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Original Research Article

Estimates of genetic parameters of spider plant (*Cleome gynandra* L.) of Burkina Faso

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Spider plant (*Cleome gynandra* L.) is a traditional leafy-vegetable consumed more and more in Burkina Faso because it is a good food complement against the nutritional deficiencies. In order to improve the species, several studies of characterization carried out showed the existence of a great genetic diversity. But, the varietal improvement requires the estimate of the heritability and the genetic advance of the characters of interests of the plant. The objective of this study is to (i) identify the agro-morphological characters that discriminate the spider plant genotypes, (ii) establish the relations which exist between them, and (iii) estimate genetic parameters in a collection of spider plant accessions of Burkina Faso. The experiment was conducted during the rainy season 2015 according Alpha design, with 100 accessions of spider plant randomly collected in Burkina Faso. In order to understand whether the observed variation was due to genetic factors, genetic parameters were estimated. The results shows that all the 12 characters discriminate significantly the spider plant genotypes. Several correlations were observed between characters related to the biomass production. These correlations are particularly interesting because the improvement of only one character induces improvement of the others and increases leaves biomass.The study shows moreover high broad sense heritability (H^2) and weak differences between the phenotypic (PCV) and genotypic (GCV) coefficients of variation, indicating that the characters expression is under genetic control. The genetic parameters indicates that variability observed for the Burkina Faso spider plant accessions could be exploited in breeding programs.

Key words: Spider plant, *Cleome gynandra*, genetic parameters, Burkina Faso

INTRODUCTION

Among the traditional leafy-vegetables cultivated in Burkina Faso, spider plant (*Cleome gynandra* L), occupies a place of choice in gardening. Its high food value contributes to the improvement of food quality (Soro et al., 2012). Thus, its consumption and its marketing are in increase, especially in the urban centers (Bosire, 2014). Also, surfaces of the culture of this vegetable are increasingly significant (Mutoro et al., 2012; Omondi- Wasonga, 2014). However, the lack of seeds of quality and the low agronomic performances constitute the major obstacles of the culture of spider plant (*Cleome gynandra* L.).

In order to lay the scientific bases of the conservation, the valorization and the varietal improvement of the species, several studies of characterization carried out showed the existence of a great genetic diversity (K'Opondo 2011, Omondi-Wasonga, 2014, Kiébré et al., 2015). However, the varietal improvement requires, in addition to genetic variability, the estimate of the heritability and the genetic advance of the characters of interests of the plant material available. Indeed, the heritability of the characters permits to know if the process of selection will be easy and if the response to the selection will be significant. As for the genetic advance, it brings more precision on contribution of selection to the varietal improvement (Drabo et al., 2013).

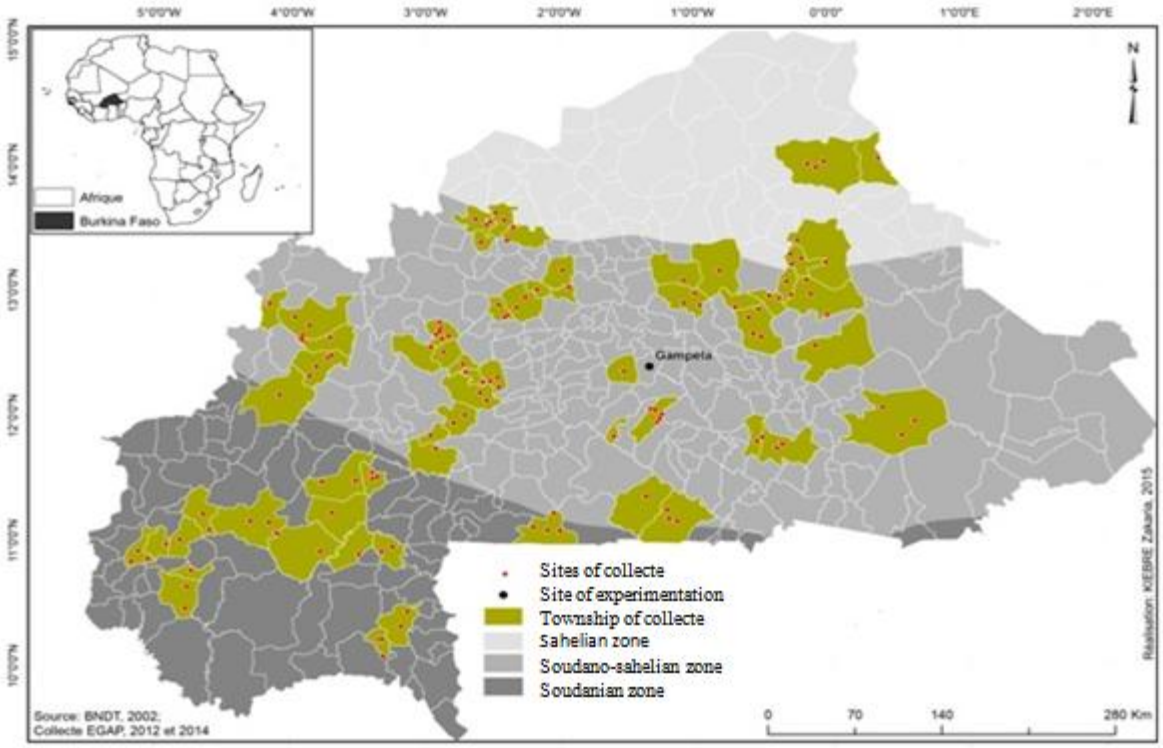

Figure 1: Climatical zones, sites of collection of the accessions and experimentation site

The objective of this study is to (i) identify the agro-morphological characters that discriminate the spider plant genotypes, (ii) establish the relations which exist between them, and (iii) estimate genetic parameters in a collection of spider plant accessions of Burkina Faso, such as broad sense heritability (H^2), genotypic (GCV) and phenotypic (PCV) coefficient of variation and genetic advance (GA) expected from selection.

MATERIALS AND METHODS

Plant Material

The missions of exploration and collection were carried out in the different climatic zones of Burkina Faso from 2012 to 2014 (Figure 1). In total, hundred (100) accessions of spider plant (*Cleome gynandra* L.) randomly collected (Marchenay et Lagarde, 1986) were retained for this study. The choice of these accessions was made on the basis of seeds quantity and germination rate. The zones of cultures of spider plant were identified with the assistance of the provincial services of Burkina Faso' s agriculture ministry.

Site of experimentation

The experiment was conducted during the rainy season 2015 at the research station of Gampela, agronomic research center of the Institute of Rural Development (IDR), 12° 15' N and 1° 12' W, situated at 20 kilometres in the East of Ouagadougou. The climate is Soudano–Sahelian type, with an annual rainfall ranging from 600 to 900 mm (Thiombiano and Kampmann, 2010). The maximal annual temperature varies between 35 to 40°C and minimal temperature varies between 18 to 19°C.

METHODS

Experimental design and management

The trial was conducted in Alpha design with 3 replications, 5 blocks per replication. Each block was separated by one meter distance. In each block every entry was represented by a row of 3 meters on which 7 hills were sown. The spaces between the rows and the plants were 0.5 m. A thinning to one plant per hill was then done 10 days after sowing. Before starting trial, the land was plowed, amended with organic matter and leveled. Fertilizer was applied at recommended doses 20 ton per hectare of fertilizer.

Data Recording

The data recording related to 12 quantitative characters measured on 4 plants per row selected randomly. The choice of the 12 characters is based on preceding studies (K'Opondo, 2011; Kiébré et al., 2015a, Kiébré et al., 2015b). Except the number of days to 50% flowering and the

Table 1. Formula used for the estimates of the genetic parameters

N°	Parameters	Formula used
1	Genotypic Variance (V_G)	$V_G = (MS_G - MS_E)/r$
2	Phenotypic Variance (V_P)	$VP = VG + (MS_E/r) = MS_G/r$
3	Broad sense heritability (H^2)	H^2 (%) = (V_G/V_P)*100
4	Genotypic coefficient of variation (GCV)	GCV (%) = (σ_G/X)*100
5	Phenotypic coefficient of variation (PCV)	PCV (%) = (σ_P/X)*100
6	Gain génétique attendu (GA)	GA = H^2 σ_P K
7	GA (% of trait mean) [GAx (%)]	GA_x (%) = (GA/trait mean)*100

MS_G is the means squared of genotype, MS_E is the means squared of the residual (error), and r is the number of replication, σ_G is the genotypic standard deviation, σ_P is the phonotypic standard deviation, X is the trait mean; K is a constant, which at the selection intensity of 5% is 2.06

Table 2. Analysis of Variance for twelve Characters in spider plant collection

Traits index	Genotypes	Error	CV%	P value
Plant height (cm)	63.40**	17.17	17.10	<0.001
Stem diameter (cm)	2.49**	1.36	61.70	<0.001
Primary branches number	6.56**	0.78	18.69	<0.001
Petiole length (cm)	9.65**	2.46	33.42	<0.001
Length of leaflet (cm)	8.18**	2.66	46.83	<0.001
Leaflet width (cm)	4.25**	0.64	25.27	<0.001
Peduncle length (cm)	9.40**	0.87	18.78	<0.001
Fruit width (cm)	0.40**	0.15	38.86	<0.001
Fruit length (cm)	8.00**	1.54	19.70	<0.001
50 % flowering (days)	20.96**	1.93	9.23	<0.001
50 % emergence (days)	5.00**	0.57	11.54	<0.001
Leaves biomass (g)	182**	46.91	65.18	<0.001

CV%: coefficient of variation, ** = significant at 1%

number of days to plants emergence measured on the entire row, the other quantitative variables were measured 45 days after sowing. These studied traits are plant height, measured from the base of plant to the last leaf of the main stem; stem diameter; number of primary branches; length of leaflet, measured from the top from the pulvinus of the central leaflet; leaflet width, measured at the middle portion of the central leaflet; petiole length, measured from the pulvinus to the base of the leaflets; peduncle length, biomass of leaves; fruit length and fruit width measured on the three first fruits of four plants per row.

Statistical Analysis

Analysis of variance (ANOVA) was performed using the GenStat v4.10.3 software (VSN International, 2011) on the quantitative variables to determine those that discriminate the accessions. The study of the relations between the characters was carried out by the correlation matrix of Pearson. Based on the variance component obtained from the ANOVA and the significance, the genetic parameters were estimated. For each character, genotypic (VG) and phenotypic (VP) variances, genotypic and phenotypic coefficient of variation (GCV and PCV), broad sense heritability (H^2) and expected genetic advance (GA) from the selection of the best 5% of genotypes were calculated according the formula (Table 1) used by Johnson et al. (1955), Singh and Chaudhary (1985) and Bernado (2002).

RESULTS

Performances of the studied accessions

Spider plant genotypes showed highly significant differences (P<0.01) for all the 12 variables measurements (Table 2). The emergence of the plants intervenes, on average, 5 days after sowing. The number of days to 50 % flowering is relatively short. It varies from 17 to 27 days after sowing. At 45 days after sowing, the plants have, in an average, 63.40 cm height, 7 primary ramifications and 182 g of fresh biomass. Great amplitudes of variation were observed for plant height (27 - 100 cm), primary branches number (2 - 11), petiole length (2 – 16.44 cm), central leaflet width (0.7 – 7.22 cm), central leaflet length (1.2 – 12.10 cm), and biomass (16.4 – 474.7 g). The coefficient of variation was large (CV> 30 %) for stem diameter (CV = 61.70 %), petiole length (CV = 33.42 %), central leaflet length (CV = 46.83 %), fruit width (CV = 38.86 %) and fresh leaves biomass (CV = 65.18 %). The others characters showed low CV%, less than 30 %.

Table 3. Correlation matrix between characters of spider plant of Burkina Faso

Traits index	Plant_h	50 % Fl	Stem_di	PBN	Pet_len	Leaf_wid	Leaf_len	Ped_len	Fru_len	Fru_ wid	Biomass
50 % Fl	0.71**										
Stem_di	0.87**	0.24									
PBN	0.72**	0.27	0.68**								
Pet_length	0.87**	0.52**	0.83**	0.68**							
Leaf_width	0.89**	0.51**	0.86**	0.63**	0.91**						
Leaf_length	0.85**	0.56**	0.79**	0.61**	0.88**	0.96**					
Ped_length	0.25	0.19	0.11	0.06	0.17	0.22	0.12				
Fru_len	0.44*	-0.09	0.47	0.22	0.55*	0.64*	0.66**	0.14			
Fru_ wid	0.36	-0.03	0.44	-0.05	0.49	0.54*	0.50*	0.07	0.60**		
Biomass	0.84**	0.56**	0.77	0.83**	0.73**	0.71**	0.68**	0.2	0.20	-0.01	
DPE	-0.41*	018	-0.39	-0.04	-0.41*	-0.39*	-0.38	0.3	-0.29	-0.63**	-0.17

Plant_h : Plant height, Stem_di : Stem diameter, PBN : primary ramifications number, Pet_len : Petiole length, Leaf_wid : leaflet width, Leaf_len : Leaflet length, Ped_len: Peduncule length, Fru_len: Fruit length, Fru_ wid: fruit width, 50 % Fl : 50% flowering, DPE: number of days to plants emergence, *: significant correlation

Relations between characters studied

Several correlations were observed between the characters (Table 3). Significant and positive correlations (P<0.01) were obtained between plant height and primary branches ramifications (r = 0.72), between plant height and petiole length (r = 0.87), leaflet width (r = 0.89) and leaflet length (r = 0.85). There were also significant and positive correlations (P<0.01) between 50 % flowering and plant height (r = 0.71), leaves biomass (r = 0.56), primary branches ramifications (r = 0.83), petiole length (r = 0.52), leaflet width (r = 0.51) and leaflet length (r = 0.56). Correlations between the characters relating to the fruit and the other characters are also observed. They are in particular the correlations between fruit length and petiole length (r = 0.55), leaflet width (r = 0.64) and leaflet length (r = 0.66).

Estimates of Genetic Parameters of spider plant of Burkina Faso

The results of the estimates of the genetic parameters of spider plant of Burkina Faso are consigned in Table 4. There are phenotypic and genotypic variances, broad sense heritability, phenotypic and genotypic coefficients of variation and genetic advance expected.

Phenotypic and genotypic variances

The phenotypic variances are higher than the genotypic variances for all the studied characters (Table 4). The phenotypic variances vary from 0.013 to 3922 respectively, for fruit width and leaves biomass. The highest value is obtained with leaves biomass (3922), followed plant height (128.040) while the stem diameter, primary ramifications number, the leaflet width, leaflet length, fruit width and peduncle length have the lowest values of phenotypic variance (< 1).

The genotypic variances vary from 0.012 to 3188.667, respectively, for fruit width and leaves biomass. The highest values are obtained with leaves biomass and plant height whereas that stem diameter, primary ramifications number, the leaflet width, leaflet length, fruit width and peduncle length have very low values, less than 1(Table 4).

Broad sense heritability

The heritability is high for all the 12 studied characters (H^2 > 50 %). The broad sense heritability varies from 68.847 % to 94.506 %, respectively for the leaflet width and the number of days to plant emergence. The number of days to plant emergence (94.506 %), fruit width (88.021 %), fruit length (87.306 %), plant height (82.133 %) and leaves biomass (81.302 %) have very high heritability values (H^2 > 80 %). Meanwhile, leaflet width (68.847 %) and primary ramifications number (69.441 %) record high heritability values, higher than 60 % (Table 4).

Phenotypic (PCV) and genotypic (GCV) coefficients of variation

The phenotypic coefficients of variation are higher than the genotypic coefficients of variation for all 12 studied characters (Table 4).

The Phenotypic and genotypic coefficients of variation of 50 % flowering (8.512 % and 7.531 %) and peduncle length (10.610 % and 9.285 %) expressed the lowest values. The phenotypic coefficients of variation of primary branches ramifications (PCV = 19.483 % and GCV = 16.235 %), leaflet width (PCV = 17.194 % and GCV = 14.267 %), leaflet length (PCV = 17.898 % and GCV = 15.871 %), fruit width (PCV = 19.913 % and GCV = 18.682 %) fruit length (PCV = 14.749 % and GCV = 13.781 %) are moderates. The Phenotypic and genotypic coefficients of variation of petiole length (24.799 % and 20.897 %), number of days to plan emergence (28.287 % and 27.499 %) and leaves biomass (34.410 %

Table 4. Estimate of the genetic parameters of spider plant of Burkina Faso

Traits index	MS_G	MS_E	V_G	V_P	H^2 (%)	GCV (%)	PCV (%)	GA	GA (% of mean)
Plant height (cm)	384.120	68.630	105.163	128.040	82.133	19.338	21.338	19.145	36.103
Stem diameter (cm)	0.212	0.0582	0.0513	0.071	72.541	18.859	22.143	0.397	33.089
Primary branches number	1.990	0.608	0.461	0.663	69.441	16.235	19.483	1.1649	27.869
Leaflet width (cm)	0.482	0.150	0.111	0.161	68.847	14.267	17.194	0.568	24.386
Leaflet length (cm)	2.559	0.547	0.671	0.853	78.638	15.871	17.898	1.496	28.993
Petiole length (cm)	6.664	1.932	1.577	2.221	71.008	20.897	24.799	2.181	36.275
50 % flowering (days)	9.955	2.162	2.598	3.318	78.282	7.531	8.512	2.938	13.727
Fruit width (cm)	0.0387	0.005	0.012	0.013	88.021	18.682	19.913	0.206	36.107
Fruit length (cm)	7.374	0.936	2.146	2.458	87.306	13.781	14.749	2.820	26.526
Peduncle length (cm)	0.746	0.175	0.191	0.249	76.582	9.285	10.610	0.787	16.738
Leaves biomass (g)	11766	2200	3188.667	3922	81.302	31.027	34.410	104.887	57.630
50 % emergence (days)	6.002	0.330	1.891	2.001	94.506	27.499	28.287	2.754	55.071

MS_G is the means squared of genotype, MS_E is the means squared of the residual (error), V_G: Genotypic variance, V_P: Phenotypic variance, H^2= broad sense heritability, GCV is genotypic coefficient of variation, PCV is phenotypic coefficient of variation, GA is genetic advance, GA (% of mean) is genetic advance as per cent of the mean

and 31.027 %) recorded high values.

On the other hand, plant height (PCV= 21.338 % and GCV= 19.338 %) and stem diameter (PCV= 22.143 % and GCV= 18.859 %) expressed high Phenotypic coefficients of variation and recorded moderates genotypic coefficients of variation (Table 4).

Expected Genetic Advance

The genetic advance (GA) varies from 0.206, for fruit width to 104.887, for leaves biomass while the genetic advance as per cent of the mean [GA (% of mean)] oscillates from 13.727 to 57.630 %, respectively for 50 % flowering and biomass (Table 4).The highest values of expected genetic advance are observed on biomass and the plant height whereas weakest values are obtained on leaflet width, fruit width and peduncle length. Among the characters, high genetic advance as per cent of mean expected from selection of best 5% of the genotypes were recorded for biomass (57.630 %), number of days of plant emergence (55.071 %), fruit width (36.107 %), petiole length (36.275 %), plant height (36.103) and stem diameter (33.089 %). The other characters genetic advance as per cent of mean expected from selection moderate i.e. lower than 30 % (Table 4).

DISCUSSION

The existence of a variability is essential to the varietal improvement. In fact, the more the variability in the basic population, the more is the chance of improvement. The identification of the 12 characters which discriminate the Burkina Faso spider plant accessions offers to the breeders the possibility to select genotypes corresponding to the local populations needs. However, the heritability and genetic advance of the interest characters must be high so that the selection process is easy and the response to the selection is more significant. Thus, the identification of characters to be improved is based on the characters variability and their heritability. A good knowledge of the genetic parameters is thus necessary for the choice of the optimal criteria for selection (Merour et al., 2008). In order to understand whether the observed variation was due to genetic factors, the genetic parameters were estimated.

For the studied characters, phenotypic coefficient of variation (PCV) is higher than genotypic coefficient of variation (GCV) for all the characters, but the differences between them are low, indicating a significant genetic control on the expression of the studied characters. Similar results were reported on the Burkina Faso sweet grains sorghum (Sawadogo et al*.,* 2014), the millet (Béninga et al., 2011) and eggplant (Danquah and Ofori, 2012). According to the classification of Sumathi et al., (2010), the genotypic and phenotypic coefficients of variation are regarded as weak when they are lower than 10 %, medium when they lie between 11 and 20 % and high when they are higher than 20 %. Thus, days to 50 % flowering and peduncle length have low PCV and GCV. Number of primary ramifications, leaflet width, leaflet length, fruit width and fruit length have moderate phenotypic and genotypic coefficients of variation. Petiole length, days to plant emergence and leaves biomass have high phenotypic and genotypic coefficients of variation while plant height and stem diameter have high phenotypic coefficients of variation and moderate genotypic coefficients of variation. The higher phenotypic and genotypic variance values showed that the genotype could be reflected by the phenotype.

These coefficients of variation give an idea of variability wide, but the estimate of the heritability permits to know the proportion of this variability which could be transmitted from parent to offspring.

The heritability is high when its value is higher than 50 % (Johnson et al., 1955). Thus, all the 12 characters studied recorded high broad sense heritability (68.847 % - 94.506

%). The high heritability values observed show that the contribution of the genotypes to the expression of the characters is significant, indicating that their expression was less influenced by environment. Thus, phenotype could be a good predictor of genotype for these spider plant genotypes. However, broad sense heritability do not permit, alone, to predict if the selection will make a substantial improvement. Thus, in addition to the heritability, the estimate of the genetic advance brings more precision (Drabo et al., 2013).

The highest values of expected genetic advance are observed for biomass and plant height. On the other hand, lowest are noted for leaflet width, fruit width and peduncle length.

As for expected genetic advance as per cent of the mean, the highest values are obtained for leaves biomass days to plant emergence, fruit width, petiole length, plant height and stem diameter. The others characters have moderates expected genetic advance as per cent of the mean, lower than 30 %.

The genetic parameters indicate that variability observed for the Burkina Faso spider plant accessions could be exploited in breeding programs.

In addition to these genetic parameters, the knowledge of the relations between the characters is essential in the definition of the selection objectives. The positive correlations, in particular the correlations between plant height and the vegetative cycle and between plant height and number of primary ramifications are particularly important for spider plant improvement. Indeed, Improvement of biomass yield potential could be done by taking account one of these characters. The significant and positive correlation between days to 50 % flowering and plant height indicates that the plants which have a long cycle are those which are largest. Indeed, these plants, taking into account the length of their vegetative cycle, have more time for the vegetative development contrary to those whose cycle is short. The significant and positive correlation between plant height and stem diameter and the correlation between plant height and primary branches number suggests that largest plants have several branches and large diameter to ensure a good stability. These correlations are particularly interesting for the producers who need the plants producing much biomass. Significant and positive correlations ($P<0.01$) were obtained between plant height and the others characters showed that improvement of biomass yield potential could be done by taking account this one character. These results observed are similar to those reported by K' Opondo (2011), Masuka et al. (2012) and Omondi-Wasonga (2014) who also observed several correlations between the parameters related to the biomass production.

CONCLUSION

This study shows that the 12 studied characters discriminate significantly the spider plant genotypes. The study also revealed interesting correlations between several characters related to the biomass production, in particular the correlations between vegetative cycle and plant dimensions. These correlations are particularly interesting because the improvement of only one character induces improvement of the others and increases biomass. The study shows moreover a more significant genetic control on the characters expression, resulting in high broad sense heritability and weak differences between the phenotypic and genotypic coefficients of variation. Moreover, high broad sense heritability coupled with high genetic advance as per cent of mean expected from selection suggests that the majority of the quantitative characters of spider plant would be under the additive genes control. The results of this study indicates that varietal improvement could be considered starting from the variability observed in this study.

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Conflict of interests

The authors declare that they have no conflicting interests.

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