GLOBAL JOURNAL OF ADVANCED RESEARCH
(Scholarly Peer Review Publishing System)

EVALUATION OF AGRO-MORPHOLOGIC DIVERSITY OF SOME ACCESSIONS OF EGGPLANT (SOLANUM MELONGENA), SOME WILD AND CULTIVATED RELATIVES AND THEIR INTERSPECIFIC HYBRID PROGENIES.

KOUASSI, Koffi Brice Aymar
Université Félix HOUPHOUËT-BOIGNY, UFR Biosciences, Laboratoire de Génétique, 22 BP 582 Abidjan 22, Côte d'Ivoire
briceaymark@gmail.com

KOUASSI, Abou Bakari
Université Félix HOUPHOUËT-BOIGNY, UFR Biosciences, Laboratoire de Génétique, 22 BP 582 Abidjan 22, Côte d'Ivoire
abou_kouassi@yahoo.fr

PROHENS, Jaime Tomas
Instituto de Conservación y Mejora de la Agrodiversidad Valenciana, UniversitatPolitècnica de València, Camino de Vera 14, 46022 Valencia, Spain
jprohens@btc.upv.es

N'GBESSO,Mako François de Paul
Centre National de Recherche Agronomique / Station de Recherche sur les Cultures Vivrières, 01 BP 633 Bouaké 01, Côte d'Ivoire
mako2ngbesso@yahoo.fr

AKANVOU, Louise
Centre National de Recherche Agronomique (CNRA) / Direction Générale / Yopougon, Adiopodoumé, KM17, Route de Dabou / 01 BP 1740 Abidjan 01, Côte d'Ivoire
makanvou@gmail.com

N'GUETTA, Assonvo Simon-Pierre
Université Félix HOUPHOUËT-BOIGNY, UFR Biosciences, Laboratoire de Génétique, 22 BP 582 Abidjan 22, Côte d'Ivoire
nguettaewatty@yahoo.fr

N'ZI, Jean Claude
Université Félix HOUPHOUËT-BOIGNY, UFR Biosciences, Laboratoire de Génétique, 22 BP 582 Abidjan 22, Côte d'Ivoire
jcnzi2@yahoo.fr

KOUASSI, Auguste
Université Félix HOUPHOUËT-BOIGNY, UFR Biosciences, Laboratoire de Génétique, 22 BP 582 Abidjan 22, Côte d'Ivoire
auguste.kouassi@gmail.com

Corresponding author: abou_kouassi@yahoo.fr , **Phone:** (+225) 49 02 56 65 / (+225) 01 34 92 40

ABSTRACT

Commercial varieties of eggplant, *Solanummelongena*, are vulnerable to future challenges related to the effects of climate change. It is therefore important to provide plant breeders and farmers with plant material that can meet these new challenges by exploiting some of the natural abilities of wild relatives.The aim of this study was to appreciate the transmissibility of interesting traits to the descendants by evaluating the agro-morphologic diversity of 8 accessions of *S. melongena*, 8 accessions of 6 wild or cultivated relatives and 36 interspecific progenies. Mean values of agro-morphologic traits revealed heterosis effects for vegetative growth characteristics in interspecific hybrids between *S. melongena* and wild relatives. A Principle Component Analysis identified three morpho-groups that discriminate *S. insanum, S. anguivi* and *S. dasyphyllum*, the respective wild ancestors of the three main cultivated eggplant species, *S. melongena*, *S. aethiopicum* and *S. macrocarpon*. In addition, interspecific hybrids belong to the same morpho-groups as the wild parental accessions, which could therefore carry dominant alleles of genes controlling the expression of these agro-morphologic traits. In general, fertile interspecific hybrids have values of production characteristics intermediate between those of parental accessions, suggesting the involvement of genes with additive effects in the expression of these traits.

General Terms: Plant Genetic Resources, Plant breeding, Genetics

Keywords: Solanummelongena, wild relatives, interspecific hybrids, agro-morphologic diversity

1. INTRODUCTION

Eggplant (*Solanummelongena* L.) is a vegetable plant belonging to the subgenus Leptostemonum. This subgenus is a multi-species complex of the Solanaceae family with about 450 species [1, 2]. The three main cultivated species of this subgenus are *Solanummelongena*, *Solanumaethiopicum* and *Solanummacrocarpon*. Among the cultivated Solanaceae species belonging to the subgenus Leptostemonum, *S. melongena* is the largest and most widespread worldwide. This species is mainly grown for its fruits that are eaten as vegetables in different parts of the world [3]. It is an important crop, especially in the tropical and subtropical regions of the world. According to the statistics of the United Nations Food and Agriculture Organization (FAO), in 2016, world production of *S. melongena* was estimated at about 51.3 million tonnes and it was the third most important cultivated species of Solanaceae after potato, *Solanumtuberosum*, and tomato, *Solanumlycopersicum*[4].

This importance of eggplant faces many problems related to its cultivation. Indeed, commercial eggplant varieties have a narrow genetic base. This reduces the choice of genotypes involved in breeding programs and renders commercial varieties of eggplant, created by research programs, vulnerable to biotic and abiotic stresses [5,6, 7].

The use of interspecific hybridization between *S. melongena* and species belonging to the different gene pools allowed the introgression of several genes of agronomic interest in *S. melongena* leading to the widening of the genetic variability within the species. Earlier work on interspecific hybridization within the subgenus Leptostemonum has resulted in hybrids between *S. melongena* and other cultivated species, *S. macrocarpon* and *S. aethiopicum*[8, 9, 10], as between *S. melongena* and many wild species of the same subgenus [11,12, 13].

So far, agro-morphologic characteristics of interspecific hybrids between *S. melongena* and the wild relatives *S. insanum, S. anguivi*, *S. dasyphyllum*, *S. linneanum* and *S. tomentosum* in agro-climatic conditions of Ivory Coast are not yet reported. The objective of this study is to determine the agro-morphologic diversity of interspecific hybrids and parental accessions in Côte d'Ivoire in order to appreciate the transmissibility of traits of interest to the descendants.

2. MATERIAL AND METHODS

2.1 Plant Material

The plant material consists of:

a) 8 accessions of S. melongena originating from Côte d'Ivoire (M1, M2, M3), Sri Lanka (M4, M5, M6, M9) and South East of Asia (M7). These accessions represent the existing diversity within S. melongena. Indeed, the 3 accessions originating from Côte d'Ivoire belong to the "western" genetic group while the 5 accessions originating from Sri Lanka and South East of Asia belong to the "eastern" genetic group [14, 15].

b) 8 accessions of 6 wild or cultivated relatives of S. melongena belonging to the primary and secondary gene pools. These are, for the primary gene pool, 2 accessions of the species S. insanum (IS1 and IS2) and, for the secondary gene pool, 1 accession of S. aethiopicum, (AT1), 2 accessions of S. anguivi (AG1 and AG2), 1 accession of S. dasyphyllum (DS1), 1 accession of S. linneanum (LN1) and 1 accession of S. tomentosum (TM1) (Table 1).

c) 36 interspecific hybrid (F1) progenies including 15 obtained with the accessions IS1, IS2 and IS3 of S. insanum, 8 with the accessions AG1 and AG2 of S. anguivi, with the accession DS1 of S. dasyphyllum, 3 with the accession AT1 of S. aethiopicum, 3 with the accession TM1 of S. tomentosum and 2 with the accession LN1 of S. linnaeanum (Table 2). Hybridizations were performed using accessions of S. melongena, primarily, as female parents and, secondarily, as male parents in cases where it was difficult to obtain fruits with the first crosses.

Table 1: Origin and code of parental accessions used for the interspecific hybridizations.

Gene pool	Species	Statut	Accession	Code	Accession origin
	S. melongena	cultivated	BBS-118/B	M1	Côte d'Ivoire
			BBS-146	M2	Côte d'Ivoire
			BBS-175	M3	Côte d'Ivoire
			7145	M4	Sri Lanka
			8104	M5	Sri Lanka
			Ampara	M6	Sri Lanka
			Kermit	M7	South East Asia (Commercial variety)
			Jeffna Special	M9	Sri Lanka (Commercial variety)
Primary gene pool	S.insanum	wild	SLKINS-1	IS1	Sri Lanka
			MM 498	IS3	Japon
Secondary gene pool	S.anguivi	wild	BBS 119	AG1	Côte d'Ivoire
			BBS 125/B	AG2	Côte d'Ivoire
	S. dasyphyllum	wild	MM 1153	DS1	Ouganda
	S. aethiopicum	cultivated	Aub21NB	AT1	Côte d'Ivoire (Commercial variety)
	S. linneanum	wild	JPT0028	LN1	Spain
	S tomentosum	wild	MM 992	TM1	South Africa

Table 2: Parental accessions and their respectives interspecific hybrid progenies

males / females	IS1	IS3	AG1	AG2	DS1	AT1	M1	M3	M5	M6	TM1
M1	M1 x IS1	M1 x IS3	M1 x AG1	-	-	-	-	-	-	-	-
M2	M2 x IS1	-	M2 x AG1	M2 x AG2	M2 x DS1	-	-	-	-	-	M2 x TM1
M3	M3 x IS1	-	M3 x AG1	-	M3 x DS1	-	-	-	-	-	-
M4	M4 x IS1	M4 x IS3	M4 x AG1	-	-	M4 x AT1	-	-	-	-	-
M5	M5 x IS1	M5 x IS3	M5 x AG1	M5 x AG2	M5 x DS1	-	-	-	-	-	-
M6	M6 x IS1	M6 x IS3	M6 x AG1	-	M6 x DS1	-	-	-	-	-	-
M7	M7 x IS1	M7 x IS3	-	-	-	M7 x AT1	-	-	-	-	-
M9	-	M9 x IS3	-	-	M9 x DS1	M9 x AT1	-	-	-	-	-
IS3	-	-	-	-	-	-	-	IS3 x M3	-	IS3 x M6	-
LN1		-	-	-	-	-	LN1 x M1	-	-	LN1 x M6	-
TM1	-	-	-	-	-	-	-	TM1 x M3	TM1 x M5	-	-

2.2 Planting and Growing Conditions

Parental accessions and F1 hybrids were planted in 2015 during the main rainy season, in an experimental plot of the National Center for Agronomic Research (CNRA) of Côte d'Ivoire, located in Yopougon / Adiopodoumé, 17 km from Abidjan city center. The geographic coordinates of the plot are 5° 19' 516" N and 004° 08' 206" W with an altitude of 37 m.

45-day-old seedlings were planted in a completely randomized design with spacing of 1.5 m between lines and 1 m between plants on the same line. Pesticides (fungicide and insecticide) were applied to plants when pest attacks were observed. Fertilization was carried out with NPK 12-22-22 fertilizer at a rate of 25 g per plant per month.

2.3 Measurement of Agro-morphologic Traits

Plants were characterised using 15 agro-morphologic traits among eggplant descriptors', including 7 traits related to vegetative growth and 8 traits related to production [16](Table 3). Vegetative growth characteristics were measured at early blooming stage. Floral traits were evaluated on 3 to 4 randomly selected inflorescences per plant. When the inflorescence consists of more than 3 flowers, stamens were counted on 3 flowers also chosen at random. The characteristics of the fruits were measured on 3 to 4 fruits per plant.

Table 3: Phenotypic descriptors used for agromorphologic characterization of parental accessions and interspecific hybrid offsprings.

N°	Descriptor	Unity (IS)	Code	Type of descriptor
1	Plant Height	cm	PLHE	Vegetative Growth
2	Plant Canopy Width	cm	PLWI	
3	Ramification Index	—	RAM	
4	Limb Length	cm	LILE	
5	Limb Width	cm	LIWI	
6	Petiole Length	cm	PELE	
7	Petiole Width	mm	PEWI	
8	Number of Flowers/Inflorescence	—	NFLIN	Production
9	Number of stamens	—	NBST	
10	Fruit Length	cm	FRLE	
11	Fruit Width	cm	FRWI	
12	Fruit Pedicel Length	cm	FRPL	
13	Fruit Pedicel Thickness	mm	FRPT	
14	Number of Fruits/Infructescence	—	NFRIN	
15	Fruit Weight	g	FRWE	

IS : International System

2.4 Data Analysis

Variations of quantitative traits were estimated from the basic statistics: phenotypic mean values, standard deviation and coefficient of variation. The values of each quantitative trait were subjected to an analysis of variance (ANOVA) by considering the groups consisting respectively of accessions of *S. melongena*, accessions of wild and cultivated relatives and F1 hybrid descendants. Phenotypic mean values of the groups were compared using Duncan's Multiple Range Test, with a significance level set to 5%.

The phenotypic diversity of accessions of *S. melongena,* accessions of wild and cultivated relatives and their interspecific hybrid progenies was structured using a Principal Component Analysis (PCA). Relevant descriptors and factorial axes of the PCA were chosen based on coefficients of correlation and quality of representation, on the one hand, and on Kaiser's criterion, on the other hand. These statistical analyses were performed using the Microsoft Office Excel 2013 and IBM SPSS Statistics 22.0 software. (IBM Corp. Armonk, NY, USA).

3. RESULTS

3.1 Comparison of Agro-morphologic Traits of Parental Accessions and Their Interspecific Hybrid Progenies.

Significant differences were observed between accessions of eggplant, *S. melongena*, and those of related species both for vegetative growth traits and production traits (Table 4). Although plant canopy width (CAWI) of *S. melongena* are on average larger than those of wild relatives, the two groups of parental accessions were not significantly different for plant height (PLHE) and ramification index (RAM). Except limb width (LIWI) for which the two groups of parental accessions did not differ significantly, values of all other characteristics of the leaves were significantly higher for accessions of *S. melongena*(Table 4).

Regarding production characteristics, accessions of wild relatives produced significantly more flowers per inflorescence (NFLIN) than accessions of *S. melongena*. The number of stamens per flower (NBST) was, however, higher for accessions of *S. melongena* (Table 4). Except the number of fruits by infructescence (NFRIN) for which mean values of the two groups of parental accessions were statistically similar, mean values of all the other fruit characteristics were significantly higher for accessions of *S. melongena* (Table 4).

On the whole, interspecific hybrids exhibited higher values of vegetative growth characteristics than cultivated and wild relative parental accessions. However, petiole length (PELE) of the hybrids was smaller than that of the accessionsof *S. melongena* and it was not significantly different from that of the accessions of wild relative species. In addition, petiole thickness (PETH) of *S. melongena* accessions was similar to that of interspecific hybrids and higher than those of wild relative parental accessions (Table 4).

For production characteristics, mean values of hybrid progenies were generally intermediate between those of accessions of *S. melongena* and wild relatives (Table 4). However, there was no significant difference between interspecific hybrids and accessions *of S. melongena* for number of flowers per inflorescence (NBIN) and fruit width (FRWI). There was also no significant difference between hybrids and wild relative parental accessions for the number of fruits by infructescence (NFRIN) (Table 4).

.**Table 4:** Means values, standard deviations and coefficients of variation of 15 agro-morphologic traits scored in field condition in Côte d'Ivoire for some accessions of *S. melongena*, wild and cultivated relatives and interspecific F1 hybrid progenies

traits	*S. melongena* (N = 41)		Wild relatives (N = 36)		Interspecific F1 Hybrids (120 ≤ N ≤ 170)		F	p
	Mean ± SD	CV (%)	Mean ± SD	CV (%)	Mean ± SD	CV (%)		
PLHE	75.85 ± 15.85^b	20.89	76.83 ± 29.57^b	38.49	93.78 ± 28.15^a	30.02	11.31	0.000
PLWI	128.84 ± 17.31^b	13.44	100.07 ± 28.47^c	28.45	145.57 ± 31.63^a	21.73	37.36	0.000
RAM	5.73 ± 0.98^b	14.62	6.16 ± 4.03^b	46.40	7.20 ± 2.45^a	34.60	18.74	0.000
LILE	24.57 ± 4.06^b	16.4	20.74 ± 7.91^c	37.40	26.79 ± 6.26^a	26.26	22.707	0.000
LIWI	17.20 ± 2.88^b	16.75	15.98 ± 5.63^b	34.78	21.21 ± 5.40^a	29.88	28.54	0.000
PELE	10.15 ± 2.77^a	26.38	7.91 ± 3.55^b	45.91	9.20 ± 2.33^b	29.79	6.83	0.001
PEWI	5.63 ± 1.12^a	19.97	4.31 ± 1.25^b	26.65	5.49 ± 1.37^a	27.65	20.11	0.000
NFLIN	2.85 ± 0.65^b	22.93	5.39 ± 3.03^a	56.16	4.72 ± 2.35^a	49.66	14.25	0.000
NBST	5.88 ± 0.81^a	13.82	5.19 ± 0.40^c	7.73	5.39 ± 0.49^b	9.07	17.69	0.000
FRLE	11.89 ± 4.00 ^{a}	33.65	2.97 ± 1.57^c	52.82	5.27 ± 4.45^b	84.40	56.89	0.000
FRWI	6.12 ± 1.61^a	26.25	3.31 ± 2.06^b	62.23	3.86 ± 1.74^b	45.01	30.59	0.000
FRPL	5.73 ± 1.61^a	20.81	2.06 ± 0.85^c	41.32	3.16 ± 1.24^b	39.37	106.48	0.000
FRPT	10.23 ± 2.42^a	23.65	4.74 ± 1.71^c	37.28	6.01 ± 3.36^b	56.05	61.08	0.000
NFRIN	1.15 ± 0.42^b	36.81	2.08 ± 1.18^a	56.65	1.24 ± 0.62^b	50.07	21.27	0.000
FRWE	163.35 ± 52.02^a	31.85	29.32 ± 21.27^c	89.52	52.65 ± 50.72^b	93.54	121.18	0.000

Mean: Average; SD: Standard Deviation; CV: Coefficient of Variation; N: number of records; F: statistic associated with the Fisher test; p: probability value associated with the Fisher test. For each agro-morphologic trait, mean values followed by the same letter are not significantly different according to Duncan's Multiple Range Test, with a significance level set to 5%.

3.2 Structure of Agro-morphologic Diversity of Parental Accessions and Interspecific Hybrid progenies

The Principal Component Analysis (PCA) performed with mean values of agro-morphologic characteristics of the different parental accessions and their interspecific hybrid descendants revealed 3 main components that explained 78.82% of the total variance. Components 1, 2, and 3 accounted, respectively, for 48.98%, 21.58%, and 8.27% of the total variance (Table 5).

The first component was negatively correlated to ramification index (RAM: r = -0.68), and to the number of fruits per infructescence (NFRIN: r = -0.66). This first component was also positively correlated to production characteristics such as fruit weight (FRWE: r = 0.89), fruit pedicel length (FRPL: r = 0.88), fruit width (FRWI: r = 0, 86), fruit length (FRLE: r = 0.85), fruit pedicel thickness (FRPT: r = 0.76) and number of stamens per flower (NBST: r = 0.74). The first component was furthermore positively correlated to leaf characteristics such as petiole thickness (PETH), petiole length (PELE: r = 0.69), limb length (LILE, 0.68), and Limb width (LIWI: r = 0.59). Since the highest correlation coefficients concern fruit characteristics, the first component explains mainly the variability of production characteristics (Table 6)

The second component was positively correlated to plant height (PLHE: r = 0.87), limb width (LIWI: r = 0.75), number of flowers per inflorescence (NFLIN: r = 0.66), and plant canopy diameter (CADI: r = 0.51) (Table 6). This component reflects mainly variability of vegetative growth characteristics.

Table 5: Eigen values and proportions of variation explained by the first three factorial components of the principal component analysis.

	Component 1	Component 2	Component 3
Eigen values	7.346	3.236	1.240
Variance explained (%)	48.976	21.576	8.265
Cumulated Variance (%)	48.976	70.552	78.817

Tableau 6: Correlation coefficients between the 15 agro-morphologic traits and the first three factorial components of the principal components analysis.

	Components		
Traits	1	2	3
PLHE	0.35	**0.87**	0.006
PLWI	0.20	**0.51**	**-0.76**
RAM	**-0.68**	-0.30	0.33
LILE	**0.68**	-0.30	0.33
LIWI	**0.59**	**0.75**	0.23
PELE	**0.69**	-0.19	0.04
PEWI	**0.76**	0.43	0.43
NFLIN	-0.43	**0.66**	-0.07
NBST	**0.74**	-0.20	0.15
FRLE	**0.85**	-0.25	0.05
FRWI	**0.86**	-0.27	-0.07
FRPL	**0.88**	-0.26	-0.06
FRPT	**0.85**	-0.34	-0.07
NFRIN	**-0.66**	0.05	0.47
FRWE	**0.89**	-0.28	0.06

In bold font, the correlation coefficients, greater than 0.5, in absolute value, between agro-morphologic traits and factorial components of the principal component analysis

The third component was negatively correlated to plant canopy width (PLWI: r = -0.76) (Table 6). Thus we analysed agro-morphologic diversity based on the projections of traits and individuals in the factorial space formed by the components 1 and 2 which account for 70.56% of the observed variability.

The projection of parental accessions and hybrids descendants in the factorial space formed by the components 1 and 2 distinguished 3 groups (Figure 1). Group 1 consisted of accessions M1, M2, M3, M4, M5, M6, M7 and M9 of *S. melongena* as well as accessions IS1 and IS3 of *S. insanum*, which is a wild relative from the primary gene pool. The different interspecific hybrids "*S. melongena* x *S. insanum"* (M1 x IS1, M1 x IS3, M2 x IS1, M3 x IS1, M4 x IS1, M4 x IS3, M5 x IS1, M5 x IS3, M6 x IS1, M6 x IS3, M7 x IS1, M7 x IS3, M9 x IS3, IS3 x M3 and IS3 x M6) are also included in this group. These parental accessions and their interspecific hybrid offspring produced a low fruit number per infructescence and mean values ranging from medium to high for fruit characteristics. These plants are also characterized by a relative weak vegetative growth (Figure 1).

Group 2 is composed of accessions AG1 and AG2 of *S. anguivi*, AT1 of *S. aethiopicum*, LN1 of *S. linneanum* and TM1 of *S. tomentosum*, which are wild relatives belonging to the secondary gene pool, and their respective interspecific hybrid descendants (M1 x AG1, M2 x AG1, M3 x AG1, M4 x AG1, M5 x AG1, M6 x AG1, M2 x AG2, M5 x AG2, M4 x AT1, M7 x AT1, M9 x AT1, LN1 x M1, LN1 x M6, TM1 x M3, TM1 x M5, M2 x TM1). This group is much more heterogeneous with plants characterized by large numbers of flowers per inflorescence and fruits per infructescence and high ramification indexes. The plants in this group also produce small fruits and have a wide range of values for vegetative growth characteristics (Figure 1).

Group 3 is formed by the accession DS1 of *S. dasyphyllum* and its interspecific hybrid descendants M2 x DS1, M3 x DS1, M5 x DS1, M6 x DS1 and M9 x DS1. This group is characterized by plants with high vegetative growth and a large number of flowers per inflorescence. In this group, interspecific hybrids were not characterized by fruit parameters as none of them produced fruits. Thus, when considering separately the projection of *S. dasyphyllum* and that of its interspecific hybrid descendants, it appears that this wild relativeis close to the accessions belonging to the group 2. Interspecific hybrid descendants of *S. dasyphyllum*, on the other hand, are much better positioned relatively to the component 2 explaining the variability of vegetative growth characteristics (Figure 1). Groups 2 and 3 could therefore be subgroups of the same group.

4. DISCUSSION

There is a great genetic diversity in wild relatives, compared to eggplant, *S. melongena*, accessions [17, 18, 19].These wild relatives harbour relevant traits as resistance to many pathogens in species such as *S. aethiopicum*, *S. anguivi*, *S. linnaeanum*, *S. violaceum* and *S. torvum*, etc. [9, 20, 21] high content of bioactive phenolic acids in species such as *S. dasyphyllum*, *S. incanum*, etc. [22]. These species also have a wide range of habitats and distribution worldwide and are extremely variable, suggesting that traits of interest can be introgressed in eggplant for breeding purpose.

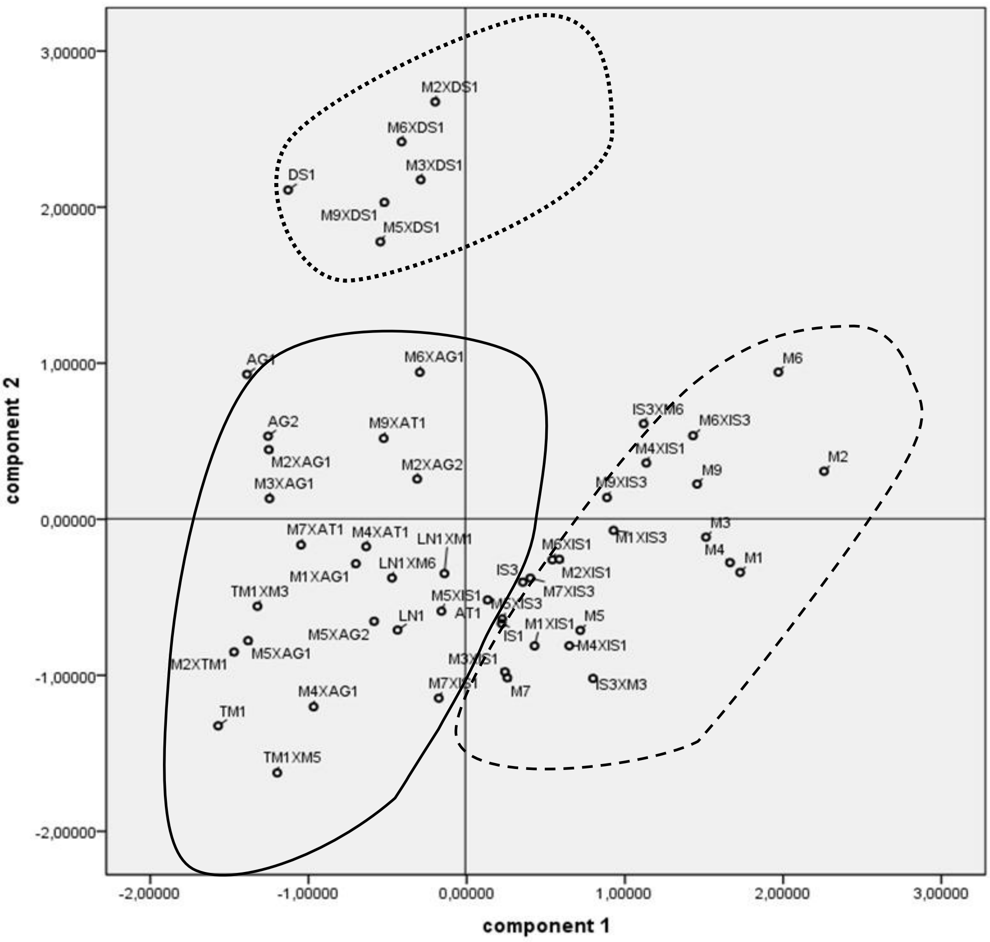

Figure 1: Distribution of accessions of eggplant, *Solanummelongena*, wild and cultivated relatives and their interspecific hybrids progenies in three agro-morphologic groups determined by factorial components 1 and 2 of the Principal Component Analysis (PCA).

Variance analysis of agro-morphologiccharacteristics revealed significant differences between accessions of *S. melongena* and wild relatives, on one side, and between parental accessions and interspecific hybrids, on the other side. On the whole, interspecific hybrids grown in the agro-climatic conditions of Abidjan, Côte d'Ivoire, exhibited higher vegetative vigor than the parental species from which they derive. These results clearly indicate the presence of heterosis effects for vegetative growth characteristics in interspecific hybrids between *S. melongena* and related species. These heterosis effects could be explained by the fact that eggplant and related species reproduce preferentially by autogamy and have a high level of homozygosity. Indeed, it is reported that when homozygous lines are crossed, heterozygosity may increase the vigor of hybrids, especially when the parents are genetically distant [23]. Similar results were reported by Prohens*et al.*[10] who obtained interspecific hybrids between *S. melongena* and *S. aethiopicum* more vigorous than parental accessions. Kaushik*et al.*[24] also reported greater vegetative vigor in interspecific hybrids between *S. melongena* and wild relatives belonging to the primary and secondary gene pools. However, in these previous studies and the present one, it appears that, for a given wild relative, there are significant differences between hybrid progenies derived from different parental accessions. This result could be explained by the presence of different alleles of the genes controlling agro-morphologic characteristics in the different accessions of the same species.

There was no significant difference between interspecific hybrids and wild parental accessions for the number of flowers per inflorescence (NFLIN). This result is similar to those obtained by Blestsos*et al*. [8] in F1 hybrid offspring of *S. melongena* and *S. macrocarpon*. However, regarding flowering time (FLTI), interspecific hybrids were close to *S. melongena* parental accessions. Since interspecific hybrids obtained with *S. dasyphyllum* did not produce fruits, they could not be evaluated for fructification in open pollination conditions, which is an important agronomic trait. This could be due to the very low viability of the pollen grains of interspecific hybrids between *S. melongena* and *S. dasyphyllum*[25]. In general, for fertile interspecific hybrids, mean values of production traits are intermediate between those of wild and cultivated parental accessions. These results suggest that genes with additive effects are important in the expression of production traits which are reported to be polygenic [26, 8, 24].

Principal component analysis of agro-morphologic descriptors provided useful information on the diversity of parental accessions and their interspecific F1 hybrids. Both vegetative growth and production traits, isolated different morpho-groups of wild and cultivated parental accessions. Interspecific hybrids ranged in the same groups as their wild parents and, this suggests that eggplant's wild relative generally carry dominant alleles of genes controlling agro-morphologic traits. Accessions of *S. melongena* and *S. insanum*, its wild ancestor [1, 2] and their hybrid offspring formed the group 1. Group 2 consisted of accessions of the species such as *S. anguivi*, S. *aethiopicum*, *S. linneanum* and *S. tomentosum*, belonging to the secondary gene pool, and their respective hybrid progenies. Group 3 consists exclusively of the species *S. dasyphyllum*and its hybrid descendants. Considering the phylogenetic classification performed by Vorontsova*et al.*[2], groups 2 and 3 could be subsets of a much more diverse group. Indeed, these authors reported that, except *S. linneanum*, all the wild species that constitute these 2 groups belong to the anguivi phylogenetic group. Due to the genetic distance between *S. melongena* and some of the species belonging to the group 2, they could be very important for introgression of relevant genes in *S. melongena*, expecting heterosis effects for the characteristics of interest. In addition, these three groups discriminate *S. insanum*, *S. anguivi* and *S. dasyphyllum*, the respective wild ancestors of the three main cultivated species, *S. melongena*, *S. aethiopicum* and *S. macrocarpon*[27, 1].

5. CONCLUSION

Comparison of mean values of agro-morphologic traits revealed heterosis effects for vegetative growth characteristics in interspecific hybrids between *S. melongena*and its wild relatives. In addition, interspecific hybrids ranged in the same morpho-groups as their wild parents, which could therefore carry dominant alleles of the genes controlling the expression of these agro-morphologic traits. The three identified morpho-groups discriminate *S. insanum*, *S. anguivi* and *S. dasyphyllum*, the respective wild ancestors, of the three main cultivated eggplant species, *S. melongena*, *S. aethiopicum* and *S. macrocarpon*. In general, for fertile interspecific hybrids, mean values of production traits were intermediate between those of parental accessions, suggesting that genes with additive effects determine the expression of these traits.

6. ACKNOWLEDGMENTS

This work was undertaken as part of the initiative **''Adapting Agriculture to Climate Change: Collecting, Protecting and Preparing Crop Wild Relatives,''** which is supported by the Government of Norway. The project is managed by the Global Crop Diversity Trust with the Millennium Seed Bank of the Royal Botanic Gardens, Kew and implemented in partnership with national and international gene banks and plant breeding institutes around the world. For further information, see the project website: http://www.cwrdiversity.org/.

References

[1] Knapp S., Vorontsova M. S., Prohens J. 2013. Wild Relatives of the Eggplant (Solanummelongena L.: Solanaceae): New understanding of species names in a complex group. PLoS ONE 8 (2): e57039. doi:10.1371/journal.pone.0057039.

[2] Vorontsova M. S., Stern S., Bohs L., Knapp S. 2013. African spiny Solanum (subgenus Leptostemonum, Solanaceae): a thorny phylogenetic tangle. Botanical Journal of the Linnean Society 173: 176 - 193. doi: 10.1111/boj.12053.

[3] Bhatti K. H., Kausar N., Rashid U., Hussain K., Nawaz K., Siddiqi E. H. 2013. Effects of biotic stresses on eggplant (Solanummelongena L.). World Applied Sciences Journal 26 (3): 302 - 311.

[4] FAO. 2018. FAOSTAT Production Databases. Food and Agriculture Organization. http://www.fao.org/faostat/fr/#data/QC. (Accessed in December, 2018).

[5] Muñoz-Falcón J. E., Prohens J., Vilanova S., Nuez F. 2009. Diversity in commercial varieties and landraces of black eggplants and implications for broadening the breeder's gene pool. Annals of Applied Biology 154: 453 - 465.

[6] Meyer R. S., Karol K. G., Little D. P., Nee M. H., Litt A. 2012. Phylogeographic relationships among Asian eggplants and new perspectives on eggplant domestication. Molecular Phylogenetics and Evolution 63: 685 - 701.

[7] Hurtado M., Vilanova S., Gramazio P., Plazas M., Andújar I. 2015. Increasing the genetic base of modern cultivars of eggplant of the semi-long black type. Bulletin UASVM Horticulture 72 (2): 281 - 287.

[8] Bletsos F., Roupakias D., Tsaktsira M., Scaltsoyjannes A. 2004. Production and characterization of interspecific hybrids between three eggplant (Solanummelongena L.) cultivars and Solanummacrocarpon L. ScientiaHorticulturae 101: 11 - 21.

[9] Daunay M. C. 2008. Eggplant. In: Prohens J., Nuez F. (Eds.) Handbook of crop breeding, Vegetables II: Fabaceae, Liliaceae, Umbelliferae, and Solanaceae, Springer, New York (USA): pp 163 - 220.

[10] Prohens J., Plazas M., Raigón M. D., Seguí-Simarro J. M., Stommel J. R.; Vilanova S. 2012. Characterization of interspecific hybrids and first backcross generations from crosses between two cultivated eggplants (Solanummelongena and S. aethiopicumKumba group) and implications for eggplant breeding. Euphytica 186: 517 - 538.

[11] Prohens J., Whitaker B. D., Plazas M., Vilanova S., Hurtado M., Blasco M., Gramazio P., Stommel J. R. 2013. Genetic diversity in morphological and phenolic acids content resulting from an interspecific cross between eggplant (Solanummelongena) and its wild ancestor (S. incanum). Annals of Applied Biology 162: 242 - 257.

[12] Kumchai J., Wei Y. C., Lee, C. Y.; Chen, F. C.; Chin, S. W. 2013. Production of interspecific hybrids between commercial cultivars of eggplant (Solanummelongena L.) and its wild relative S. torvum. Genetics and molecular research 12: 755 - 764.

[13] Plazas M., Vilanova S., Gramazio P., Rodriguez-Burruezo, A., Fita A., Herraiz F. J., Ranil R., Fonseka R., Niran, L., Fonseka H., Kouassi B., Kouassi A. B., Kouassi, A. Prohens J. 2016. Interspecific Hybridization between Eggplant and Wild Relatives from DifferentsGenepools. Journal of the American Society for Horticultural Science 141 (1): 34 - 44.

[14] Vilanova S., Manzur J. P., Prohens J., 2012.-Development and characterization of genomic simple sequence repeat markers in eggplant and their application to the study of diversity and relationships in a collection of different cultivar types and origins. *Molecular Breeding,* 30: 647 - 660.

[15] Cericola F., Portis E., Toppino L., Barchi L., Acciarri N., Ciriaci T., Sala T., Rotino G. L., Lanteri S., 2013.- The population structure and diversity of eggplant from Asia and the Mediterranean basin. *PLoS ONE* 8: 73702.

[16] IBPGR (International Board of plants Genetics Resources) 1990. Descripteur pour l'aubergine. 23 p.

[17] Weese T. L. and Bohs L. 2010. Eggplant origins: out of Africa, into the Orient. Taxon 59: 49 - 56.

[18] Mutegi E., Snow A. A., Rajkumar M., Pasquet R., Ponniah H., Daunay M. C., Davidar P. 2015. Genetic diversity and population structure of wild/weedy eggplant (Solanuminsanum; Solanaceae) in southern India: Implications for conservation. American Journal of Botany, 102: 140 - 148.

[19] Rotino G. L., Sala T., Toppino L. 2014. Eggplant. In: Pratap A and Kumar, J. (Eds.). Alien Gene Transfer in Crop Plants. Springer, New York (USA). Vol. 2, pp 381 - 409.

[20] Gousset C., Collonnier C., Mulya K., Mariska I., Rotino G. L., Besse P., Servaes A., Sihachakr D. 2005. Solanumtorvum, as a useful source of resistance against bacterial and fungal diseases for improvement of eggplant (S. melongena L.). Plant Science 168: 319 - 327.

[21] Plazas M., Prohens J., Cuñat A. N., Vilanova S., Gramazio P., Herraiz F. J., Andújar I. 2014. Reducing capacity, chlorogenic acid content and biological activity in a collection of scarlet (Solanumaethiopicum) and gboma (S. macrocarpon) eggplants. International Journal of Molecular Science 15: 17221 - 17241.

[22] Gallien C. L. 1991. Génétique. Sixième édition: Presse universitaire de France, Paris (France) 277 p.

[23] Kaushik P, Prohens J., Vilanova S., Gramazio P., Plazas M. 2016. Phenotyping of eggplant wild relatives and interspecific hybrids with conventional and phenomics descriptors provides insight for their potential utilization in breeding. Frontiers in Plant Science 7: 677.doi: 10.3389/fpls.2016.0067**.**

[24] Kouassi B., Prohens J., Gramazio P., Kouassi A. B., Vilanova S., Galán-Ávila A., Herraiz F. J., Kouassi A., Seguí-Simarro J. M., Plazas M. 2016. Development of backcross generations and new interspecific hybrid combinations for introgression breeding in eggplant (Solanummelongena). ScientiaHorticulturae 213: 199 - 207.

[25] Doganlar S., Frary A., Daunay M. C., Lester R. N., Tanksley, S. D. 2002. Conservation of gene function in the Solanaceae as revealed by comparative mapping of domestication traits in eggplant. Genetics 161: 1713 - 1726.

[26] Daunay M. C. and Hazra P. 2012. Eggplant. In: Peter K. V., Hazra P., (Eds.). Handbook of Vegetables. Studium Press, Houston, TX, pp 257 - 322.