii) estimate key genetic parameters.

II. MATERIALS AND METHODS

A. Materials

➢ *Description of the Experimental Site*

For this study, two trials were established at the experimental station of Gampéla (Institute du Development Rural), a village attached to the commune of Saaba (Kadiogo; 12°15' N, 1°12' W), during the 2021 and 2022 cropping seasons. This region is characterized by a Sudano-Sahelian climate with annual rainfall that fluctuates highly from month to month (Thiombiano and Kampmann, 2010). The soils are predominantly loamy-sandy, with low physicochemical fertility and a water pH ranging from 5.26 to 5.64 (Tondé, 2019). During the first trial in 2021, total rainfall reached 978 mm (distributed over 45 rainy days), with temperatures ranging from 20.7 °C to 36.6 °C. The second campaign (2022) experienced more abundant precipitation, totaling 1074.9 mm across 52 days, with temperatures ranging between 21.30 °C and 35.30 °C. During both cycles, peak rainfall occurred in August, recording 378 mm in 2021 and 410 mm in 2022.

➢ *Plant Material*

The plant material consisted of 40 accessions, comprising 20 accessions of *Corchorus tridens* collected across seven provinces (Bam, Passoré, Kadiogo, Sanguié, Nahouri, Ziro, and Poni) and 20 accessions of *Corchorus fascicularis* collected across four provinces (Gourma, Kadiogo, Namentenga, and Bougouriba).

B. Methods

➢ *Data Collection*

For each experimental year, a total of 26 traits comprising fourteen (14) qualitative and twelve (12) quantitative traits were evaluated for both species.

- *Qualitative Traits*

To eliminate any developmental bias, all qualitative traits were evaluated on a single day during the 50% flowering stage. Except for seed-specific traits, which required laboratory evaluation under magnification, all phenotypic data were collected directly in the field. Table 1 provides a comprehensive overview of the examined attributes (including growth habit, pubescence, shape, and coloration of the vegetative and reproductive organs) alongside their respective descriptors.

Table 1 Qualitative Traits and Code for *Corchorus tridens and Corchorus fascicularis* Observed During the Study.

N°	Trait	Code	N°	Trait	Code
1	Branching habit	BH	8	Fruit apex shape	FAS
2	Stem color	SC	9	Stem pubescence	SP
3	Leaf color	LC	10	Leaf pubescence	LP
4	Stipule color	SPC	11	Leaf shape	LS
5	Fresh fruit color	FFC	12	Leaf margin	LM
6	Dry fruit color	DFC	13	Fruit shape	FS
7	Dry seed color	DSC	14	Seed shape	SS

- *Quantitative Traits*

A total of twelve quantitative variables were recorded, with measurements taken from three representative plants per row. The only exception was the number of days to 50% flowering, which was monitored on a whole-plot basis. These agronomic traits covered four main categories: stem morphology (height, diameter, and primary branch count), leaf dimensions (petiole length, blade length, and blade width), fruit characteristics (peduncle length, fruit length, and fruit diameter), and phenological cycle (Table 2). For leaf and fruit parameters, three samples were collected and measured from each of the three sampled plants.

Table 2 Quantitative Traits Descriptors Used for Characterization of *Corchorus tridens and Corchorus fascicularis* Accessions in the Study

N°	Traits	Code	Descriptors
1	Day to 50% flowering	DF	Number of days from seed germination to 50% flowering
2	Plant height	PH	Plant height at maturity measured from the base of the plant to the tip of the main stem using a meter ruler (cm)
3	Stem diameter	SD	Diameter of the plant base at soil level (mm)
4	Number of branches	NB	Total number of branches per plant
5	Petiole length	PL	Length from the insertion point on the stem to the base of the leaf blade (cm)
6	Leaf width	LW	Length of matured leaf at widest point (cm)
7	Leaf length	LL	Length of a matured lamina from the proximal end of the mid-vein to the distal end, excluding the petiole (cm)
8	Leaf fresh mass	LFM	Total fresh mass for three plants (g)

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9	Leaf dry mass	LDS	Total dry mass for three plants (g)
10	Pedoncule length	POL	Length from the node of the branch to the point of attachment of the fruit (cm
11	Fruit length	FL	Length from the point of attachment of the pedoncule to the apex (cm
12	Fruir diameter	FD	Diameter of the mature fruit at its widest point using a caliper (mm)

➢ *Statistical Data Analysis*

Statistical analyses were performed using XLSTAT Pro software (version 7.1). A one-way analysis of variance (ANOVA) was conducted on the data for each species to identify discriminating traits. Newman-Keuls post-hoc test was used for means separation to compare the performance of the accessions within each year. Additionally, a two-way ANOVA (season × accession) was performed to identify the traits that discriminate among accessions and to assess the effects of the accession × season interaction. The relationships between quantitative traits were evaluated using a Pearson correlation matrix. Subsequently, Agglomerative Hierarchical Clustering (AHC) and Discriminant Factor Analysis (DFA) were carried out. Finally, key genetic parameters (Table 3) were estimated for each of the discriminating traits.

Table 3 Formulas Used for the Estimation of Genetic Parameters.

Paramètres	**Formules**
Genotypic variance (GV)	$\mathrm{GV} = \frac{MSG - MSE}{r}$
Phenotypic variace (PV)	$PV = VG + \frac{MSE}{r}$
Heritability (H^2)	$H^2(\%) = \frac{VG}{VP} * 100$
Genotypic coefficient of variation (GCV)	$GCV(\%) = \frac{\sqrt{VG}}{\mathrm{X}} * 100$
Phenotypic coefficient of variation (PCV)	$PCV(\%) = \frac{\sqrt{VP}}{\mathrm{X}} * 100$
Expected genetic advance (GA)	$GA = H^2 * \sqrt{VP} * I$
Expected genetic advance as a percentage of the mean [GAx (%)]	$GAx(\%) = \frac{\mathrm{GA}}{\mathrm{X}} * 100$

MSG: Mean Square of Genotypes; MSE: Mean Square of Error; r: Number of Replications; i: Selection Intensity (at a 5% Selection Intensity, I = 2.06); X: Trait Mean; $\sqrt{VG}$: Standard Deviation of Genotypic Variance; $\sqrt{VP}$: Standard Deviation of Phenotypic Variance

III. RESULTS

➢ *Morphological Characteristics of Corchorus tridens*

The studied accessions of *Corchorus tridens* are characterized by a cylindrical, glabrous, purplish-red stem featuring a staggered primary branching pattern (Figure 1A). The leaves are green with a lanceolate blade and a serrated leaf margin (Figure 1B). The fruits are green with red slits, exhibiting a cylindrical cross-section and an open apex at maturity (Figure 2A). When dry, the fruits turn gray (Figure 2B) and contain trapezoidal, glossy brown seeds characterized by oblique raphes and longitudinal veins (Figure 3).

Fig 1 Aerial Vegetative Organs of *C. tridens*
A) Stem of *C. tridens*; B) Leaves of *C. tridens*.

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Fig 2 Fruit Colors in *C. tridens*
A) Fresh Fruit; B) Dry Fruit.

Fig 3 Seed Shapes and Colors in *C. tridens*

➢ *Morphological Characteristics of Corchorus fascicularis*

Two distinct stem colors were observed among the *C. fascicularis* accessions: green stems (Figure 4A), recorded in 72.66 % of the accessions, and purple stems (Figure 4B), accounting for 27.34 %. All stems are cylindrical, glabrous, and display a staggered primary branching pattern. The leaves feature green blades with serrated margins and are either lanceolate (Figure 4C) or ovate-lanceolate (Figure 4D) in shape. Similarly, all fruits are cylindrical, appearing green when fresh (Figure 5A) and turning light brown when dry (Figure 5B). The seeds are dark brown, trapezoidal in shape, and characterized by longitudinal veins (Figure 5C).

Fig 4 Aerial Vegetative Organs of *C. fascicularis*
A) Green Stem; B) Purple Stem; C) Leaf with Lanceolate Blade; D) Leaf with Ovate-Lanceolate Blade.

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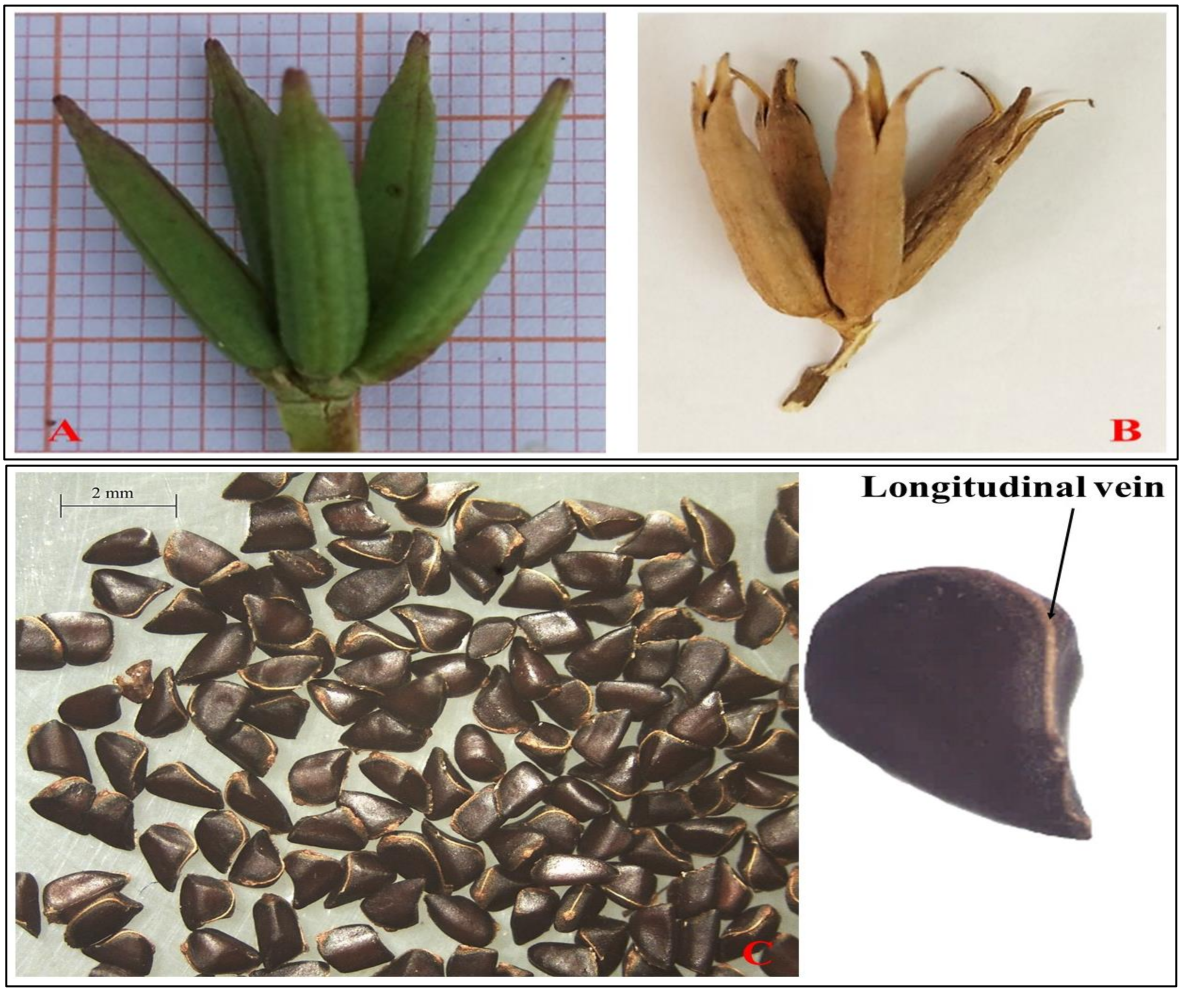

Fig 5 Morphological Characteristics of *C. fascicularis* Fruits
A) Fresh fruit; B) Dry fruit; C) Shape and color of seeds.

Consequently, based on leaf blade shape and stem coloration, the 20 *C. fascicularis* accessions were classified into two distinct morphotypes:

- The green morphotype: characterized by a green stem and lanceolate leaves (Figure 6A). This morphotype represents most of the accessions (72.66 %).
- The purple morphotype**:** characterized by a purple stem and ovate-lanceolate leaves (Figure 6B). This morphotype constitutes the minority of the accessions (27.34 %).

Fig 6 Morphotypes Identified within *C. fascicularis* Accessions
A) Green Morphotype; B) Purple Morphotype.

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- *Description of Agro-Morphological Variability Based on Quantitative Traits in Corchorus tridens*

The results of the analysis of variance (Table 4) reveal that only peduncle length, fruit length, and fruit diameter failed to discriminate among the accessions. For all other traits, a highly significant difference ($p < 0.01$) was observed among accessions. Substantial variations between minimum and maximum values were recorded for these traits during both cropping seasons. Accordingly, the number of days to 50% flowering ranged from 56 to 65 days in 2021 and from 49 to 87 days in 2022. At the flowering stage, plant height varied between 27 and 94 cm in 2021 and from 20 to 114 cm in 2022. The number of primary branches ranged from 10 to 20 in 2021 and from 10 to 63 in 2022. Fresh leaf biomass varied from 68 to 264.06 g in 2021 (dry weight: 20.30 to 90 g) and from 88.11 to 335.55 g in 2022 (dry weight: 26.34 to 107.35 g).

Very highly significant interactions ($p < 0.01$) between accessions and season were observed for all traits, except for peduncle length, fruit length, and fruit diameter. The highest values for leaf blade length and width, petiole length, and fruit diameter were recorded during the 2021 cropping season. Conversely, the 2022 cropping season was characterized by a longer period to 50% flowering. During this second season, plants reached greater heights, exhibiting a more robust appearance, more extensive development of primary branches, and increased leaf biomass production.

The coefficient of determination (R^2) was high for the number of days to 50 % flowering in 2021, as well as for fresh and dry weights in 2022, whereas it remained low for the other variables.

Table 4 Average Performance of *C. tridens* Accessions During the 2021 and 2022 Growing Seasons and Accession x Season Interaction

	Season 2021					Season 2022					P value
Traits	**Min**	**Max**	**Moy**	**R²%**	**Pr > F**	**Min**	**Max**	**Moy**	**R²%**	**Pr > F**	**Accession*saison**
PL (cm)	0.7	3.40	2.06	37.50	< 0.000 1	1.00	3.13	1.77	28.43	< 0.000 1	< 0.0001
LL (cm)	4.80	14.73	11.13	45.06	< 0.000 1	6.57	13.37	10.34	32.61	< 0.000 1	< 0.0001
LW (cm)	1.03	3.87	2.67	44.68	< 0.0001	1.60	3.93	2.57	25.77	< 0.0001	< 0.0001
POL (cm)	0.20	1.27	0.33	9.62	0.588 5 ns	0.27	0.63	0.40	13.60	0.174 3 ns	**0.254 ns**
FL (cm)	2.13	4.67	3.67	6.97	0.878 7 ns	2.73	5.00	3.92	19.44	0.009 5	**0.2658ns**
FD (cm)	0.18	0.26	0.21	8.90	0.6775 ns	0.19	0.28	0.23	32.59	< 0.0001	**0.16601ns**
LFM (g)	68.00	264.06	149.80	37.23	< 0.000 1	88.11	335.55	168.46	62.62	< 0.000 1	< 0.0001
LDS (g)	20.30	90.00	47.49	32.48	< 0.0001	26.34	107.37	51.30	61.08	< 0.0001	< 0.0001
PH (cm)	27.00	94.00	49.06	19.50	0.009 2	20.00	114.00	72.46	49.22	< 0.000 1	< 0.0001
SD (cm)	0.30	1.10	0.67	24.94	0.000 2	0.65	1.89	1.24	34.31	< 0.000 1	< 0.0001
NB	10.00	20.00	14.54	21.29	0.003 0	10.00	63.00	17.68	19.21	0.010 9	< 0.0001
DF	56.00	65.00	59.85	56.28	< 0.000 1	49.00	87.00	72.03	43.55	< 0.000 1	< 0.0001

- *Legende: a and b : means within the same column followed by the same letter are not significantly different at the 1% level, according to the Newman-keuls test (a >b). Acc- accessions; Min-minimum; Max-maximum; PL-petiole length; LL-leaf length; LW- Leaf width; POL-peduncle length; FL- Fruit length; FD-Fruit diameter; LFM-leaf fresh mass; LDS-leaf dry mass; PH- plant height; SD-Stem diameter; NB- Number of branches; DF-day to 50% flowering; R²- coefficients of determination; Pr > F-F of Fisher.*

- *Description of Agro-Morphological Variability Based on Quantitative Traits in Corchorus fascicularis*

The results of the analysis of variance show wide ranges between the minimum and maximum values for all traits (Table 5). Notable variations were observed for the number of days to 50 % flowering (57 to 64 days in 2021 and 68 to 86 days in 2022), plant height (26 to 108 cm in 2021 and 40 to 133 cm in 2022), and leaf biomass. Specifically, fresh leaf weight ranged from 16.68 to 102.31 g in 2021 and from 35.65 to 544.71 g in 2022, while dry leaf weight ranged from 6 to 29 g in 2021 and from 13.78 to 167.90 g in 2022.

Statistical analysis also revealed very highly significant differences ($p < 0.01$) among accessions for most of the studied traits, except for peduncle length and fruit diameter. Significant accession × season interactions were observed for most of the traits ($p < 0.0001$), except for leaf blade width, peduncle length, and fruit diameter. Optimal values for most traits were recorded during the 2022 cropping season, except for fruit length, which peaked in 2021.

The coefficient of determination was high ($R^2 > 50$ %) for fresh and dry leaf weights, number of primary branches, and number of days to 50% flowering in 2022. For the remaining traits, it was low ($R^2 < 50$ %).

Table 5 Average Performance of *C. fascicularis* Accessions During the 2021 and 2022 Growing Seasons and Accession x Season Interaction

	Season 2021					**Season 2022**					**P value**
Variables	**Min**	**Max**	**Moy**	**R²%**	**Pr > F**	**Min**	**Max**	**Moy**	**R²%**	**Pr > F**	**Accession*saison**
PL (cm)	0.90	3.40	2.07	24.82	0.000 3	0.67	4.07	1.99	36.67	< 0.000 1	0.0140
LL (cm)	5.83	12.77	8.59	29.98	< 0.000 1	4.07	12.97	8.43	31.37	< 0.000 1	0.0001
LW (cm)	1.27	3.13	2.19	27.17	< 0.000 1	0.93	4.07	2.28	21.91	0.002 0	**0.513 ns**
POL (cm)	0.10	0.15	0.11	21.27	**0.301 0 ns**	0.10	0.13	0.10	10.50	**0.477 8 ns**	**0.602 ns**
FL (cm)	1.13	1.80	1.42	21.36	0.002 9	1.03	1.53	1.26	27.08	< 0.000 1	< 0.0001
FD (cm)	0.16	0.25	0.21	13.26	**0.1984 ns**	0.17	0.26	0.22	11.05	**0.412 4 ns**	**0.2010 ns**
LFM (g)	16.68	102.31	54.47	30.42	< 0.000 1	35.65	544.71	148.64	65.93	< 0.000 1	< 0.0001
LDS (g)	6.00	29.00	17.07	27.44	< 0.0001	13.78	167.90	49.72	67.36	< 0.0001	< 0.0001
PH (cm)	26.00	108.00	71.31	28.06	< 0.000 1	40.00	133.00	94.44	47.54	< 0.000 1	< 0.0001
SD (cm)	0.40	1.50	0.81	36.06	< 0.000 1	0.70	2.28	1.31	27.56	< 0.000 1	< 0.0001
NB	10.00	24.00	16.19	34.83	< 0.000 1	11.00	32.00	19.40	56.35	< 0.000 1	< 0.0001
DF	57.00	64.00	59.82	30.38	< 0.000 1	68.00	86.00	72.32	81.33	< 0.000 1	< 0.0001

- *Legend: a and b : means within the same column followed by the same letter are not significantly different at the 1% level, according to the Newman-keuls test (a >b). Acc-accessions; Min-minimum; Max-maximum; PL-petiole length; LL-leaf length; LW- Leaf width; POL- pedunculi length; FL- Fruit length; FD-Fruit diameter; LFM-leaf fresh mass; LDS-leaf dry mass; PH- plant height; SD-Stem diameter; NB- Number of branches; DF-day to 50% flowering; R²- coefficients of determination; Pr > F-F of Fisher.*

➢ *Correlations Among Quantitative Traits in C. tridens and C. fascicularis*

The correlations among the studied quantitative traits for *C. tridens* and *C. fascicularis* are presented in Tables 6 and 7, respectively. For both species, fresh leaf weight was strongly and positively correlated with dry leaf weight (r = 0.96 for *C. tridens* and r = 0.99 for *C. fascicularis*), plant height (r = 0.54 for *C. tridens* and r = 0.77 for *C. fascicularis*), stem diameter (r = 0.80 for *C. tridens* and r = 0.78 for *C. fascicularis*), and the number of primary branches (r = 0.83 for *C. tridens* and r = 0.76 for *C. fascicularis*).

Additionally, strong positive correlations were observed between plant height and both stem diameter (r = 0.86 for *C. tridens* and r = 0.77 for *C. fascicularis*) and the number of primary branches (r = 0.76 for *C. tridens* and r = 0.86 for *C. fascicularis*). Furthermore, the number of primary branches exhibited a strong positive correlation with stem diameter (r = 0.87 for *C. tridens* and r = 0.88 for *C. fascicularis*).

Table 6 Correlation Table for 12 Quantitative Traits of *C. tridens* Accessions

Traits	**PL**	**LL**	**LW**	**POL**	**FL**	**FD**	**LFM**	**LDS**	**PH**	**SD**	**NB**	**DF**
PL (cm)	1											
LL (cm)	0.33	1										
LW (cm)	0.28	0.27	1									
POL (cm)	0.07	-0.02	0.02	1								
FL (cm)	-0.28	0.10	0.04	-0.25	1							
FD (cm)	-0.23	0.32	0.34	-0.09	**0.55**	1						
LFM (g)	-0.41	0.31	0.20	0.16	0.07	0.27	1					
LDS (g)	-0.43	0.37	0.23	0.05	0.13	0.33	**0.98**	1				
PH (cm)	-0.57	0.36	0.20	-0.11	0.26	**0.55**	**0.64**	0.70	1			
SD (cm)	-0.58	0.37	0.31	-0.02	0.14	0.45	**0.80**	**0.82**	**0.88**	1		
NB	-0.62	0.14	0.31	0.11	0.23	0.47	**0.68**	**0.70**	**0.82**	0.87	1	
DF	0.07	0.32	-0.10	-0.41	-0.23	0.04	-0.14	-0.06	0.08	-0.06	-0.30	1

- *Legend: PL-petiole length; LL-leaf length; LW- Leaf width; POL- peduncle length; FL- Fruit length; FD-Fruit diameter; LFM-leaf fresh mass; LDS-leaf dry mass; PH- plant height; SD-Stem diameter; NB- Number of branches; DF-day to 50% flowering.*

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Table 7 Correlation Table for 12 Quantitative Traits of *C. fascicularis* Accessions

Traits	PL	LL	LW	POL	FL	FD	LFM	LDS	PH	SD	NB	DF
PL (cm)	**1**											
LL (cm)	**0.86**	**1**										
LW (cm)	**0.84**	**0.68**	**1**									
POL (cm)	-0.31	-0.20	-0.16	**1**								
FL (cm)	0.16	0.38	0.05	0.19	**1**							
FD (cm)	-0.06	0.02	-0.10	0.00	0.17	**1**						
LFM (g)	**0.48**	**0.59**	**0.51**	-0.15	0.27	0.13	**1**					
LDS (g)	**0.48**	**0.56**	**0.48**	-0.24	0.23	0.07	**0.97**	**1**				
PH (cm)	**0.63**	**0.78**	0.43	-0.25	0.33	0.19	**0.59**	**0.57**	**1**			
SD (cm)	0.43	**0.65**	0.27	-0.37	0.24	0.27	**0.64**	**0.59**	**0.70**	**1**		
NB	0.43	**0.57**	0.23	-0.35	0.21	0.36	**0.58**	**0.59**	**0.79**	**0.79**	**1**	
DF	**0.46**	0.20	**0.54**	0.09	-0.23	-0.41	-0.14	-0.09	-0.06	-0.37	-0.31	**1**

➢ *Estimation of Genetic Parameters in the Accessions*

The genetic parameters estimated for the quantitative traits (Table 8 and Table 9) show that phenotypic variance (PV) values were higher than genotypic variance (GV) values across all traits. Similarly, the phenotypic coefficients of variation (PCV) were higher than the genotypic coefficients of variation (GCV). These coefficients of variation (PCV and GCV) ranged from high to moderate or low depending on the trait. Broad-sense heritability was either high ($H^2 > 70$ %) or moderate for all evaluated traits. Regarding the expected genetic advance as a percentage of the mean (Gax), values were classified as high (Gax> 40 %), moderate (25 % < Gax < 40 %), or low (Gax < 25 %). High phenotypic (PCV) and genotypic (GCV) coefficients of variation, coupled with high broad-sense heritability (H^2) and high expected genetic advance as a percentage of the mean, were concurrently observed for fresh and dry leaf weights, petiole length, and plant height.

Table 8 Gentic Parameter of *Corchorus tridens* Accessions

Traits	VG	VP	GCV (%)	PCV (%)	H² (%)	Gax (%)
PL (cm)	0,23	0,29	23,33	26,04	80,21	43,04
LL (cm)	5,93	6,93	21,87	23,65	85,52	41,66
LW (cm)	0,44	0,52	24,84	26,90	85,29	47,26
LFM (g)	1902,08	2378,20	29,11	32,55	79,98	53,64
LDS (g)	156,66	208,00	26,36	30,37	75,31	47,12
PH (cm)	35,18	69,01	12,09	16,93	50,98	17,78
SD (cm)	0,02	0,03	18,67	23,29	64,26	30,83
NB	1,81	3,23	9,26	12,36	56,09	14,28
DF	8,49	9,35	4,87	5,11	90,78	9,55

- *Legend ; PL-petiole length; LL-leaf length; LW- Leaf width; POL- pedunculi length; FL- Fruit length; FD- Fruit diameter; LFM-leaf fresh mass; LDS-leaf dry mass; PH- plant height; SD-Stem diameter; NB- Number of branches; DF-day to 50% flowering; GV- genotypic variance; PV- phonotypic variance ; H^2- heritability; GCV - genotypic Coefficient of variation ;PCV : phenotypic Coefficient of variation, GA : Expected genetic advance ; GAx- Expected genetic advance as a percentage of the mean*

Table 9 Gentic Parameter of *Corchorus fascicularis* Accessions

Traits	VG	VP	GCV	PCV	H² (%)	Gax
PL (cm)	0,36	0,45	30,04	33,69	79,49	49,19
LL (cm)	1,71	2,32	15,53	18,05	74,02	23,68
LW (cm)	0,10	0,18	14,00	18,43	57,68	16,63
FL (cm)	0,01	0,02	5,88	7,13	68,03	8,24
LFM (g)	13156,22	14016,51	77,17	79,65	93,86	149,20
LDS (g)	1378,69	1462,88	74,69	76,93	94,25	145,00
PH (cm)	417,18	480,08	21,63	23,20	86,90	38,72
SD (cm)	0,06	0,08	18,46	22,26	68,79	26,16
NB	26,33	29,00	26,45	27,76	90,80	49,47
DF	35,68	36,68	8,26	8,38	97,27	16,55

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➢ *Spatial Structure of Diversity Among the 20 C. tridens Accessions*

Agglomerative Hierarchical Clustering (Figure 7) revealed that the 20 accessions are structured into three distinct groups. This clustering occurred independently of the geographical origin of the accessions. Cluster I consist of eleven accessions originating from seven provinces, namely Kadiogo, Passoré, Sanguié, Ziro, Poni, Bam, and Nahouri. Cluster II comprises five accessions obtained from the provinces of Nahouri, Sanguié, and Ziro. Cluster III contains four accessions, with one accession from each of the following provinces: Nahouri, Ziro, Passoré, and Yatenga.

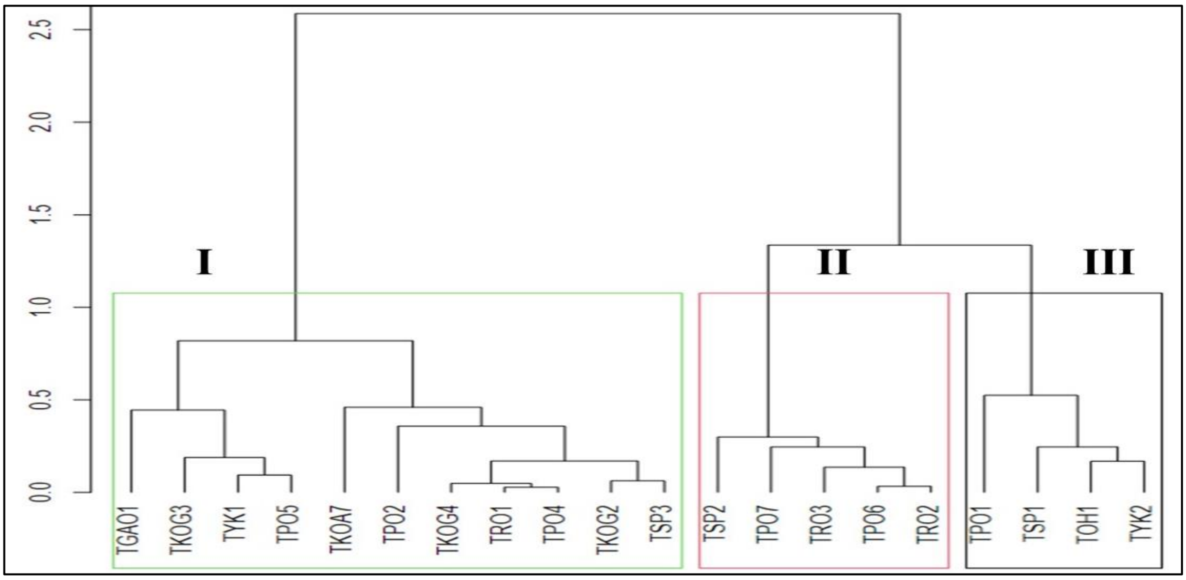

Fig 7 Hierarchical Clustering Dendrogram of 20 *Corchorus tridens* Accessions Based on Quantitative Traits

The characterization of the clusters derived from the AHC using Discriminant Factor Analysis (DFA) (Figure 8) revealed a significant difference ($p < 0.05$) among the three clusters. Wilks' Lambda test yielded an observed F-value of 19.56 and a critical F-value of 3.30 among the three groups, with a p value < 0.0001. According to McLachlan (1992), the squared Mahalanobis distances were 22.95 between Clusters I and II, 25.66 between Clusters I and III, and 61.81 between Clusters II and III.

The results of the analysis of variance followed by the Newman-Keuls post-hoc test (Table 10) indicate that, except for fruit-related traits (LOE, LOF, DAF), all other parameters significantly discriminated among the three agro-morphological clusters. Cluster I cluster accessions characterized by tall plants, robust stems, substantial branching, and high leaf biomass yield. Cluster II comprises late-maturing (long-cycle) accessions featuring leaves with shorter and narrower blades, as well as shorter petioles. Cluster III consists of early-maturing (short-cycle) and short-statured accessions.

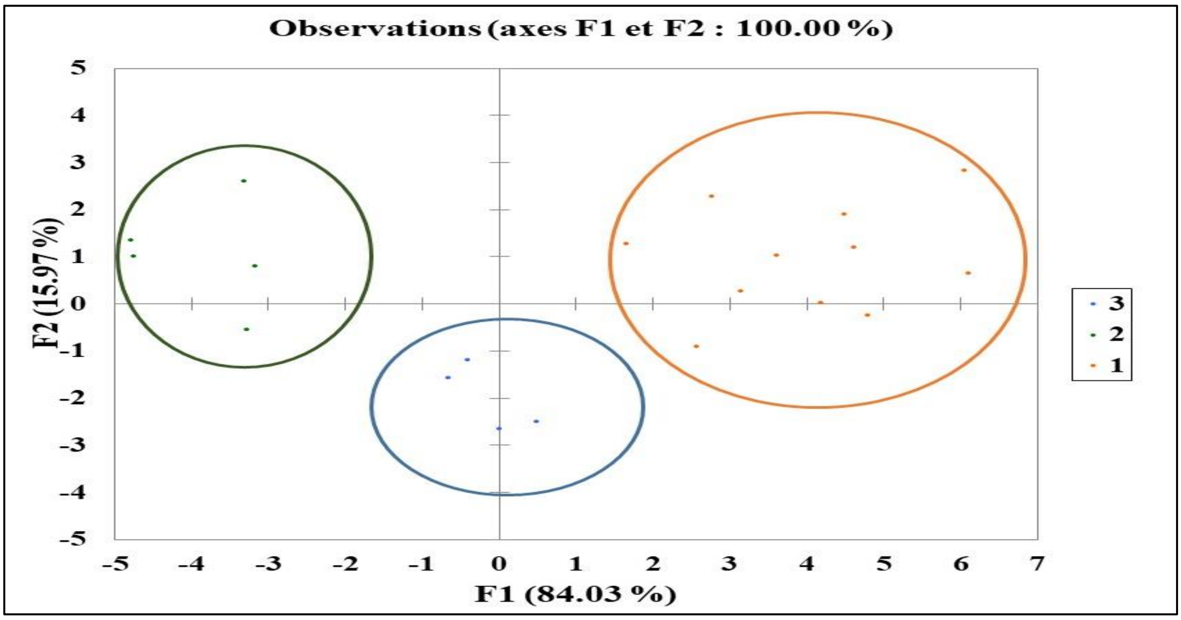

Fig 8 Distribution of Accessions Groups from AHC on the First Two Axes (1/2) of the Discriminant Function Analysis (DFA)

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Table 10 Average Performance of the Three Clusters Identified by Agglomerative Hierarchical Clustering (AHC)

Traits	Cluster I	Cluster II	Cluster III	R²%	Pr > F
PL (cm)	1.94 a	**1.77 b**	2.01 a	3.13	0.003 4
LL (cm)	11.30 a	**9.52 c**	10.71 b	15.14	< 0.000 1
LW (cm)	2.76 a	**2.32 b**	2.62 a	11.49	< 0.000 1
POL (cm)	0.36 a	0.36 a	0.39 a	1.08	0.143 1 ns
FL (cm)	3.80 a	3.81 a	3.77 a	0.14	0.773 0 ns
FD (cm)	0.26 a	0.25 a	0.25 a	1.23	0.109 0 ns
LFM (g)	**185.16 a**	123.19 b	132.47 b	24.41	< 0.000 1
LDS (g)	**57.00 a**	39.84 b	40.43 b	20.88	< 0.000 1
PH (cm)	**64.60 a**	58.88 b	**52.54 c**	6.10	< 0.000 1
SD (cm)	**1 011 a**	0.91 b	0.86 b	3.23	0.002 8
NB	**16.85 a**	15.07 b	15.36 b	3.73	0.001 1
DF	65.79 b	**67.73 a**	**64.11 c**	2.26	0.017 0

- *Legend: a and b : means within the same column followed by the same letter are not significantly different at the 1% level, according to the Newman-keuls test (a >b). Acc-accessions; Min-minimum; Max-maximum; PL-petiole length; LL-leaf length; LW- Leaf width; POL- pedunculi length; FL- Fruit length; FD-Fruit diameter; LFM-leaf fresh mass; LDS-leaf dry mass; PH- plant height; SD-Stem diameter; NB- Number of branches; DF-day to 50% flowering; R²- coefficients of determination; Pr > F-F of Fisher.*

➢ *Spatial Structure of Diversity Among the 20 C. fascicularis Accessions*

Agglomerative Hierarchical Clustering (Figure 9) revealed that the 20 accessions are structured into three distinct clusters. Cluster I consist of four accessions originating from the provinces of Kadiogo, Kouritenga, and Bougouriba. Cluster II comprises eleven accessions obtained from the provinces of Gourma, Namentenga, and Kadiogo. Cluster III contains five accessions from the provinces of Kouritenga, Namentenga, and Bougouriba.

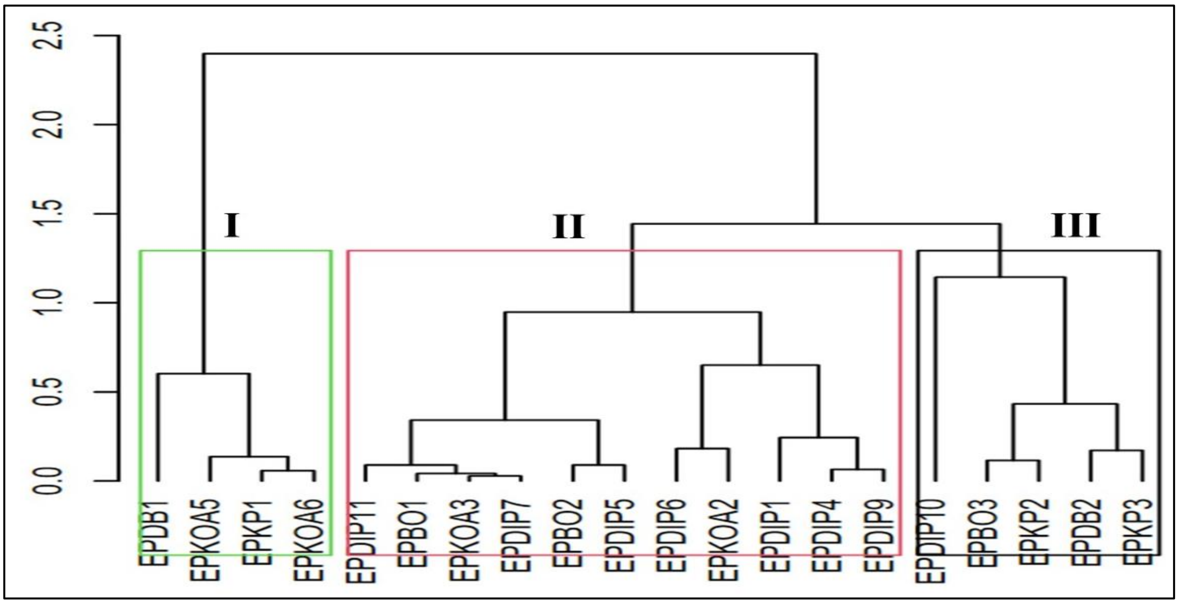

Fig 9 Hierarchical Clustering Dendrogram of 20 *Corchorus fascicularis* Accessions Based on Quantitative Traits

The characterization of the clusters derived from the AHC using Discriminant Factor Analysis (DFA) (Figure 10) revealed a significant difference ($p < 0.05$) among the three clusters. Wilks' Lambda test yielded an observed F-value of 12.15 and a critical F-value of 2.15 among the three groups, with a p-value < 0.0001. According to McLachlan (1992), the squared Mahalanobis distances were 68.47 between Clusters I and II, 126.24 between Clusters I and III, and 90.89 between Clusters II and III.

The results of the analysis of variance followed by the Newman-Keuls post-hoc test (Table 11) indicate that all evaluated variables significantly discriminated among the three agro-morphological clusters. Cluster I encompass accessions characterized by tall, highly branched plants with robust stems. The accessions constituting this group exhibit high leaf biomass production. Cluster II consists of early-maturing (short-cycle) accessions that produce large fruits.

Cluster III comprises late-maturing (long-cycle) accessions. The individuals in this cluster are short-statured with slender stems and produce long fruits.

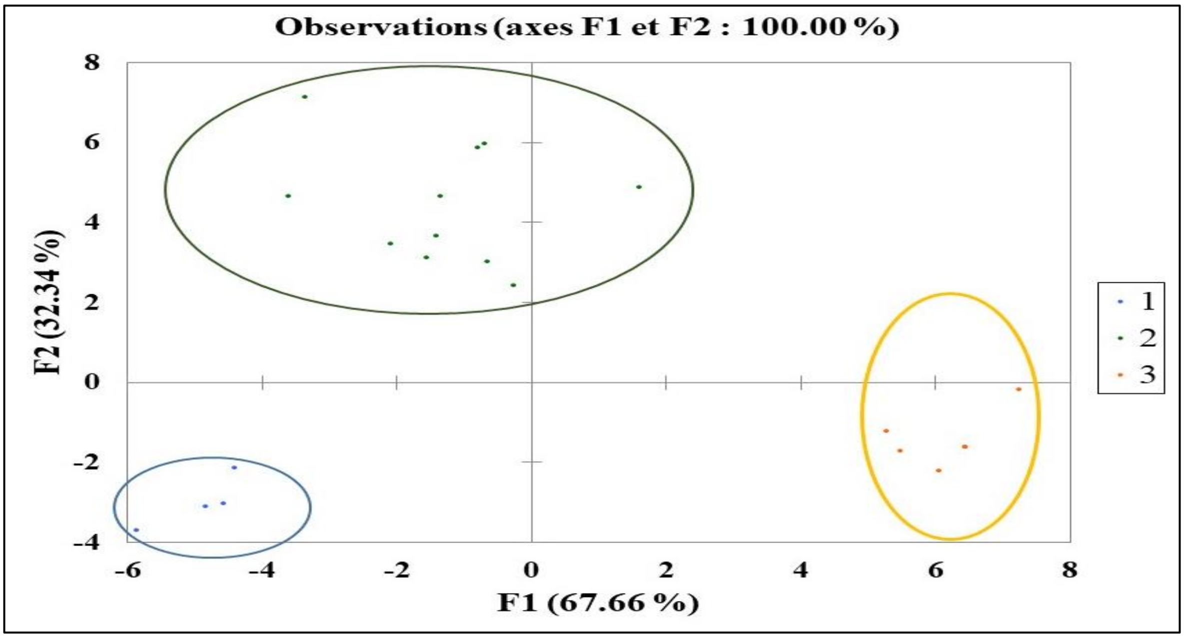

Fig 10 Distribution of Accessions Groups from AHC on the First Two Axes (1/2) of the Discriminant Function Analysis (DFA)

Table 11 Average Performance of the Three Clusters Identified by Agglomerative Hierarchical Clustering (AHC)

Traits	Cluster I	Cluster II	Cluster III	R^2	Pr > F
PL (cm)	2.48 a	1.94 b	2.02 b	15.58	< 0.000 1
LL (cm)	9.40 a	8.25 b	8.44 b	10.31	< 0.000 1
LW (cm)	2.50 a	2.15 b	2.21 b	9.33	< 0.000 1
POL (cm)	0.12 b	0.12 b	0.13 a	1.90	0.032 6
FL (cm)	1.34 b	1.32 b	1.38 a	3.28	0.002 6
FD (cm)	0.22 a	0.22 a	0.21 b	2.10	0.0228
LFM (g)	140.50 a	93.87 b	87.32 b	6.66	< 0.000 1
LDS (g)	46.80 a	31.23 b	27.43 b	7.56	< 0.000 1
PH (cm)	90.88 a	81.50 b	79.49 c	3.75	0.001 1
SD (cm)	1.13 a	1.06 b	0.99 c	1.64	0.052 2
NB	19.18 a	17.63 b	17.06 b	3.41	0.002 0
DF	66.63 b	65.20 c	67.54 a	2.19	0.019 2

- *Legend: a and b: means within the same column followed by the same letter are not significantly different at the 1% level, according to the Newman-keuls test (a >b). Acc-accessions; Min-minimum; Max-maximum; PL-petiole length; LL-leaf length; LW- Leaf width; POL- pedunculi length; FL- Fruit length; FD-Fruit diameter; LFM-leaf fresh mass; LDS-leaf dry mass; PH- plant height; SD-Stem diameter; NB- Number of branches; DF-day to 50% flowering; R^2- coefficients of determination; Pr > F-F of Fisher.*

IV. DISCUSSION

The agro-morphological characterization conducted over two cropping seasons demonstrates that several qualitative and quantitative traits discriminate among accessions within both studied *Corchorus* species (*C. tridens* and *C. fascicularis*). This highlights the existence of substantial intraspecific phenotypic variability within these species. However, the identification of a single morphotype in *C. tridens* suggests narrower morphological intraspecific variability in this species compared to *C. fascicularis*. Throughout the two-year characterization, the qualitative traits remained constant from one season to the next. This indicates that these traits are highly stable and minimally influenced by environmental conditions. Indeed, qualitative traits are typically governed by a limited number of genes (monogenic or oligogenic inheritance) (Wasonga *et al.*, 2015), and their phenotypic expression is generally more resilient to pedoclimatic variations compared to polygenic traits.

Conversely, the variability and performance of quantitative traits among the evaluated accessions exhibited significant fluctuation between cropping seasons, indicating a strong environmental influence. Since phenotypic expression results from the combined effects of the genotype and environmental factors, seasonal variations in performance can be attributed to environmental action. Accordingly, the superior agronomic performances observed during the 2022 cropping season indicate more favorable climatic conditions, which allowed the plants to maximize their agronomic potential. Species of the genus *Corchorus* thrive when annual rainfall ranges between 1000 and 2000 mm, paired with temperatures around 30 °C (Jansen *et al.*, 2007; Maity *et al.*, 2012; Sweetbird, 2017). Consequently, the cumulative rainfall of 1074.9 mm distributed over 52 days in 2022, combined with monthly temperatures ranging from 21.30 °C to 35.30 °C, provided highly favorable conditions for optimal development. In contrast, the lower rainfall volume in 2021 (978 mm) coupled with poor temporal distribution over only 45 rainy days restricted the plants from fully expressing their agronomic capacity. Furthermore, the highly significant accession × season interactions observed for most quantitative traits confirm that accessions across different species respond differentially to environmental factors. This differential response across seasons suggests that accessions within the same species are genetically distinct. Such findings confirm the presence of significant intraspecific diversity that could be effectively exploited in future breeding programs for these species.

Because quantitative traits are generally subject to pedoclimatic variations, partitioning the sources of this variability is crucial to identifying the most effective selection criteria. The narrow discrepancies observed between the phenotypic coefficients of variation (PCV) and genotypic coefficients of variation (GCV) across all traits in both species suggest that environmental factors exerted a minimal effect on the overall variability and agronomic performance of the studied accessions. Consequently, the observed phenotypic variability appears to be primarily driven by genotypic expression. Phenotypic variability in *Corchorus* accessions has similarly been documented by Begum and Kumar (2011) in India, and Nwangburuka Denton (2012) in Nigeria, and Soliman *et al.* (2014) in Egypt. Moreover, the high broad-sense heritability values recorded for most traits in both species indicate that these traits are highly heritable, suggesting that direct selection based on observed phenotypic variability would be effective. Indeed, while genetic variances outline the extent of overall variability, heritability estimates determine the proportion of this variance that is transmissible to offspring. As noted by Usman *et al.* (2014) and Khan *et al.* (2015), heritability provides a reliable proxy for the predictability of trait transmission from parents to subsequent generations. Furthermore, the combination of high broad-sense heritability (H^2), high genotypic coefficients of variation (GCV), and high expected genetic advance as a percentage of the mean (Gax) for fresh leaf weight, dry leaf weight, plant height, and petiole length in both species indicates that these traits can serve as reliable selection criteria for identifying elite genotypes in crop improvement programs. For selection to be highly efficient, the joint estimation of H^2, GCV, and Gax is essential, as it yields more reliable genetic insights (Ibrahim and Hussein, 2006). According to Shukla *et al.* (2006) and Nwangburuka and Denton (2012), when both genetic advance and heritability are high for specific traits, it implies that the inheritance of these traits is predominantly governed by additive gene action.

V. CONCLUSION

This study provides a comprehensive understanding of the intraspecific variability within two *Corchorus* species in Burkina Faso. The results highlight strong positive correlations among several of the evaluated agro-morphological traits. Although phenotypic coefficients of variation (PCV) were systematically higher than genotypic coefficients of variation (GCV), high heritability estimates were recorded for leaf blade length, fresh leaf weight, and the number of days to 50% flowering across both species. Ultimately, the significant genetic diversity uncovered in this study underscores excellent prospects for the genetic improvement and sustainable conservation of these underutilized species.

➢ *Disclaimer (Artificial Intelligence)*

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

➢ *Competing Interests*

Authors declare no competing interests exist.

➢ *Authors' Contributions*

This work was carried out in collaboration among all authors. Author SZ designed the study, wrote the sample collection, and conducted the trial and collected the data, performed the statistical analyses, and drafted the manuscript. Author SB conceived the theme of the study and read the first draft of the manuscript. Author ND and contributed to the interpretation of the data. Author BKP read and validated the study protocol. All authors read and approved the final manuscript.

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