Journal of Applied Biosciences (2008), Vol. 8 (1): 280 – 287.
ISSN 1997 – 5902: www.biosciences.elewa.org

Changes in leaf lamina shape and size during banana shoot development

Blomme G[1]*, Turyagyenda LF[1], Soka G[1] and R Swennen[2]

[1]International Network for the Improvement of Banana and Plantain (INIBAP); P.O.Box 24384, Kampala, Uganda; and f.turyagyenda@inibap.co.ug; [2] Laboratory of Tropical Crop Improvement, Katholieke Universiteit Leuven (K.U.Leuven), Kasteelpark Arenberg 13, 3001 Leuven, Belgium, rony.swennen@biw.kuleuven.be

* Corresponding author email: G.Blomme@CGIAR.org

ABSTRACT

Objectives: To assess changes in leaf lamina shape during the growth of lateral shoots and to determine how fast suckers from different genotypes develop broad leaves that are capable of photosynthesis, and thus reduce dependency on the parent for nutrients.

Methodology and results: Assessments of the size of leaf lamina of peeper, sword sucker, maiden sucker and water sucker leaves of *Musa* spp. were carried out on cultivars Gros Michel (dessert - *Musa* AAA group) and 'Gonja' plants (plantain - *Musa* AAB group) in Rwanda and on the plantain cultivars Agbagba and Mimi Abue, and the dessert banana 'Kparanta' [*Musa* AAB group in Nigeria. The rate of change in leaf length:width ratio during progressive leaf emissions were assessed on 16 *Musa* genotypes at the NARO banana farm at Kawanda in Uganda. Leaves of water suckers of all genotypes had significantly wider lamina compared to leaves of sword suckers of the same length. Leaf width of peepers and sword suckers did not exceed 20 cm in most cases and there was a gradual change from sword or lanceolate type of leaves to a broader leaf lamina type. The leaf length:width ratio decreased with an increase in height of the leaf petioles' insertion point on the pseudostem. All genotypes obtained an RL50 before leaf seven except for 'Pisang lilin', 'Bogoya' and 'Fougamou' suggesting that sucker independence from the mother plant may be delayed in these three genotypes.

Conclusion and application of findings: The progressive leaf lamina broadening of the youngest leaves indicates increased independence of the suckers from the mother plant. Water suckers, which are loosely or not attached to the mother plant and hardly rely on the mother plant for nutrition, develop broad leaves even at the height of large peepers or small sword suckers. Maiden suckers are less dependent on the mother plant suggesting that lateral shoots become less dependent on the mother plants as they increase in size and develop broader leaves.

Key words: lateral shoot independence, maiden sucker, peeper, sword sucker, water sucker

Citation: Blomme G, Turyagyenda LF, Soka G, and R Swennen, 2008. Changes in leaf lamina shape and size during banana shoot development. *Journal of Applied Biosciences* 8 (1): 280 – 287.

INTRODUCTION

Bananas and plantains are grown perennially and they produce consecutive generations from suckers (i.e. lateral shoots) that develop from the main plant. The first cycle after planting is called the plant crop while the sucker succeeding the harvested plant is the ratoon. The second cycle is called the first ratoon crop while the third cycle is the second ratoon crop (Swennen & Ortiz, 1997).

Sucker development consists of distinct physiological stages: peeper (small sucker appearing just above the ground and bearing scale leaves only), sword sucker (large sucker with lanceolate type leaves), and maiden sucker (large non-fruiting sucker with foliage leaves) (Simmonds, 1966; Swennen & Wilson, 1983; Swennen, 1984; Swennen & Ortiz, 1997).

Growth of vigorous suckers reduces the cycle duration (Swennen *et al*., 1984; Ortiz & Vuylsteke, 1994) and results in higher yields (Swennen & De Langhe, 1985). Thus a larger sucker at flowering and harvest of the mother plant is desirable because it will guarantee a fast succession of harvests and thus increase the yield on a time basis.

However, sucker growth depends on the level of inhibition exerted by the mother plant. Genotypes with inhibited sucker growth have peepers and/or a few sword suckers at flowering of the plant crop and hence, succession of harvests is slow. In contrast, genotypes with a non-regulated suckering have a large number of maiden suckers at flowering of the plant crop. This will however enhance competition between the developing suckers and the bunch of the mother plant. The most ideal would be regulated suckering behaviour consisting of one to three suckers which develop freely while other suckers remain inhibited (Vuylsteke *et al*., 1993). Hence, a fast succession is guaranteed and excessive competition between suckers is avoided.

Dessert bananas (*Musa* AAA group) most often have well-developed suckers at maturity of the plant crop and hence the first ratoon cycle is shorter than the plant crop cycle (Barker & Steward, 1962; Robinson & Nel, 1990). In contrast, a large number of plantain (*Musa* AAB group) genotypes have inhibited suckering which is caused by the strong apical dominance exerted by the main plant (Braide & Wilson, 1980; Swennen & Wilson, 1983; Swennen *et al*., 1984). This apical dominance is controlled by plant growth regulators *i.e.* auxins that are produced by the apical meristem of the main plant, which inhibits the growth of lateral buds (De Langhe *et al*., 1983). Hence, suckers of most plantain genotypes remain small until late after flower initiation of the plant crop. Suckers that are inhibited in their growth will mainly have scale or lanceolate type of leaves.

Peepers, sword suckers and maiden suckers represent a distinct physiological stage in sucker growth with distinct morphological features, the most important being the leaf lamina size. The objective of this study was to assess changes in leaf lamina shape during the growth of lateral shoots and to determine how fast suckers from different genotypes develop broad leaves to manufacture their own food through photosynthesis, and thus reduce their dependence on the parent for nutrients.

MATERIALS AND METHODS

Assessments of leaf lamina sizes of large numbers of peeper, sword sucker and maiden sucker leaves of the dessert banana 'Gros Michel' and the plantain 'Gonja' were carried out on plants growing at the ISAR on-station *Musa* collection at Rubona, Rwanda, and on the plantains 'Agbagba' and 'Mimi Abue', and the dessert banana 'Kparanta' at the IITA research station, at Onne in Nigeria (Table 1). The IITA High Rainfall station at Onne in southeastern Nigeria (4°42' N, 7°10' E, 5 m asl), represents a humid forest ecological zone. The soil is derived from coastal sediments and is a deep and freely drained Typic Paleudult/ Haplic Acrisol (FAO/ISRIC/ISSS, 1998). This soil belongs to the coarse-loamy, siliceous isohyperthermic family. The average annual rainfall is 2,400 mm distributed monomodally from February to November. The average daily solar radiation at Onne is 12.6 MJ m^{-2}. The national banana germplasm collection at Rubona, Rwanda is a field collection maintained at 1,723 masl at 2°29'14.6S latitude and 29°46'20.6E longitude. The average annual rainfall is 1,120 mm. The minimum annual temperature is 14°C, while the maximum temperature is 25 °C. The soil is considered as ultisol with pH 5.5 and is mulched by Tripsacum species two times a year during the dry season (May–August) and (December–January). The accessions are planted in eight plant plots. The distance between plants in the same row and between the rows was 3 m. The leaf size assessment of individual suckers/shoots in Nigeria continued until the pre-flowering stage. Leaves of water suckers, which have the same shape as maiden sucker leaves were also measured for all genotypes. Leaf lamina length and leaf lamina width were measured for each assessed leaf. The leaf length was taken as the length from the leaf petiole to the tip of the leaf while the lamina width was taken at the widest part of the leaf. Leaf length and leaf widest width were plotted for each genotype.

In addition, changes in leaf shape of 16 cultivars grown at the NARO, Kawanda Research Station in Uganda were studied (Table 1). The Kawanda Agricultural Research Institute is located at 32°32'E and 0°25'N at an elevation of 1,177 masl. The climate is moist, sub humid, with a mean annual rainfall of 1,132 mm which is bi-modally distributed. The main wet season begins in April while the short rains begin in September. The soils are classified as Eutric Ferralsols (Yost & Estwaran, 1990). They are reddish–brown loams 25 cm deep, overlying uniform red clay. Leaf size (lamina length and widest width) was assessed on a single lateral shoot until the 20th leaf. The height of the leaf petiole's insertion point on the pseudostem (PH, cm) was also measured for each leaf. Leaf length:width ratio's (L:W) were calculated and the RL25, RL50 and RL75 was determined. RL25 corresponds with a 25% reduction in the L:W ratio, while RL75 corresponds with a 75% reduction in L:W ratio.

RESULTS AND DISCUSSION

Leaf width of peepers and sword suckers did not exceed 20 cm in most cases. There was a gradual change from sword or lanceolate type leaves to a broader leaf lamina type (Plate 1). The broadening of leaf lamina results in increased ability of the lateral shoots to manufacture their own assimilates by photosynthesis, thus reducing their dependence on the mother plant.

Leaves of water suckers had significantly wider lamina compared to leaves of sword suckers of similar length (Figures 1-2). Water suckers have a loose connection to the mother plant and therefore do not fully rely on the mother plant for the necessary photosynthetic products. They therefore tend to develop broad leaves at an early stage compared to peepers or sword suckers which are closely linked to the mother plant and obtain a greater proportion of photosynthetic assimilates from the mother plant.

Table 1: Location of assessment, name, grouping and suckering behaviour of the assessed Musa genotypes.

Location of assessment	Common name	Genome group	Local use	Suckering behaviour
Rwanda - ISAR *Musa* Collection	Gros Michel	AAA	Dessert	Regulated
Rwanda - ISAR *Musa* Collection	Gonja	AAB	Plantain	Inhibited
Nigeria - IITA Onne research station	Agbagba	AAB	Plantain	Inhibited
Nigeria - IITA Onne research station	Mimi Abue	AAB	Plantain	Regulated
Nigeria - IITA Onne research station	Kparanta	AAB-Pome subgroup	Dessert	Regulated
Uganda - NARO Kawanda *Musa* Collection	Gros Michel	AAA	Dessert	Regulated
Uganda - NARO Kawanda *Musa* Collection	Calcutta 4	AA	Wild Banana - *Musa acuminata* ssp. *burmannica*	Non-regulated
Uganda - NARO Kawanda *Musa* Collection	Enzirabahima	AAA-EAHB	Cooking	Regulated
Uganda - NARO Kawanda *Musa* Collection	FHIA1	AAAB - hybrid	Multiple use	Regulated
Uganda - NARO Kawanda *Musa* Collection	FHIA3	AABB - hybrid	Multiple use	Regulated
Uganda - NARO Kawanda *Musa* Collection	FHIA17	AAAA - hybrid	Multiple use	Regulated
Uganda - NARO Kawanda *Musa* Collection	Fougamou	ABB	Cooking/Beer	Regulated
Uganda - NARO Kawanda *Musa* Collection	Gonja	AAB	Plantain	Inhibited
Uganda - NARO Kawanda *Musa* Collection	KM5	AAA	Dessert	Non-regulated
Uganda - NARO Kawanda *Musa* Collection	Muracho	AAB	Starchy banana	Regulated
Uganda - NARO Kawanda *Musa* Collection	*Musa* balbisiana	BB	Wild Banana	Regulated
Uganda - NARO Kawanda *Musa* Collection	Nfuuka	AAA-EAHB	Cooking	Regulated
Uganda - NARO Kawanda *Musa* Collection	Pisang Lilin	AA	Wild Banana	Non-regulated
Uganda - NARO Kawanda *Musa* Collection	Prata	AAB	Beer	Regulated
Uganda - NARO Kawanda *Musa* Collection	Robusta	AAA	Dessert	Regulated
Uganda - NARO Kawanda *Musa* Collection	Saba	ABB	Cooking/Beer	Regulated

Source: Daniells et al., 2001; Nsabimana & Staden, 2005; Pillay et al., 2006; Swennen, 1990; Swennen et al., 1995.

Table 2: Leaf length: width (L: W) ratio for leaves 1 and 20, and the RL25, RL50 and RL75 for 16 genotypes assessed at Kawanda, Uganda.

Cultivar	L:W ratio at leaf 1	RL25	RL50	RL75	L:W ratio at leaf 20
Calcutta 4	8.30	(2) 6.23	(5) 4.00	(10) 2.08	3.23
Pisang lilin	10.00	(10) 7.50	(12) 4.09	(X)* 2.50	3.79
Musa balbisiana	10.00	(2) 7.50	(3) 5.00	(6) 2.50	2.68
Enzirabahima	18.75	(5)14.06	(6) 9.33	(7) 4.69	2.58
Nfuuka	25.00	(3)18.75	(5) 9.33	(6) 6.25	2.74
Muracho	6.00	(3) 4.50	(5) 2.67	(X) 1.50	3.23
Gonja	7.00	(1) 5.25	(7) 3.17	(X) 1.75	2.11
Prata	16.00	(3)12.00	(5) 4.57	(10) 4.00	2.56
Robusta	15.00	(1)11.25	(4) 7.00	(6) 3.75	2.57
Gros Michel	8.00	(8) 6.00	(10) 3.50	(X) 2.00	2.83
KM5	18.00	(2)13.50	(3) 4.73	(7) 4.50	3.17
Fougamou	4.00	(4) 3.00	(10) 2.00	(X) 1.00	2.34
Saba	5.00	(2) 3.75	(4) 2.50	(X) 1.25	2.79
FHIA1	26.00	(2) 19.50	(4) 8.67	(11) 6.50	2.44
FHIA17	20.00	(2) 15.00	(3) 10.00	(11) 5.00	2.17
FHIA3	18.75	(2) 14.06	(3) 9.38	(7) 4.69	2.79

*The RL75 was not reached within the first 20 leaves. Figures in brackets are leaf numbers.

In this study leaf shapes of maiden suckers were not different from the leaves of water suckers suggesting that maiden suckers are also less dependent on the mother plant. These findings suggest that lateral shoots become less dependent on mother plants for assimilates as leaves broaden. Maiden suckers are mature lateral shoots and are believed to depend less on the mother plant while sword suckers largely depend on the mother plants as their leaves are too narrow to sufficiently feed them. Peepers with lanceolate leaves with no lamina depend entirely on the mother plant.

Results from the experiment carried out in Uganda indicate that the leaf length:width (L:W) ratio is strongly affected by the leaf width (Figure 3). The ratio sharply decreases with an increase in leaf width. In addition, leaf width increases with an increase in height of the leaf petioles' insertion point on the pseudostem (Figure 4). Since the height of leaf insertion increases with the age of the shoot, the leaf length to width ratio decreases with age.

All the genotypes obtained an RL50 before the 7th leaf except for cultivars 'Pisang lilin', 'Bogoya' and 'Fougamou' (Table 2). These three genotypes also never obtained a RL75 even at the 20th leaf when the assessed lateral shoots had a height of at least 170 cm. This suggest that lateral shoots of 'Pisang lilin', 'Bogoya' and 'Fougamou' take longer to develop broad lamina type leaves and hence independence from the mother plant may be delayed. '*Musa balbisiana*', 'Km5', 'FHIA3' and 'FHIA17' attained RL50 by leaf 3 (Table 2) suggesting that lateral shoots of these genotypes become less dependent on the mother plant at an earlier age.

The observed leaf shapes of sword sucker leaves, maiden sucker leaves, mature plant leaves and water sucker leaves were similar across environments and genotypes. However, the speed at which leaves of a lateral shoot changed from lanceolate type leaves to broader type leaves differed according to genotype.

ACKNOWLEDGEMENTS: Financial support by the Flemish Office for International Co-operation and Technical Assistance (VVOB) and the Belgian Directorate General for Development Cooperation (DGDC) is gratefully acknowledged. We would also like to acknowledge ISAR, IITA and NARO at whose research stations the data was collected.

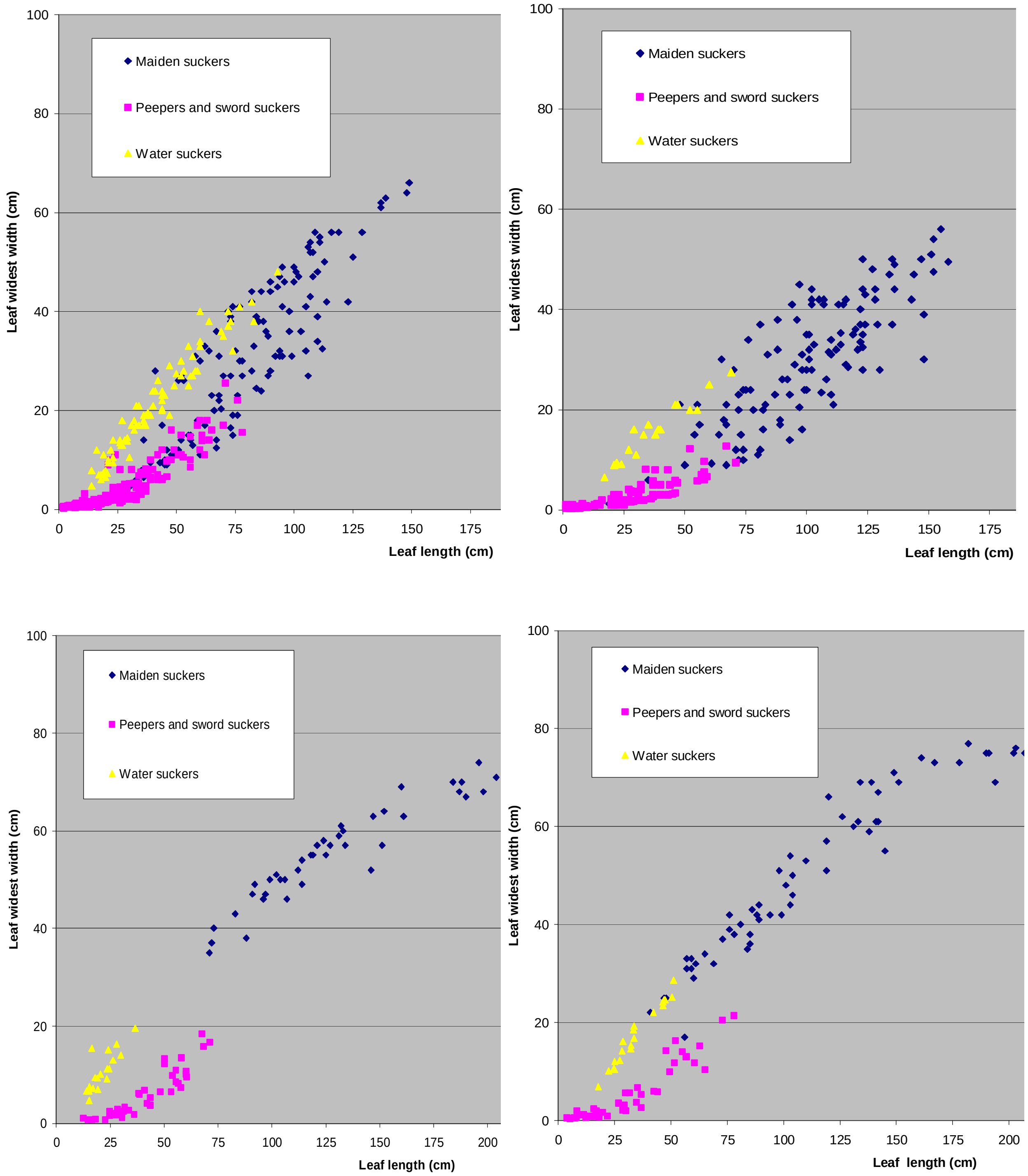

Figure 1: Relationship between leaf lamina length and leaf lamina widest width for peepers, sword suckers, maiden suckers and water suckers. Figures are from top left moving clockwise (A) plantain 'Gonja'; (B) dessert banana 'Gros Michel'; (C) plantain 'Mimi Abue'.; (D) plantain 'Agbagba'.

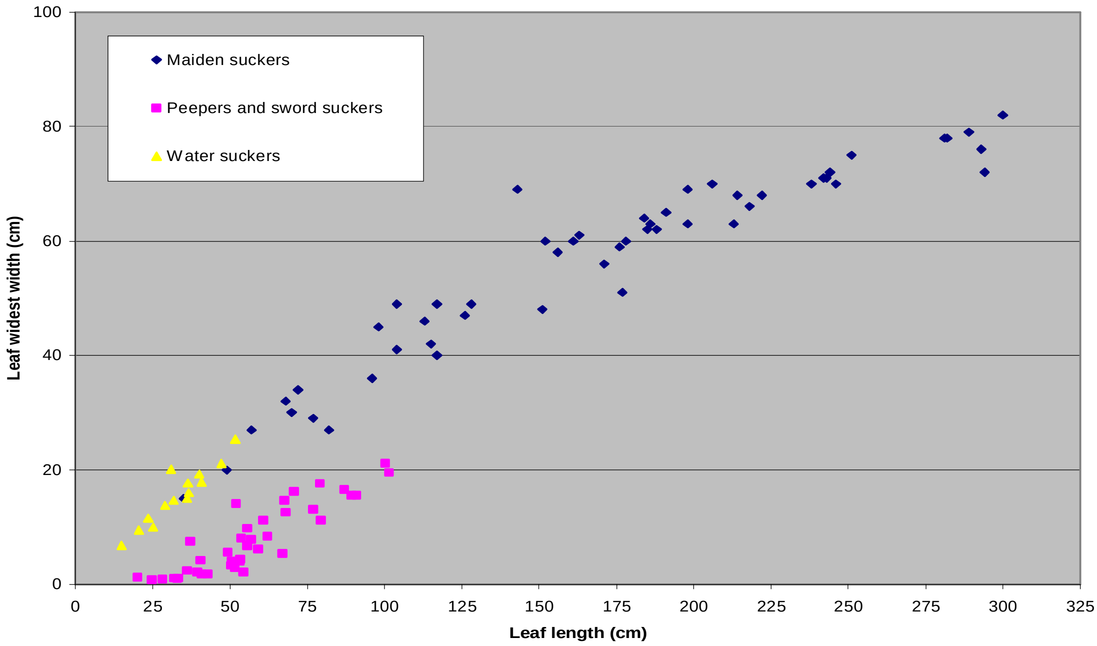

Figure 2: Relationship between leaf lamina length and leaf lamina widest width for peepers, sword suckers, maiden suckers and water suckers of the dessert banana 'Kparanta'.

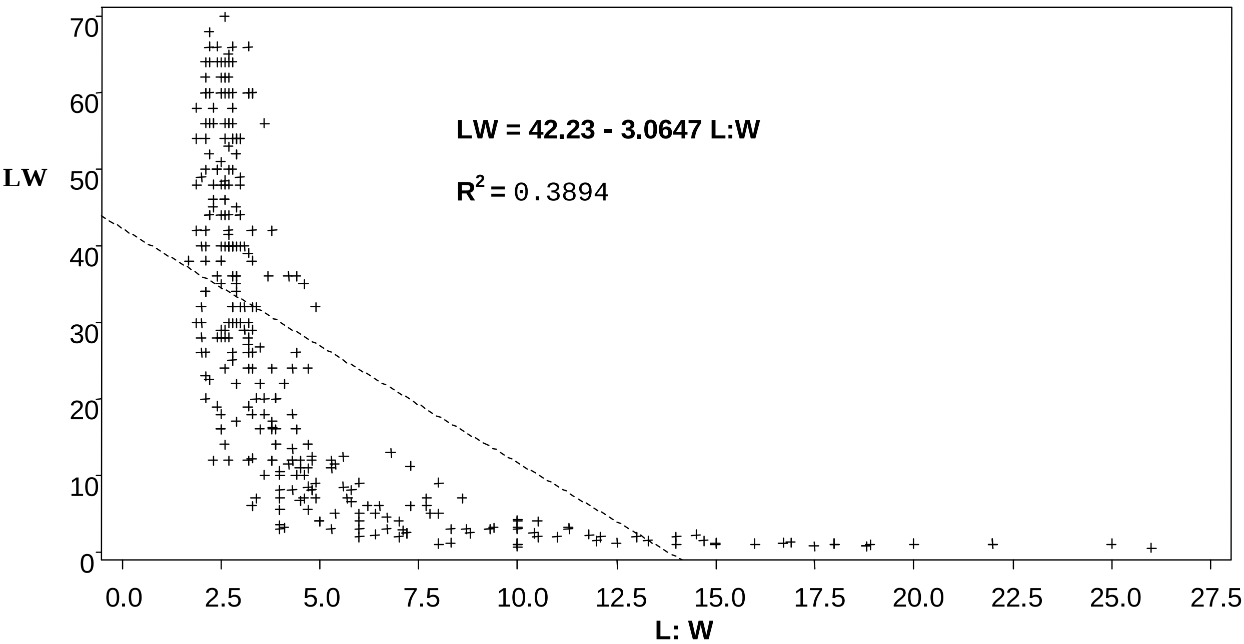

Figure 3: The relationship between leaf width (LW, cm) and the leaf length:width ratio (L:W) for 16 genotypes grown at Kawanda, Uganda.

Plate 1: Leaves taken from a maiden sucker of the dessert banana 'Gros Michel': gradual change from the older sword or lanceolate type leaves to the newly formed broader lamina leaf type.

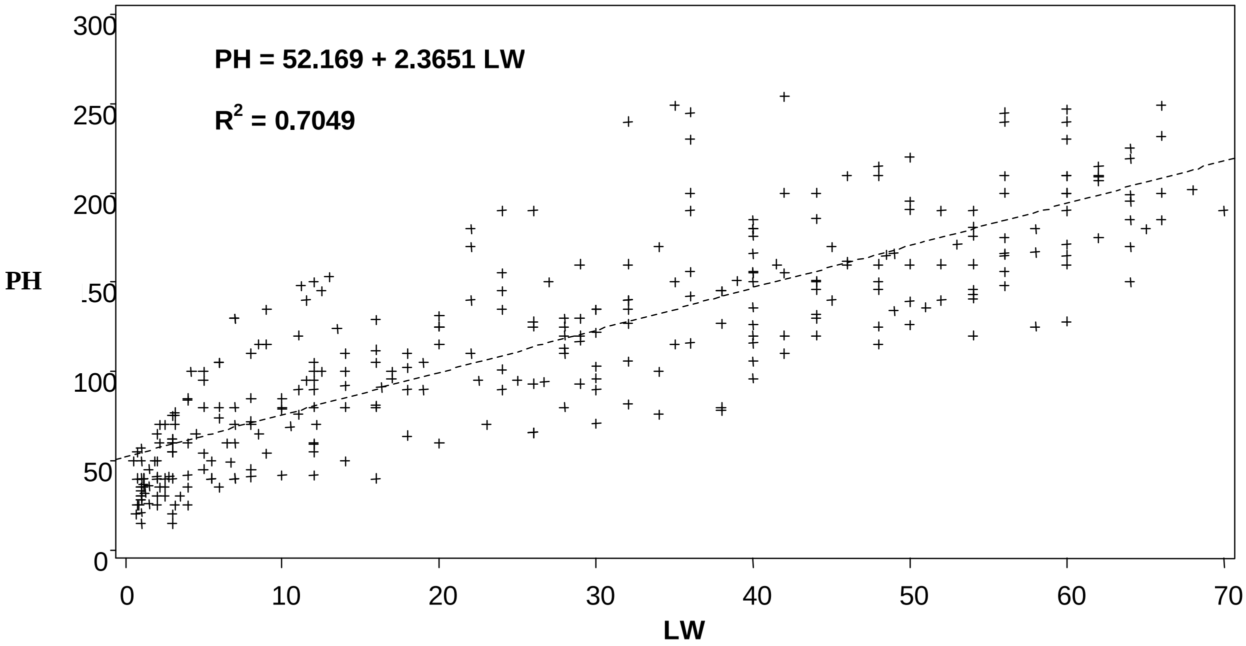

Figure 4: The relationship between the height of the leaf petiole's insertion point on the pseudostem (PH, cm) and leaf width (LW, cm) for 16 genotypes grown at Kawanda, Uganda.

REFERENCES

Barker W. and Steward F, 1962. Growth and development of the banana plant. II. The transition from the vegetative to the floral shoot in *Musa acuminata* cv. Gros Michel. Ann. Bot. 26: 413-423.

Braide J. and Wilson G, 1980. Plantain decline: a look at possible causes. Paradisiaca 4: 3-7.

Daniells J, Jenny C, Karamura D, and Tomekpe K, 2001. *Musa*logue: a catalogue of *Musa* germplasm. Diversity in the genus *Musa* (E. Arnaud and S. Sharrock, compil.). International Network for the Improvement of Banana and Plantain, Montpellier, France. pp. 213.

De Langhe E, Swennen R, Wilson G, 1983. Aspects hormonaux du rejetonnage des bananiers plantains. Fruits 38: 318-325.

FAO/ISRIC and ISSS, 1998. World Reference Base for Soil Resources. World Soil Resources Reports Nr. 84, FAO, Rome, Italy, 88 p.

Nsabimana A. and Staden J, 2005. Characterization of the banana germplasm collection from Rubona, Rwanda. Scientia Horticulturae 107: 58–63.

Ortiz R. and Vuylsteke D, 1994. Genetics of apical dominance in plantain (*Musa* spp., AAB Group) and improvement of suckering behavior. J. Amer. Soc. Hort. Sci. 119(5): 1050-1053.

Pillay M, Ogundiwin E, Tenkouano A, and Dolezel J, 2006. Ploidy and genome composition of *Musa* germplasm at the International Institute of Tropical Agriculture (IITA). *African Journal of Biotechnology*. 5(13): 1224-1232.

Robinson JC. and Nel DJ, 1990. Competitive inhibition of yield potential in a 'Williams' banana plantation due to excessive sucker growth. Sci. Hortic. 43: 225-236.

Simmonds NW, 1966. Bananas. 2nd ed. Longman, London and New York.

Swennen R. and De Langhe E, 1985. Growth parameters of yield of plantain (*Musa* cv. AAB). Annals of Botany 56:197-204.

Swennen R, 1990. Limits of morphotaxonomy: names and synonyms of plantain in Africa and elsewhere. Jarret R. L. (ed.). The identification of genetic diversity in the genus *Musa*. Proceedings of an International Workshop. Los Baños, Philippines, 5-10 September 1988. INIBAP, Montpellier, France:172-210.

Swennen R, Vuylsteke D, Ortiz R, 1995. Phenotypic diversity and patterns of variation in West and Central African Plantains (*Musa* spp., AAB Group *Musa*ceae). Economic Botany 49 (3):320-327.

Swennen R, 1984. A physiological study of the suckering behavior in plantain (*Musa* cv. AAB). Ph. D. thesis, Dissertationes de Agricultura n°132, Faculty of Agriculture, Katholieke Universiteit Leuven, pp. 180.

Swennen R. and Wilson GF, 1983. La stimulation du développement du rejet baïonnette du bananier plantain (*Musa* spp. groupe AAB) par application de gibberelline (GA_3). Fruits 38: 261-265.

Swennen R. and Ortiz R, 1997. Morphology and growth of plantain and banana. IITA Research Guide 66 (first edition). Training Program , International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. pp. 32.

Swennen R, Wilson GF, De Langhe E, 1984. Preliminary investigation of the effects of gibberellic acid (GA_3) on sucker development in plantain (*Musa* cv. AAB) under field conditions. Tropical Agriculture (Trinidad) 61: 253-256.

Vuylsteke D, Swennen R, Ortiz R, 1993. Development and performance of Black Sigatoka-resistant tetraploid hybrids of plantain (*Musa* spp., AAB group). Euphytica 65:33-42.

Yost D. and Estwaran H, 1990. Major Land Resource Areas of Uganda. World Soil Resources, Soil Conservation Service, USDA, Washington D.C.