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Short Communication

Correlation and principal component analyses in plantain (*Musa* spp., AAB group) somaclonal variants

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Banana and plantain (*Musa* spp.) are important staple food crops in Sub-Saharan Africa and contribute substantially to the incomes of smallholders who grow the crops in backyards or home gardens [1]. The impact of black Sigatoka (*Mycosphaerella fijiensis* Morelet), a leaf spot disease has been recognized as a limitation to *Musa* production, resulting to yield losses of between 20 to 90% [2]. Breeding for resistant cultivars has been credited as the most appropriate control measure. However, *Musa* improvement through conventional breeding approaches is difficult due to low seed fertility and narrow genetic base. The application of biotechnological methods have facilitated the breeding process and somaclonal variants resulting thereof have shown tolerant to black Sigatoka disease and higher yield [3]. In breeding, crop yield is a complex trait whose expression depends on the interplay of other related traits that can be best explained by appropriate biometrical tools. Correlation reveals the different traits that contribute to crop yield [4] while principal component analysis is used to show diversity in germplasms [5]. In this study, we have used these tools to explain the traits that contribute to yield and characterize plantain somaclonal variants.

Approximately 500 somaclones from both 'Agbagba' (False Horn plantain) and 'Bise Egome' (French plantain) were evaluated for black Sigatoka disease response and yield characteristics under field conditions at the Onne Campus, Rivers State University of Science and Technology, Port Harcourt, Nigeria in 1996. For each cultivar, off-type and true-to-type cultivars were subjected to micropropagation, whereby meristems were excised and initiated into axenic culture, following standard shoot-tip culture procedures [6]. All cultures were maintained at 27-32^{o}C with a 14-hour photoperiod provided by 40-W cool-white fluorescent tubes. The *in vitro* seedlings were transplanted into potted soil and hardened under nursery conditions for 2-3 months before field establishment. Observations were made from February 1997 to December 1998 covering the first and second ratoon crop cycles. The development of black Sigatoka symptoms was monitored every 2-3 days on each newly emerging and tightly rolled leaf known as the 'cigar leaf'. Data were collected on leaf emergence time (LET), youngest leaf spotted (YLS), disease development time (DDT) and lifetime of leaf (LTL). LET is the average number of days between the emergence of two consecutive leaves. YLS is the ordinal position of the youngest leaf bearing necrotic spots with dry centres. Leaves were numbered from the first topmost leaf downward. DDT is the time elapsed between 'cigar stage' and the appearance of necrotic spots with dry centers. LTL was recorded as the number of days between 'cigar stage' and leaf death either due to normal senescence or complete infection (100% of the leaf area is spotted) by the black Sigatoka disease. Data were also collected on phenology and yield traits: days for fruit filling, which is the duration (days) between the date of flowering and the date of harvesting, plant height at flowering (cm), height of tallest sucker at harvest (cm), number of suckers, bunch weight (kg), number of hands and fingers per bunch. Fruit weight (g), length (cm) and girth (cm) were also measured, taking the top middle finger of each hand as a reference. Data were analyzed using PROC CORR (Procedure Correlation) and PROC PRINCOMP (Procedure Principal Component) [7].

The result on correlation (Table 1) shows that Bunch Weight (BW) is positively correlated with LET (r = 0.61), YLS (r = 0.86), DDT (r = 0.12) and Number of Figures (NF) (r = 0.73), but negatively correlated with LTL (r = –0.27) and DFF (r = –0.13). This means that somaclones with higher YLS values produced

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heavier bunches and more number of fingers due to increased photosynthetic activities resulting from less necrotic spots on the leaves. Also, LTL was strongly correlated with DDT (r = 0.78), but negatively correlated with YLS (–0.2). Thus, slower disease development increased the longevity of the leaves, thereby reducing the formation of necrotic spots with dry center. Similarly, YLS was positively correlated with LET (r = 0.54), which implies that faster the rate of leaf production, the higher YLS value with older leaves bearing necrotic spots. Finger girth (FG) was positively correlated with DFF (r = 0.66), Number of Hands (NH) (r = 0.83) and Average Finger Length (AFL) (r = 0.45). Thus in all the somaclones, number of fingers per bunch, higher YLS and longer DDT contributed significantly to heavy bunch weight. The relatively low correlation coefficients observed suggested that little difference exists among somaclones for specific traits (Table 1).

Principal component analysis (PCA) restructured the original data set (Table 1) into six major components, with the first three accounting for 67% of the total variation (Table 2). PCA coefficients are functions of the eigenvalues and eigenvectors of the variance/covariance matrix. Eigenvalues measure the

Table 1. Correlation analysis of some disease, phenology and yield traits in *Musa* (AAB) somaclones at Onne, southeast Nigeria, 1997-98

	YLS	DDT	LTL	DFF	HTSh	BW	NH	NF	AFL	AFW	AFG	PHf	NSf
LET	0.54***	0.32**	0.07	–0.15*	–0.18**	0.61**	–0.03	0.35**	–0.04	–0.06	–0.01	–0.04	–0.03
YLS		–0.07	–0.2***	–0.2**	–0.17**	0.86***	0.01	0.56**	–0.04	–0.09	0.01	0.16**	0.09
DDT			0.78***	–0.02	–0.05	0.12*	0.06	0.01	–0.1	0.06	0.03	0.05	–0.01
LTL				0.08	0.04	–0.27***	–0.02	–0.27***	–0.07	0.26***	–0.03	0.15**	0.11*
DFF					–0.34***	–0.13*	0.29***	–0.05	0.26***	–0.24***	0.66***	–0.37***	–0.1
HTSh						–0.1	–0.15	–0.19***	–0.05	0.28***	–0.22***	0.29***	0.19**
BW							0.05	0.33***	–0.02	–0.02	–0.03	0.19	0.002
NH								0.73***	0.35**	–0.34***	0.83***	–0.56***	–0.18**
NF									0.05	–0.34***	–0.02	0.05	–0.14
AFL										–0.17**	–0.14	0.07	–0.14
AFW											0.45***	–0.63***	0.20***
AFG												–0.4***	–0.17**
PHf													0.30**
NSf													

LET: Leaf emergence time; YLS: Youngest leaf spotted; DDT: Disease development time; LTL: Lifetime of leaf; DFF: Days to fruit filling; PHf; Plant height at flowering; HTSh: Height of tallest sucker at harvest; NSf: Number of suckers at flowering; BW: Bunch weight; NH: Number of hands; NF: Number of fingers; AFL: Average finger weight; AFG: Average finger girth. *,**,***Significant at P = 0.05, 0.01 and 0.001, respectively.

Table 2. Principal component analysis of some disease, phenology and yield traits in *Musa* (AAB) somaclones at Onne, southeast Nigeria, 1997-98

Trait	PRIN 1	PRIN 2	PRIN 3	PRIN 4	PRIN 5	PRIN 6
Loading[y]						
Leaf emergence time	–0.155	0.033	0.165	–0.318	0.214	**–0.752**
Youngest leaf spotted	0.369	–0.162	0.264	0.038	–0.096	**0.506**
Disease development time	0.220	0.144	**0.815**	–0.273	–0.140	–0.154
Lifetime of leaf	0.291	0.244	**0.760**	–0.488	–0.018	–0.001
Days to fruit filling	**–0.784**	0.087	0.270	–0.509	0.105	0.212
Plant height at flowering	0.438	0.187	0.111	0.201	**0.584**	0.053
Height of tallest sucker at harvest	**0.473**	–0.019	–0.262	–0.153	0.002	0.221
Number of suckers at flowering	–0.141	0.198	0.055	0.186	**0.643**	0.095
Bunch weight	0.295	**–0.537**	0.423	0.438	0.055	–0.022
Number of hands	**–0.586**	–0.054	0.321	0.062	–0.247	0.292
Number of fingers	0.392	**–0.552**	0.345	0.503	–0.114	–0.162
Average finger length	0.365	**0.631**	0.145	0.428	–0.383	–0.157
Average finger weight	0.352	**0.828**	–0.080	0.297	–0.030	–0.022
Average finger girth	0.436	**0.715**	–0.034	0.423	–0.215	–0.080
Eigenvalues	4.750	2.960	2.470	2.050	1.720	1.240
Percentage variation explained	31.300	19.500	16.300	13.500	11.300	8.100
Cumulative variance	21.600	35.000	46.300	55.600	63.400	69.700

[y]Significant contributors to the total variation in bold

variance accounted for by a given component and are useful for determining the number of significant factors. The sum of the eigenvalues will equal the number of original values, with each principal component accounting for a progressively smaller percentage of the remaining variance [8]. PRIN 1 has an eigenvalue of 4.8 and represents two phenological traits (days to fruit filling and height of tallest sucker at harvest), in addition to number of hands. PRIN 2 has an eigenvalue of 3.0 and explains 19.5% of the total variation (Table 2). PRIN 2 was loaded on yield traits, including bunch weight, number of fingers, average finger length, weight and girth. Disease development time and lifetime of leaf contributed to PRIN 3. Thus, growth and bunch traits especially average finger weight contributed more to PRIN 1 and PRIN 2 and were responsible for the variations among somaclones. Thus, the conventional morphological taxonomy of plantain based on plant stature [9] can also be applied to the somaclones Swannen *et al.*, [5] used these traits together with inflorescence type (number of neutral flowers and persistence of male bud) to classify plantains in West and Central Africa.

In conclusion, correlation and principal component analyses gave a better understanding of trait association among somaclones. Correlation coefficients were low, showing little variation among somaclones for specific traits. Principal component analysis as explained by relative percentage variation confirms that somaclonal variation is narrow and mimics naturally occurring variation.

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