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Effect of the position of hand from bunch of *Musa* spp. on the expression of number of intraclonally cross-pollinated seeds

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ABSTRACT

This study assessed the ability to yield the intraclonally cross-pollinated seeds of clones Honduras (HON) and Cameroon (CAM) from *Musa balbisiana* (*M. balbisiana*) and THA018-THA, Calcutta4 (CAL), Microcarpa (MIC), Zebrina (ZEB) and Truncata (TRU) from *Musa acuminata (M. acuminata)*. Ten variables were measured. Anova and two-sample Student's t and Z tests were applied. Results shown that *M. acuminata* differ in *M. balbisiana.* The latter is more vigourous and productive in seeds than the former. Clones HON and CAM expressed the highest values of vegetative and seeds yielding in fruit. They might be used, not only in the conservation of genetic resources of banana in the form of seeds in laboratory, but also in hybridisation programme. Nonetheless, in hybrids dedicated to trade, such ability to yield seeds must be eliminated by successives back crosses in the view to releasing edible fruit. In clone HON, the distal hand is more productive in seeds than the medium and proximal ones. In contrast, in clone THA, all the three positions yield the same number of seeds. Their uses must take into account such particularity.

INTRODUCTION

Banana is monocotydone plant of the Musaceae (Guyot, 1992; https://fr.wikipedia.org/wiki/Bananier, accessed on 15 May 2019). Banana is originated from Southeast Asia and the Pacific region and is thought to have been domesticated more than 7000 BP (Perrier et *al*., 2011). East and Central Africa then became secondary centers of diversity.

In the world; the number of cultivated and edible babanas and plantains is about four hundred. Most of the

domesticated bananas are triploid and their fruits, parthenocarpic, contain no seed. With a few exceptions, triploid varieties are more vigorous and productive than the diploid ones. The latter are now rare.

In contrast, wild and diploid bananas produce inedible fruits, filled with seeds. More than 50 wild banana species exist, but two species, *Musa acuminata* and *Musa balbisiana*, are known for their role in the domestication of most edible bananas (Perrier et *al*., 2009). The range of *M. acuminata* extends from west to east, from eastern India to New Guinea, covering the Philippines and Indonesia. Upon such axis, *M. acuminata* expresses strong morphological variability, structured in clones (Cheesman, 1947b). The wild forms, of variable height, are often slender but present large variations of shapes and length of the bunches and fruits. About 9 clones have been defined according to the authors such as De Langhe and Devreux (1960) as well as Simmonds (1966).

M. balbisiana is also a wild, uncultivated species, although originally from Southeast Asia, is substantially farther north than *M. acuminata* clones and is now present in all tropical areas of the planet. It is probably the most common and widespread species of all *Musa* species (Cheesman, 1947a). They are very vigorous, very tall plants. They have a strong vegetative vigour, a strong budding and a very good anchorage in the soil. The species *M. balbisiana* express lower variability than the previous one.

Edible varieties are generally sterile and long-term conservation options are therefore limited by the vegetative nature of their propagation system. These clones must be conserved *ex sit*u in the field or *in vitro* or cryopreserved in laboratory.

The wild banana trees conserved the two propagation systems, namely by seed and by sucker. The two means are important, namely the use of seed to conserve genetic diversity.

Little is known about the yielding of seeds according to hand position on the bunch and that of fruit on the hand. From this, three hand positions on the bunch and two positions of fruit on the hand can be defined. Nonetheless, Burgos-Hernández et *al*., (2014) achieved controlled self and cross pollinations in bananas.

Thus, effect of the position of hand on the bunch as well as that of the fruit on the hand of banana on the expression of intraclonally cross-pollinated seeds yielding is poorly known. Indeed, the existence of a gradient as a function of the appearance of hands was never assessed as to determine the quantity of seeds in each hand position. Likewise, the influence of the internal and external positions of fruits from the hand on the yielding of pollinations has never been performed. Thus, we postulate that the variation in the yielding of intraclonally cross-pollinated seeds, in banana clones, is due to the hand position from bunch as well as that of fruit on the hand.

This work aimed to know the effect of the hand position from bunch as well as that of fruit on the hand of banana on the expression of the number of intraclonally cross-pollinated seeds.

2. MATERIALS AND METHODS

2.1. Site of study, plant materials and experimental designs

Research works were conducted from January to September 2016 at the CARBAP research station based on Njombé, Cameroon. This Station is located at 7° 22' 10.74" North latitude, 12° 20' 40.51" west longitude and 80 meters above sea.

The plant materials were constituted of 2 species, namely *Musa acuminata* and *Musa balbisiana*. Five representatives accounted for *M. acuminata* as against 3 for *M. balbisiana*. *Musa acuminata* differ in *Musa balbisiana* by some morphological and genetic characteristics (Table 1).

Table 1: Country of origin, species, sub-species, clones and some of their characteristics.

Species	Genotype	Sub-species	Clone	Some characteristics	Country of origin*
Musa acuminata	AA	*zebrina*	Zebrina - ZEB	Fruit length ≤ 15cm	Java Island, Indonesia
	AA	*truncata*	Truncata-TRU	Close to some clones from *ssp malaccensis.* It prefers altitude above 1000 m	High Kelantan, Malaysia
	AA	*microcarpa*	Microcarpa - MIC	It is characterised, as its name suggests it, by several tiny fruits	Borneo Island, Indonesia
	AA	*siamea*	Tha 018 -THA	They differ in previous by emitting the hermaphrodite flowers while the previous ones emit female flowers.	Thailand
	AA	*burmannica*	Calcutta 4-CAL	Fruit position: curved obliquely at an angle of 45°	Burma, Myanmar
Musa balbisiana	BB	*pisang klutuk wulung*	Pisang klutuk kulung-PKW	Seeds aborted after selfing	Indonesia, Purwodadi
	BB	*cameroon*	Cameroon-CAM	As other clones *M. acuminata*, seeds don't abort after selfing	Cameroon
	BB	*honduras*	Honduras-HON	Seeds abort after selfing	South East Asia

Country of origin* : Informations, namely "country of origin" have been took in book of De Langhe et *al*., 1961.

Pollination system and conditions of the achieving of intraclonally cross-pollinations

Five banana plants per clone were used for pollinations. Clone, bunch, hand and fruit, taken as factors, combined or not, were used to test their individual or combined effects. Consequently, treatment was defined here as variants of a factor or variants combination of 2 factors tested, namely clone and hand position as well as clone and fruit position.

Four replications of these previously cited treatments were used.

In the morning, genebank is visited to search for the female inflorescences about to open. It is bagged. This requires the bagging of male inflorescence. One or two days after, first, in the morning, pollen is withdrawn thus placed on fruit stigma of each hand open. After each pollination, the bag is placed again on the inflorescence to prevent unwanted pollen. Such operation repeated until the appearance of all female hands. Bag is withdrawn two days after the last pollination which corresponds to the last female hand (figure 1). Hands were cleaned with alcohol at 90° to deactivate pollen.

Four and a half months later, bunch starts to become mature. It is conserved in shed to standardise the maturation. First, hands from bunch are withdrawn then ranked in three lots as a function of their position from the bunch: (i) proximal, (ii) medium and (iii) distal. Likewise, their position related to inflorescence axis is also qualified: (i) internal and (ii) external. First, fruits of each bunch are placed in container, have open then watered. Seeds are handly counted in quadruplicate (Figure 1).

Variables measurement

Regarding the measured variables, four types of variables were measured. It is about vegetative system, bunch, fruit and seed variables. Concerning vegetative system variable, there are (i) the circumference (C), (ii) height of plant (H). Regarding bunch variable : (i) weight of bunch (PR), (ii) number of hand per bunch (NMR), (iii) number of fruits yielded per bunch (NFR), (iv) number of fruit per hand (NFM). As for fruit variable: (i) length of fruit in centimetre (LF) and (ii) circumference of fruit in centimetre (CF). As far as the seed variable is concerned: (i) number of seeds per fruit (NGF).

Figure 1 : Operation of controlled self pollination in banana clone. A, Withdrawing pollen. B, deposit of pollen. C, Bagging of self pollinated inflorescence. (1 barre = 8 cm. Source: Ongagna, 2017).

Methods of data analysis

Versions 2007.6 and 22.0 of Xlstat and SPSS softwares were used, respectively. Parametric methods, mainly Anova as well as two samples Student's test were applied. Means comparison according to both Newman-Keuls as well as Z and t Student tests at level of 5% were used.

RESULTS

1. Intraclonally cross-pollinated seeds and fruits count variation brought per bunch of especies *M. acuminata* and *M. balbisiana*

Test of the species effect revealed that only the interval flower-cut was not discriminating. In contrast, the five other variables were discriminating. Consequently, for the first above cited variable, the means separation of clones was done under the two grouped species whereas for the nine other variables, mean classifications were carried out for each of species taken separately. Magnitude of variation stretched out from 3.59 to 17.60%. (Table 2; Figures 2, 3, 4 and 5).

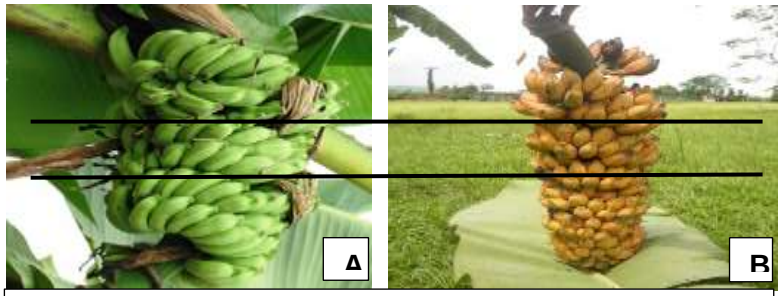

Figure 2 : Bunches. A, bunch brought by plant from clone Calcutta04 belonging to *M. acuminata*. B, bunch mature and harvested belonging to clone Honduras from *M. balbisiana*. Black line showing level of cut with a view to obtain three positions of hand on bunch : proximal hand, medium hand and distal hand. (1 barre = 20 cm. Source : Ongagna, 2016).

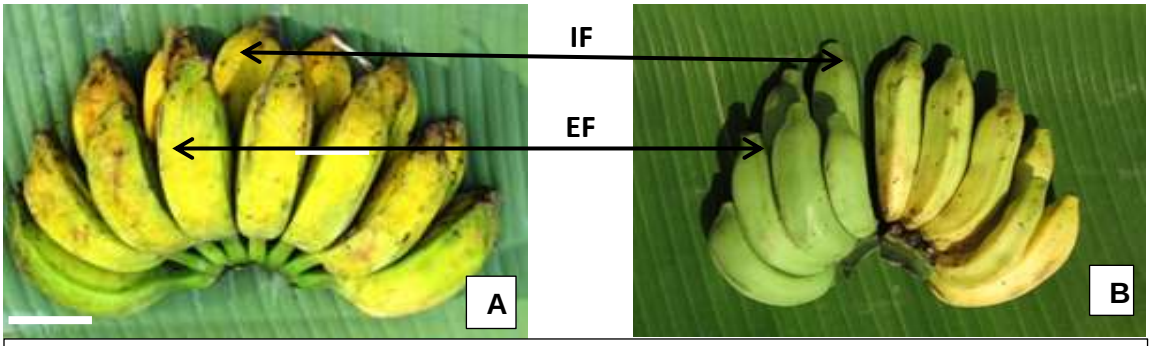

Figure 3: Fruits position on hand. A, fruit in external position of hand from clone Honduras. B, fruit in internal position of hand from clone Calcutta. Black line showing two types of fruits: external fruit, internal fruit. (1 barre = 7 cm. Source: Ongagna, 2017).

Figure 4: Picture showing the longitudinal and transversal cut from clone Honduras belonging to *M. balbisiana* (1 barre = 10 cm. Source : Ongagna, 2017).

Figure 5: Banana seeds. A, seeds from clone *M. balbisiana.* B, seeds from clone *M. acuminate*. (1 barre = 6 cm. Source: Ongagna, 2017).

Table 2 : Classification of means of the IFC, NFR, NMR, PR, C, H as a function of species *M. acuminata and M. balbisiana.*

Organ*	Dependent variable *	Species*	Mean*	CV(%)*	Dependent variable	Species	Mean	CV(%)
Vegetative system	C	*acuminata*	39.480a	11.66	H	*acuminata*	281.000a	12.40
		balbisiana	70.500b	7.63		*balbisiana*	481.000b	16.66
Bunch	**Dependent variable**	**Species**	**Mean**	**CV (%)**	**Dependent variable**	**Species**	**Mean**	**CV (%)**
	IFC	*acuminata*	125.360a	5.43	PR	*acuminata*	6.000a	11.52
		balbisiana	131.000a	9.79		*balbisiana*	24.100b	12.64
	Dependent variable	**Species**	**Mean**	**CV(%)**	**Dependent variable**	**Species**	**Mean**	**CV(%)**
	NMR	*acuminata*	9.360a	11.49	NFR	*acuminata*	160.200a	17.60
		balbisiana	14.700b	17.58		*balbisiana*	257.700b	12.02
	Dependent variable	**Species**	**Mean**	**CV(%)**				
	NFM	*acuminata*	15.866a	10.98				
		balbisiana	20.614b	8.50				
Fruit	**Dependent variable**	**Species**	**Mean**	**CV (%)**	**Dependent variable**	**Species**	**Mean**	**CV (%)**
	LF	*acuminata*	10.640a	15.32	CF	*acuminata*	7.220a	12.97
		balbisiana	11.900b	6.20		*balbisiana*	14.400b	3.59
Seed	**Dependent variable**	**Species**	**Mean**	**CV (%)**				
	NGF	*acuminata*	61.458a	16.99				
		balbisiana	233.479b	19.14				

Organ* : Vegetative system : Accounted for the pseudostem and height of plant. This one consisted of sheathing leaves. **C :** Circumference of pseudostem at one metre from the ground. **H:** Height of babana plant. **IFC :** Interval flower-cut. **PR :** Weight of bunch. **NMR :** Number of hand per bunch. **NFR :** Number of fruits yielded per bunch. **NFM :** Number of fruit per hand. **LF :** Length of fruit in centimetre. **CF :** Circumference of fruit in centimetre. **NGF :** Number of seeds per fruit. **Species*:** Clone of species used. **Mean*:** Mean accompanied of the same letter in column are statistically identical according to Student's parametric t-test at 5% level. **CV(%)* :** Coefficient of variation.

1.1. Intraclonally cross-pollinated fruit descriptors variation for both species *M. acuminata* and *M. balbisiana* taken collectively and separately relatively to the interval flower-cut

With respect to the interval flower-cut of the species *M. acuminata* and *M. balbisiana* taken collectively, no significant difference was found among seven clones tested. Dispersion of the measured variable around mean spread out from 2.78 to 12.21% (Table 3).

In contrast, taken separately, at the level of species *M. acuminata*, when we consider the vegetative system, the height of plant discriminated clones into two sub-sets. Firstly, accounted for clones CAL and TRU, was characterised by low height of plant (H). Secondly, composed of clone THA, was distinguished by high height of plant. Variation magnitude of the distribution of the measured variable spread out from 7.19 to 13.30% (Table 4).

Concerning the circumference of pseudostem (C), two classes were noted. First, composed of clone ZEB, was marked by small circumference of plant at 1 metre from the ground. Second, consisted of CAL, TRU, MIC and THA, was singular in strong circumference of plant at 1 metre from the ground. Coefficient of variation varied from 7.35 to 11.71% (Table 4).

For organ bunch, when we peer the weight of bunch (PR), two groups were recorded. First, constituted of clones CAL, ZEB, MIC and TRU, was marked by low weight of bunch. Second, composed of clone THA, was characterised by high weight of bunch. Coefficient of variation stretched out from 11.79 to 14.14% (Table 4).

Regarding the number of hand per bunch (NMR), two classes were identified. Firstly, composed of clone CAL, was marked by small number of hand per bunch. Secondly, consisted of clone MIC, was marked by strong number of hand per bunch. Variation magnitude of the distribution of the measured variable stretched out from 7.19 to 13.30% (Table 4).

As far as the number of fruit per bunch (NFR) is concerned, two sub-sets was identified. First, constituted of clones ZEB, TRU, CAL and THA, was characterised by low number of fruit per bunch. Second, consisting of clone MIC, was marked by strong number of fruit per bunch. Coefficient of variation fluctuated from 4.42 to 13.77% (Table 4).

Concerning the number of fruit per hand (NFM), three classes was noted. First, constituted of clones ZEB and TRU, was marked by low number of fruit per hand. Second, constituted of clones CAL and THA, was distinguished by average number of fruit per hand. Third, consisting of MIC, was charaterised by strong number of fruit per hand. Coefficient of variation fluctuated from 6.61 to 8.72% (Table 4).

As for organ fruit, the length of fruit (LF) allowed the discriminating of clones into four groups. Firstly, composed of clone ZEB, was marked by very weak length of fruit. Secondly, consisting of clone CAL, was singular in weak length of fruit. Thirdly, constituted of clone TRU, was characterised by average length of fruit. Fourthly, composed of clone THA, was marked by important length of fruit. Coefficient of variation oscillated from 2.35 to 5.37%.

Concerning the circumference of fruit (CF), two classes were observed. First, consisting of clones MIC and ZEB, was marked by low circumference of fruit. Second, composed of clones TRU and THA, was singular in high circumference of fruit. Magnitude of variation stretched out from 1.26 to 6.63% (Table 4).

Regarding organ seed, for the number of seeds per fruit (NGF), discriminated clones into four sub-sets. First, constituted of clone ZEB, was characterised by very low number of seeds per fruit. Second, composed of clone CAL, was characterised weak number of seeds per fruit. Third, composed of clone TRU, was characterised by average number of seeds per fruit. Fourth, consisting of clone THA, was marked by important number of seeds per fruit. Coefficient of variation oscillated from 2.35 to 5.37% (Table 4).

In the same way, always taken separately, regarding species *M. balbisiana*, considering the vegetative system, the height of plant (H) discriminated clones into two sub-sets. Clone HON expressed low height of plant whereas clone CAM shown high height of plant. However, the circumference of pseudostem was not able to discriminate the two clones. Magnitude of variation of the measured variable was 9.08 and 17.42% (Table 5).

Considering organ bunch, the weight of bunch (PR), the number of hand per bunch (NMR) and the number of fruit per bunch (NFR) allowed the discriminating of two clones into two homogeneous sub-sets. First, composed of clone CAM, was characterised by low value of the mean each of variables while second constituting of clone HON, was marked by high value of the mean of each of considered variables. However, for the circumference of fruit (CF), no significant difference was recorded between means of clones CAM and HON. Variability around of each of means varied from 3.02 to 5.05% (Table 5).

For organ fruit, the length of fruit (LF) discriminated clones into two distinct groups. First, composed of clone CAM, was marked by low length of fruit. Second, consisting of clone HON, was singular in high length of fruit. In contrast, the number of fruit per hand (NFM), only one homogeneous group was recorded. Coefficient of variation stretched out from 4.80 to 5.05% (Table 5).

Regarding organ seed, the number of seeds per fruit (NGF), no statistical difference was noted between the means of two clones. Coefficient of variation spread out from 12.52 to 14.92% (Table 5).

Table 3: Classification of seven clones both especies *M. acuminata* and *M. balbisiana* as a function of the interval flower-cut.

Organ	Dependent variable	Clone*	Mean*	CV (%)
Bunch	IFC	ZEB	120.200a	8.03
		THA	123.600a	3.27
		CAL	124.200a	5.44
		HON	126.400a	5.18
		MIC	128.600a	2.78
		TRU	130.200a	4.11
		CAM	135.600a	12.21

Variable*.
Clone *: vegetative copy obtained from root suckers. **Mean*:** It was counted in days. Source : authors of this article.

Table 4 : Classification of clones CAL, TRU, ZEB, MIC and THA of the only species *M. acuminata* as a function of nine variables .

Organ*	Dependent variable*	Clone	Mean	CV (%)	Dependent variable	Clone	Mean	CV (%)
Vegetative system	H (cm)	CAL	245.000a	13.30	C (cm)	ZEB	33.800a	10.12
		TRU	268.000a	10.44		CAL	39.400b	11.71
		ZEB	284.000ab	7.19		TRU	39.800b	8.41
		MIC	290.000ab	9.36		MIC	41.400b	8.47
		THA	318.000b	7.91		THA	43.000b	7.35
	Dependent variable	**Clone**	**Mean**	**CV (%)**	**Dependent variable**	**Clone**	**Mean**	**CV (%)**
Bunch	PR (kg)	CAL	5.000a	14.14	NMR	CAL	8.400a	10.65
		ZEB	5.000a	14.14		THA	9.200ab	9.095
		MIC	6.000a	11.79		TRU	9.400ab	5.83
		TRU	6.000a	11.79		ZEB	9.400ab	9.515
		THA	8.000b	8.84		MIC	10.400b	12.90
	Dependent variable	**Clone**	**Mean**	**CV (%)**	**Dependent variable**	**Clone**	**Mean**	**CV (%)**
	NFR	ZEB	128.600a	13.00	NFM	ZEB	13.663a	8.72
		TRU	133.200a	4.42		TRU	14.216a	7.00
		CAL	141.600a	13.77		CAL	16.856b	8.12
		THA	160.000a	8.05		THA	17.456b	8.16
		MIC	237.600b	11.83		MIC	22.915c	6.61
	Dependent variable*	**Clone**	**Mean**	**CV(%)**	**Dependent variable***	**Clone**	**Mean**	**CV(%)**
Fruit	LF	ZEB	8.600a	2.35	CF	MIC	6.400a	6.63
		CAL	10.000b	5.37		ZEB	6.400a	1.26
		MIC	10.400bc	5.16		CAL	7.600ab	5.58
		TRU	11.400c	4.71		TRU	7.600b	5.58
		THA	12.800d	4.19		THA	8.100b	5.24
	Dependent variable*	**Clone**	**Mean**	**CV(%)**				
Seed	NGF	ZEB	33.792a	10.71				
		CAL	47.875b	9.09				
		MIC	56.417bc	4.83				
		TRU	61.542c	8.33				
		THA	106.167d	12.56				

Dependent variable*: There are the nine variables measured during the experiment. Means associated with the same letter in column are not statistically different according to Newman-Keuls test at 5% likelihood. Source : authors of this article.

Table 5: Classification of two clones of species *M. balbisiana* as a function of the nine other measured variables.

Organ*	Dependent variable*	Clone	Mean*	CV (%)	Dependent variable*	Dependent variable*	Mean	CV (%)
Vegetative system	H	HON	430a	17.42	C	CAM	70a	3.00
		CAM	532b	9.08		HON	71a	9.08
Bunch	**Dependent variable***	**Clone**	**Mean**	**CV (%)**	**Dependent variable***	**Dependent variable***	**Mean**	**CV (%)**
	PR	CAM	17.4a	5.62	NMR	CAM	12.6a	10.44
		HON	30.8b	9.86		HON	16.8b	15.81
	Dependent variable*	**Clone**	**Moyenne**	**CV (%)**	**Dependent variable***	**Variable**	**Mean**	**CV (%)**
	NFR	CAM	230.8a	12.04	NFM	CAM	18,411a	5,58
		HON	284.6b	7.76		HON	17,043a	9,96
Fruits	**Dependent variable**	**Clone**	**Mean**	**CV(%)**	**Dependent variable**	**Clone**	**Mean**	**CV(%)**
	LF	CAM	11.400a	4.80	CF	CAM	14.000a	5.05
		HON	12.400b	4.42	CF	HON	14.800a	3.02
Seed	**Dependent variable**	**Clone**	**Mean**	**CV(%)**				
	NGF	CAM	203.333a	14.92				
		HON	263.625a	12.52				

Organ*: There **v**egetative system, bunch, fruit and seed. **Dependent variable*:** There are the nine variables measured during the experiment. **Means:** Those associated with the same letter in column are not statistically different according to Student's parametric method at 5% probability. Source : authors of this article.

2. Intraclonally cross-pollinated seeds number variation obtained from both hand on bunch and fruit on hand of especies *M. acuminata* and *M. balbisiana*

Before analysing the treatments associating the position of the hand on bunch and that of fruit on hand, their interations were assessed. Thus, interactions Clone x Hand position (p-value = 0.261), Clone x Fruit position (p-value = 0.068) and Clone x Hand position (p-value = 0.126), Clone x Fruit position (p-value = 0.240), for each species *M. acuminata* and *M. balbisiana*, respectively, were not significant.

With respect to species *M. acuminata*, the number of seeds obtained from of the position of hand on bunch (NGPM), three sub-sets were recorded. Firstly, composed of the proximal hand of clone ZEB (ZEB_ MP), was marked of low seeds from proximal hand. Secondly, accounted for distal and proximal hands of clones MIC and TRU (MIC_MD and TRU_MP), respectively, was characterised by average and high, respectively, number of seeds obtained from of the position of hand on bunch. Thirdly, accounted for distal, medium and proximal hands of clone THA (THA_MD, THA_MM and THA_MP), respectively, was characterised by high number of seeds obtained from of the position of hand on bunch. Variation coefficient varied from 2.87 to 10.45% (Table 6).

Regarding, the number of seeds obtained from the position of fruit on hand (NGPF), seven clusters were observed. The first one, constituted of the seeds from of external fruits of clone CAL (CAL_FE), was characterised by very very weak number of seeds obtained from the position of fruit on hand. The second one, accounted for the seeds from of fruits of clones ZEB both the external and internal positions (ZEB_FE and ZEB_FI), respectively, was singular in very weak number of seeds obtained from the position of fruit on hand. The third one, consisting of the seeds from of fruits of clone MIC in the external position (MIC_FE), was marked by number averagely weak of the number of seeds obtained from the position of fruit on hand. The fourth one, composed of the seeds from of fruits of clone MIC in the internal position (MIC_FI), was marked by averagely high number of the number of seeds obtained from the position of fruit on hand. The fifth one, constituted of the seeds from of fruits of clone CAL in the internal position (CAL_FI), was characterised by high number of the number of seeds obtained from the position of fruit on hand. The sixth one, consisting of the seeds from of fruits of clone THA in the internal position (THA_FI), was marked by very high number of the number of seeds obtained from the position of fruit on hand. The seventh one, constituted of the seeds from of fruits of clone THA in the external position (THA_FE), was singular in very very high number of the number of seeds obtained from the position of fruit on hand. Variability fluctuated from 2.63 to 6.28% (Table 6).

Regarding species *M. balbisiana*, the number of seeds from of the position of hand on bunch (NGPM), fouth groups were noted. The first one, constituted of seeds from the proximal hand of clone CAM (CAM_MP), was characterised by very low number of seeds from proximal hand of bunch. The second one, composed of seeds from medium and proximal hands of clones HON and CAM, respectively, was marked by low number of seeds from of the position of hand on bunch. The third one, accounted for seeds from distal hands of clone CAM (CAM_MD), was marked by average number of seeds from of the position of hand on bunch. The fourth one, accounted for seeds from distal hands of clone HON (HON_MD), was singular in very high number of seeds from of the position of hand on bunch. Variation coefficient varied from 3.65 to 8.86% (Table 7).

Regarding, the number of seeds obtained from the position of fruit on hand (NGPF), no significant difference was noted. Coefficient of variation varied from 3.12 to 9.45% (Table 7).

Table 6: Classification of treatment associating clone of species *M. acuminata* and position of hand and fruit on bunch as a function of the number of seeds yielded.

Dependent variable*	Treatment*	Mean	CV (%)	Dependent variable*	Treatment*	Mean	CV (%)
NGPM	ZEB_ MP	27.125a	4.67	**NGPF**	CAL_FE	21.000a	2.89
	ZEB_MD	34.750ab	5.90		ZEB_FE	32.167b	4.87
	ZEB_MM	39.500abc	7.86		ZEB_FI	35.417b	5.82
	CAL_MD	44.625abc	10.45		MIC_FE	50.833c	4.44
	CAL_MM	48.250abc	6.58		TRU_FE	56.833cd	2.83
	CAL_MP	50.750abc	8.91		MIC_FI	62.000d	3.52
	MIC_MP	50.750abc	4.57		TRU_FI	66.250de	3.89
	MIC_MM	54.625bc	2.87		CAL_FI	74.750e	6.28
	TRU_MD	59.500bc	5.83		THA_FI	93.167f	3.94
	TRU_MM	60.000bc	6.85		THA_FE	119.167g	2.63
	MIC_MD	63.875c	8.82				
	TRU_MP	65.125c	7.39				
	THA_MD	96.750d	3.69				
	THA_MM	104.750d	5.38				
	THA_MP	117.000d	3.58				

NGPM *: number of seeds obtained from of the position of hand on bunch. **ZEB_ MP :** number of seeds obtained from proximal hand of clone Zébrina, ZEB_MD : number of seeds obtained from distal hand of clone Zébrina, ZEB_MM : number of seeds obtained from medium hand of clone Zébrina, **CAL_MD** : number of seeds obtained from distal hand of clone calcutta4, **CAL_MM** : number of seeds obtained from medium hand of clone calcutta4, **CAL_MP** : number of seeds obtained from proximal hand of clone calcutta4; **MIC_MP** : number of seeds obtained from proximal hand of clone microcarpa, **MIC_MM** : number of seeds obtained from medium hand of clone microcarpa, **MIC_MD**: number of seeds obtained from distal hand of clone microcarpa, **TRU_MD** : number of seeds obtained from distal hand of clone truncata, **TRU_MM** : number of seeds obtained from medium hand of clone truncate, **TRU_MP** : number of seeds obtained from proximal hand of clone truncate, **THA_MD** : number of seeds obtained from distal hand of clone THA 018, **THA_MM**: number of seeds obtained from medium hand of clone THA 018, **THA_MP**: number of seeds obtained from proximal hand of clone THA 018, **NGPF**: number of seeds obtained from the position of fruit on hand, **CAL_FE**: number of seeds from external fruits of clone calcutta4, **CAL_FI:** number of seeds from internal fruits of clone calcutta4, **ZEB_FE**: number of seeds from external fruits of clone zébrina, **ZEB_FI**: number of seeds from internal fruits of clone zébrina, **MIC_FE**: number of seeds from external fruits of clone microcarpa, **MIC_FI**: number of seeds from internal fruits of clone microcarpa, **TRU_FE**: number of seeds from external fruits of clone truncate, **TRU_FI**: number of seeds from internal fruits of clone truncata, **THA_FI**: number of seeds from internal fruits of clone THA 018, **THA_FE**: number of seeds from external fruits of clone THA 018. **Means**: associated with the same letter in column are not statistically different according to Newman-Keuls test at 5% likelihood. Source : authors of this article.

Table 6 : Classification of treatment associating clone of species *M. balbisiana* and position of hand and fruit on bunch as a function of the number of seeds yielded.

Dependent variable*	Treatment	Mean	CV(%)	Dependent variable*	Treatment	Mean	CV(%)
NGPM	CAM_MP	86.750a	6.67	**NGPF**	HON_FE	164.583a	3.12
	HON_MP	139.750b	8.68		HON_FI	167.333a	5.67
	CAM_MM	142.875b	8.86		CAM_FI	265.000a	5.89
	CAM_MD	363.000c	3.65		CAM_FE	337.000a	9.45
	HON_MM	415.375cd	6.78				
	HON_MD	426.625d	7.86				

NGPM *: number of seeds obtained from of the position of hand on bunch. **CAM_MP**: number of seeds obtained from proximal hand of clone cameroun. **HON_MP** : number of seeds obtained from proximal hand of clone Honduras. **CAM_MM** : number of seeds obtained from medium hand of clone Cameroon. **CAM_MD** : number of seeds obtained from distal hand of clone cameroun. **HON_MM** : number of seeds obtained from medium hand of clone Honduras. **HON_MD:** number of seeds obtained from distal hand of clone Honduras. **NGPF**: number of seeds obtained from the position of fruit on hand. **HON_FE**: number of seeds from external fruits of clone Honduras. **HON_FI** : number of seeds from internal fruit of clone Honduras. **CAM_FI** : number of seeds from internal fruit of clone Cameroon. **CAM_FE:** number of seeds from external fruits of clone Cameroon. **Means**: means associated with the same letter in column are not statistically different according to Newman-Keuls test at 5% likelihood.

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DISCUSSION

A study was conducted in the target to optimise the management of genetic banana resources. Seven wild banana accessions, from Njombé genebank, Cameroon, were cross-pollinated in the same clone to appreciate their abilities to yield seeds with a view to test subsequently their capability to germinate onto different substrates. Some authors such as Dessaux (1988) and Burgos-Hernández et *al*., (2014) worked on the yielding of seeds from somes banana accessions. The former worked on species *M. ornata*. Our work shown *M. balbisiana* is more productive in seeds than *M. acuminata*. In the same way, clone THA was the most productive in species *M. acuminata* while no significant difference was detected between the two clones HON and CAM in *M. balbisiana*. Likewise, distal, medium and proximal hands as well as internal and external fruits from clone THA were the most productive in *M. acuminata*. In species *M. balbisiana* it is the distal hand from HON that was the most productive in seeds.

Variation of the number of seeds in proximal, medium and distal positions of the hand as well as that of the number of seeds in internal and external position of fruit are independent of the variation clone and the fruit as well as that of the hand position. The lack of the significance of interaction authorised us to analyse the hand effects. Unlike Issali (2011) who analysed and shown the influence of interaction between staminodes and petals cultured onto the same medium in the Petri dish, our present work was not able to demonstrate that. This allowed us to classify the treatments Clone x Hand position and Clone x Fruit position for each of species.

Regarding the vegetative system, *M. balbisiana* expressed more important growth of the height and circumference of plant (H and C) than *M. acuminata*. Indeed, at the phenotypic level, *M. balbisiana* is more vigourous than *M. acuminata*. Our results are similar to those from Champion (1963) and Jenuwein (1988). Nevertheless, such important growth disadvantages them when they ared exposed to gust of wind and when they must to be hybridised. It was the same for the weight of bunch (PR), number of hand per bunch (NMR), number of fruits yielded per bunch (NFR), number of fruit per hand (NFM), length of fruit in centimetre (LF), circumference of fruit in centimetre (CF) and number of seeds per fruit (NGF) from bunch, fruit and seed, respectively, except for the (IFC; Table 2). The number of seeds per fruit (NGF) from *M. balbisiana* is, nonetheless, an advantage when it is necessary to manage through conservation at laboratory more great quantity of seeds than *M. acuminata.*

Regarding *M. acuminata*, relatively to vegetative system, clone THA as well as CAL, TRU, MIC and THA shown an important development of the height and circumference of plant (H and C), respectively (Table 4). However, Clone CAM from *M. balbisiana* expressed the highest height of plant (Table 5). Even if the two clones, namely THA and CAM have the higest values, numerically, those from clone CAM are higher. Champion (1967) and Jenuwein (1988) displayed wild cultivated bananas express an average height from 2 to 5 m as well as circumference ranging from 20 to 65 cm. Consequently, the latter is more exposed to gust of wind and difficulties of hybridisations. The height of clone THA is compatible with hybridisation work. This one can avoid it the falling by windfalls.

Clone THA and and HON from *M. acuminata* and *M. balbisiana,* respectively, shown the highest values of the weight of bunch (PR). This can find an explanation through the number of hand per bunch (NMR) and number of fruits yielded per bunch (NFR) which are the highest in each species. Nonetheless, clone HON from *M. balbisiana* shows higher value of the above cited variables (Tables 4 and 5). Our results for *M. acuminata* varied from 5 to 8 Kg as against 17.4 to 30.8 Kg for *M. balbisiana*. They are similar to those from Lassoudière (2010) who shown the weight of bunch of a *M. acuminata* fluctuates from 4 to 8 Kg as against 17 to 43 Kg for *M. balbisiana*. Our number of the hand per bunch (NMR) spread out from 8.4 to 10.4 in *M. acuminata* as against 12.6 to 16.8 for *M. balbisiana*. Such high value of the weight of bunch can trigger the falling of plant. Our results differ in from Burgos-Hernández et *al*., (2014) who revealed that in fertile diploid, the number of hand is about 6 as against 8 to 10 for us. Such high value of the weight of buch triggers the falling of plant. In the same way, the bunch revealed that clone THA expressed the highest weight of bunch whereas clone MIC shown high value of the number of hands per bunch (NMR), number of fruits yielded per bunch (NFR) and number of fruits per hand (NFM). Our results are beyond those from Burgos-Hernández et *al*., (2014). The latter revealed in fertile diploid, the number of hand is about 6 as against 8 to 10 for us. Concerning the number of hand per bunch (NMR) and number of fruits yielded per bunch (NFR), clone MIC yields more hands, consequently the number of fruits per hand is high as well as the number of fruits per bunch is also high.

Clone THA and HON from *M. acuminata* and *M. balbisiana*, respectively, displayed the highest values of the length of fruit (LF; Tables 4 and 5). Nevertheless, values from clone HON were comparable to those from THA (12.4 cm as against 12.8 cm; Tables 4 and 5). Our obtained results are beyond those from Vineesh et *al*., (2013) who shown by working on *M. acuminata* subsp. *burmannica* that the average length and diameter of fruits varied from 7.41 to 2.47 cm. If we should select of the future parents, clones THA and TRU should be part of that. The same clone THA yields many seeds (Table 4).

The three positions of hands from the bunch of clone THA from *M. acuminata* shown comparable potential to that of the distal position of HON from *M. balbisiana* in relation to the number of seeds obtained from of the position of hand on bunch (NGPM). It oscillated from 96.750 to 117.000 of clone THA from *M. acuminata*, whereas that of clone HON was 426.625 seeds per distal hand. The yielding of seeds is dependent genotype and dependent position, in clone HON from *M. balbisiana*. Nevetheless, in some clones, the hands have the same potential of seeds yielding. For example clone THA from *M. acuminata*. The abundance of seeds in *M. balbisiana* is caused by the existence of two ranks of ovaries level in axillary placentation while in *M. acuminata*, ovaries are laid out on only one rank (Escalant, 1987). Consequently, when we consider the yielding of seeds, for clone THA, we should not be afraid of low yielding of selfings, by reason of the lack of the influence of the hand position on the expression of yielding in self-pollinated seeds. However, for others such as clone HON, we must focuse only on the distal hand. When it will be decide to use them in hybridisation programme, back crosses will be necessary to eliminate the ability to yield seeds for the consumption need.

CONCLUSION

In conformity of the formulated hypothesis, which postulated that the variation in the yielding of seeds, in banana clones, is due to the hand position from bunch, our works shown that this one is, in general, dependent genotype for 7 clones tested, nevertheless, hand position for some of them exert great influence on the seeds yielding.

Clones x hand position and clone x fruit position did not interact. They were classified in the form of treatment.

Some variables such as the circumference and height of plant, weight of bunches (PR), number of hands per bunch (NMR), number of fruits yielded per bunch (NFR), number of fruits per hand (NFM), length of fruit in centimetre (LF), circumference of fruit in centimetre (CF), number of seeds per fruit (NGF) discriminated *M. acuminata* and *M. balbisiana*. In each of species, for clones from *M. acuminata*, the same above cited variables also discriminated while clones from *M. balbisiana*, only the height of plant (H), weight of bunch (PR), number of hand per bunch (NMR), number of fruits yielded per bunch (NFR), length of fruit in centimetre (LF) discriminated them. Clone THA from *M. acuminata* and clone HON from *M. balbisiana* are good candidates for conservation of wild banana in the form of seeds at laboratory. Nonetheless, clones from *M. acuminata,* are the best for hybridisation relatively to their low size.

In general, the yielding of seeds in clones from *M. acuminata* and *M. balbisiana*, tested here, is dependent genotype. For some of them such as clone THA, the hand position does not exert an influence on the expression of the yielding of seed. Nonetheless, some clones such as HON from *M. balbisiana* yields more seeds from the distal hand.

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REFERENCES

Burgos-Hernández M., Castillo-Campos G., Mata-Rosas M., González D., Vovides A.P. and Murguía-González, J. (2014). Seed germination of the wild banana Musa ornata Musaceae Seed Sci. & Technol., 42, 16-27, http://doi.org/10.15258/sst.2014.42.1.02

Champion, J. 1967. Les bananiers et leur culture. Tome 1. Botanique et génétique des bananiers (Paris : SETCO Edts).

Cheesman, E.E. 1947. a. Classification of the bananas. III Critical notes on species. b. M. acuminata Colla. Kew Bulletin 2. b. Classification of the bananas. III Critical notes on species. a. M. balbisiana. Kew Bulletin 2.

Cheesman, E.E. 1947. b. Classification of the bananas. III Critical notes on species. a. M. balbisiana. Kew Bulletin 2.

De Langhe, E. and Devreux, M. 1960. Une clone nouvelle de Musa acuminata Colla. Bull. Jard. Bot. Brux. 30 (3) 375-388.

De Langhe E., 1961. La taxonomie du plantain en Afrique équatoriale. J. Agric. Trop. Bot. Appl. 8 : 10-11.

Dessaux D., 1988. Etude des facteurs de la stérilité des bananiers (Musa sp.) et des relations citotaxinomiques entre Musa acuminata COLLA et Musa balbisiana COLLA, s.I. Fruits, 43 (10), pp 539-557 ; (11) pp 615-638 ; (12) pp 685-700.

Escalant J.-V. 1987 : Les bananiers diploïdes en culture in vitro (M. acuminita et M. balbisiana) : Etude du comportement et recherche de variabilité. Thèse de doctorat à l'Université des sciences et techniques du Languedoc, Academie de Montpellier, France, p.21.

Guyot M. 1992. Systématique des angiospermes : référence à la flore du Togo. Edition financée par la Mission Française de Coopération et d'Action Culturelle de Lomé. Diffusion auprès de la bibliothèque de l'Université du Benin, Togo, p 172-173.

Issali A. E., Abdoulaye Traoré, Adiko Amoncho, Mpika J., Allou Kouassi, Konan J. L., Kohi Ngoran J. A. and Abdourahamane Sangaré, 2011. Staminodes and petals interaction in co-culture and growth of somatic embryo-derived plantlets of Theobroma cacao L., in the greenhouse. Journal of Applied Bioscience (from India). 37 (1): 1-8.

Jenuwein H. 1988. Avocado, Banana, Coffee. How to Grow Useful Exotic Plants for Fun. 126 pp.

Lassoudière, A., 2010. L'histoire du bananier (Versailles : Quae).

Perrier, X., Bakry, F., Carreel, F., Jenny, C., Horry, J.P., Lebot, V. and Hippolyte, I. 2009. Combining biological approaches to shed light on the evolution of edible bananas. Ethnobotany Research and Applications 7, 199-216.

Simmonds, N.W. 1966. Bananas. 2nd ed. Tropical Agriculture Series (London: Longmans).

Vineesh, P. S., Skaria, R., Mukunthakumar, S., Padmesh, P. and Decruse, S. W. 2015. Seed germination and cryostorage of Musa acuminata subsp. burmannica from Western Ghats. South African Journal of Botany 100: 158-163.

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