Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension
Volume 8 Number 3 September 2009 pp 151 - 161
ISSN 1119-7455

THE EFFECTS OF ORGANIC AND INORGANIC FERTILIZERS ON GROWTH, YIELD AND BLACK SIGATOKA DISEASE REACTION OF SOME PLANTAIN (*MUSA* SPP. AAB) GENOTYPES IN SOUTH-EASTERN NIGERIA.

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ABSTRACT

Three plantain hybrids ('29525', '30456-3', 'PITA 14') and a landrace genotype 'Agbagba' (as control) were field evaluated in response to organic and inorganic fertilizers at the International Institute of Tropical Agriculture, High Rainfall Station, Onne, Rivers State, Nigeria, for two cropping cycles. The experimental design was a 4 x 3 factorial in randomized complete block, replicated thrice. Growth, yield and black sigatoka disease parameters were measured during the two cropping (plant and ratoon crop) cycles of evaluation. The genotypes '29525' and 'PITA 14' produced significantly (P < 0.05) higher leaf area, number of standing leaves and index of non-spotted leaves; however, genotype '30456-3' retained more functional leaves at harvest while genotype '29525' produced heavier bunches/ha during the two cropping cycles. Poultry manure supported the best plant growth and yield parameters, especially index of non-spotted leaves, number of standing leaves at flowering and at harvest, leaf retention index and bunch yield/ha. There was a strong and positive relationship between the index of non-spotted leaves and bunch yield/ha. The newly developed hybrids ('29525' and '30456-3') were confirmed to be tolerant to black sigatoka disease with fertilizer application reducing the severity of the disease. Similarly, these two new hybrids had comparatively good agronomic traits that could warrant their recommendation for on-farm adaptive trial.

***Keywords**: Musa genotypes, Fertilizer, Black Sigatoka disease, Growth, Yield.*

INTRODUCTION

Plantain is one of the major staple foods for over 100 million people in sub-Saharan Africa (Englberger *et al*., 2006). FAO (2006) reported that the world production of plantains and bananas was about 100 million metric tonnes.

Black sigatoka disease, first described as black leaf streak in the Sigatoka Valley in Fiji in 1963 (Rhodes, 1964) is the most important constraint to plantain and banana production worldwide and endangers the food security of the resource-limited farmers (Craenen, 1998; Pasberg-Gauhl *et al*., 2000). This disease is caused by the ascomycete fungus, *Mycosphaerella fijiensis* Morelet. Mobambo *et al*. (1993) reported yield loss of 33 to 50% caused by black Siagtoka disease in West Africa. Plants are severely defoliated by the disease and a decrease in functional leaf area results in yield loss through a reduction of fruits per bunch and lower fruit weight (Mobambo *et al*., 1993). Black siagtoka disease also causes delayed flowering and harvest, and premature fruit ripening. The intensive use of fungicides is required in commercial plantain production but fungicides are very harmful to the environment in addition to the production costs and the appearance of fungicide-resistant strains of the pathogen. Hence, chemical control may not be feasible for increased production by resource-limited farmers. The utilization of resistant *Musa* cultivars is a more appropriate solution to control black sigatoka disease (Vuylsteke *et al*., 1993; Tomekpe *et al*., 1999). Since 1987, breeding was initiated by International Institute of Tropical Agriculture (IITA) to develop germplasm with durable black sigatoka resistance as well as develop plantain hybrids resistant to black sigatoka. 'PITA 14', '29525' and '30456-3' are some of the tetraploid hybrids developed by IITA. Whereas 'PITA 14' has undergone multilocational and on-farm adaptive trials (Baiyeri and Tenkouano, 2007) the genotypes '29525' and '30456-3'are newly selected materials which have not undergone such trials.

High soil fertility status is associated with lower black sigatoka disease severity on plantain (Mobambo *et al*., 1994). This is expressed by the plant through having a higher number of standing leaves and less leaf area with black sigatoka symptoms (Mobambo *et al*., 1994). Besides, an understanding of plant response pattern to soil fertility is an important agronomic index for sustainable production under regular cultivation culture especially in farmers' field.

Thus, this experiment was carried out to [i] evaluate the black sigatoka disease responses of the newly developed hybrids in comparison with the IITA adopted hybrid ('PITA 14') and the susceptible Nigerian landrace, 'Agbagba'; and [ii] determine the growth and yield responses of these genotypes to organic and inorganic fertilizers.

MATERIALS AND METHODS

The experiment was carried out in IITA, High rainfall station, Onne, Rivers State, Nigeria. The location is on latitude 04° 43´N, longitude 07° 01´E and 10 m altitude, the site is characterized by an ultisol derived from coastal sediments; soil has low pH of 5.3 and low cation exchange capacity. The area has a uni-modally distributed annual rainfall of about 2400 mm. The location is also associated with high relative humidity with average values ranging from 78% in February to 89% in July and September (Ortiz *et al.*, 1997). The physico-chemical properties of the soil of the study area and the poultry manure used for the study are as shown in Table 1.

The experiment was a 4 x 3 factorial arranged in a randomized complete block design with three replications. Four plantain genotypes comprising three tetraploid hybrids ('29525', '30456-3', 'PITA 14') and a triploid landrace, as control, ('Agbagba') constituted the first factor. The second factor comprised two fertilizer types and a control (poultry manure, inorganic fertilizer and no fertilizer). The plants were obtained through micro propagation at IITA and planted in a single-row plot of five plants replicated thrice per treatment combination. The planting density was 1667 plants/ha with a spacing of 3 m between rows and 2 m within row. These plants were screened under natural field condition. Urea (300 kg/ha nitrogen) and muriate of potash (550 kg/ha K_2O) applied in six-split doses were used as inorganic fertilizer as recommended by Swennen and De Langhe (1985) and 20 t/ha of poultry manure was used as organic fertilizer. Half dose of the poultry manure was applied at planting and the remaining applied as top dressing at six months after planting.

The planting holes measured 40 cm x 40 cm x 40 cm and each of the holes, before planting received 15g of Furadan 5G for the control of plantain weevil (*Cosmopolites sordidus*) and root-knot nematodes (Obiefuna,1984). One follower sucker, as ratoon plant was always maintained after flowering. De-suckering was repeated at every 4-6 weeks. Weeding was carried out using herbicide ('round-up') and slashing, when necessary. Pruning of dead leaves was done every 2-3 weeks. Other agronomic management done were carried out as recommended by Swennen (1990). Growth data were measured at three and six months after planting (MAP), and at flowering; data on yield and yield attributes were measured at harvest. The following parameters were recorded at 3 and 6 MAP – plant height, plant girth, number of standing leaves (fresh and erect leaves), total leaf area of the three topmost leaves (Obiefuna and Ndubuizu, 1979; Baiyeri and Tenkouano, 2008). At flowering, plant height, plant girth taken at 100 cm above the ground level, number of standing leaves, youngest leaf spotted with black sigatoka disease (the youngest leaf, counting from the top showing the first symptoms of black sigatoka disease), and height of tallest sucker were recorded. At harvest, the number of standing leaves, total weight of the standing leaves, bunch yield per hectare, number of fruit per bunch and the fruit weight were collected. From the primary parameters measured, the index of non-spotted leaf (INSL) and leaf retention index were calculated. The INSL was calculated as the ratio between youngest leaf spotted at flowering (YLSF) and the total number of standing leaves at flowering (NSLF) (Craenen, 1998).

$$INSL = ((YSLF-1)/NSLF) \times 100$$

The leaf retention index (LRI) was calculated as ratio between the number of standing (green) leaves at harvest (NSLH) and the total number of standing (green) leaves at flowering (Baiyeri *et al.*, 2008).

$$LRI = (NSLH/NSLF) \times 100$$

All the data collected were subjected to analysis of variance using GENSTAT (2003) and least significant difference (LSD) test at 5% probability level was used to compare the means. The Pearson's multiple correlation analyses using SPSS release 15.0 (SPSS, 2006) was used to assess correlations among some parameters.

RESULTS

The physicochemical properties of the experimental site and the nutritional quality of the poultry manure applied are shown in Table 1. The soil was sandy loam, acidic and relatively low in cations. The poultry manure was however, high in essential plant nutrients.

Analysis of variance (Table 2) showed that genotype significantly ($P < 0.05$) influenced most parameters, except youngest leaf spotted at flowering. Fertilizer type was significant for total leaf area, youngest leaf spotted at flowering, index of non-spotted leaves at flowering, number of standing leaves at harvest, total leaf weight, leaf retention index, bunch yield/ha and number of fruits/bunch. The genotype-by-fertilizer type interaction effect was significant for total leaf area, height of tallest sucker at flowering, number of standing leaves, total leaf weight, leaf retention index, bunch yield/ha and fruit weight but not for plant height and girth (Table 2).

Plant responses at vegetative growth and flowering stages:

Genotype effect: ‘PITA 14’ and ‘29525’ had better growth at 3 and 6 MAP (Table 3). ‘PITA 14’ had taller plants while ‘29525’ had better foliage parameters. These genotypes also had thicker pseudostems at both 3 and 6 MAP. The genotype ‘30456-3’ had the lowest of all the growth parameters (Table 3). Table 4 shows the host response to growth and black sigatoka disease at flowering of the plant and ratoon crops. In the plant crop, ‘Agbagba’ produced tallest plants and thickest plant girth while ‘PITA 14’ and ‘29525’ had similar but highest tolerance to sigatoka disease, as indicated by the index of non-spotted leaves and youngest leaf spotted at flowering. However, ‘30456-3’ produced tallest follower sucker. In the ratoon crop, ‘Agbagba’ and ‘PITA 14’ had similar but tallest plants. ‘PITA 14’ and ‘30456-3’ had similar but healthier leaves (high index of non-spotted leaves and youngest leaf spotted at flowering) whereas plant girth was similar and higher for all the genotypes except ‘30456-3’.

Table 1 Physicochemical properties of the experimental site and poultry manure sample utilized Fort he study

	Top soil (0-15 cm)	Sub-soil (15-30cm)	Poultry manure
Chemical properties			
Nitrogen (g/kg)	1.3	0.7	15.6
Phosphorus (mg/kg)	49.10	66.31	14.0
Potassium (g/kg)	1.4	1.5	17.9
Calcium (cmol/kg)	2.06	0.72	3.76
Magnesium(cmol/kg)	0.13	0.03	0.41
CEC (cmol/kg)	3.19	3.02	Nd
Zinc (mg/kg)	4.26	3.87	11.36
Copper (mg/kg)	0.72	1.08	Nd
Iron (mg/kg)	150.13	196.65	313.22
Physical properties			
pH (H_20)	5.30	4.73	Nd
Organic carbon (%)	1.37	0.90	Nd
Sand (%)	76.67	70.00	Nd
Silt (%)	8.00	6.67	Nd
Clay (%)	15.33	22.67	Nd
Textural class	Sandy loam		

nd= Not determined

Table 2: ANOVA showing sources of variation, degree of freedom and mean square for various parameters in the plant crop

Sources	Df	PHT (cm)	PG (cm)	TLA (m^2)	YLSF	INSLF (%)	HTSF (cm)	NSLH	TLWT (kg)	LRI (%)	BWT (t/ha)	NFB	FWT (g)
Replication	2	1607.60**	70.44**	0.10**	6.84**	45.27**	7066.60**	5.58**	3.76**	339.27**	16.90**	66.69**	1610.00**
Genotype (G)	3	11133.70***	183.09**	0.93**	3.30^{ns}	271.63***	3450.10*	7.27***	5.46***	525.52***	214.14***	30716.50***	39220.00**
Fertilizer type (F)	2	393.80^{ns}	7.60^{ns}	0.46**	21.55***	211.83**	1845.70^{ns}	7.48***	4.71***	554.37***	46.78*	670.59**	1443.00^{ns}
G x F	6	533.80^{ns}	14.54^{ns}	0.10**	2.22^{ns}	33.43^{ns}	4233.40**	3.42***	2.10**	349.41***	43.59*	194.45^{ns}	4414.00*
Error	22	332.20	27.01	0.03	1.85	22.95	994.10	0.48	0.39	49.40	10.75	90.01	1623.00
Total	35	-	-	-	-	-	-	-	-	-	-	-	

PHT= Plant height at flowering; PG= Plant girth at flowering (at 100 cm above the ground level); TLA= Total leaf area of the three topmost leaves at 6 MAP; YLSF= Youngest leaf spotted at flowering; INSL= Index of non-spotted leaves at flowering; HTSF= Height of tallest sucker at flowering; NSLH= Number of standing leaves at harvest; TLWT= Total leaf weight at harvest; LRI= Leaf retention index; BWT/ha= Bunch yield/ha; NFB= Number of fruits/bunch; FWT= Fruit weight; *, **, ***= Significant at 5%, 1% and 0.1% probability level respectively; ns= Non-significance.

Fertilizer type effect: The plant height, plant girth and height of tallest sucker at 3 MAP were significantly higher with the application of poultry manure than inorganic fertilizer or no fertilizer application (Table 3). At 6 MAP, application of either poultry manure or inorganic fertilizer produced taller plants and suckers as well as wider pseudostem than no fertilizer application. However, there was no significant difference between poultry manure and inorganic fertilizer application (Table 3). The number of standing leaves was similar in both 3 and 6 MAP. The application of organic (poultry) manure in the plant crop supported higher tolerance to black sigatoka disease than the inorganic fertilizer or no fertilizer application, as indicated by the index of non-spotted leaf and youngest leaf spotted (Table 4). Plant height and girth was highest for 'Agbagba' in the ratoon crop. All the other parameters were statistically similar among the fertilizer types.

Interaction effect: At 3 MAP, the application of poultry manure produced significantly ($P < 0.05$) bigger pseudostem in '29525' than the other treatment combinations. At 6 MAP, the photoactive leaf area was widest for '29525' when it received inorganic fertilizer (Table 5). The genotype, '30456-3,' produced significantly lower values for plant girth and leaf area irrespective of the fertilizer type. At flowering, the interaction only influenced the height of tallest sucker in the plant crop (Fig. 1). Tallest follower sucker was produced by '30456-3' in all the fertilized plots.

Plant responses at harvest:

Genotype effect: In the plant crop, the number of standing leaves and total leaf weight were higher for '30456-3' and 'Agbagba' than the other genotypes (Table 6). However, these parameters were similar among the genotypes in the ratoon crop. The leaf retention index was similar but significantly ($P < 0.05$) higher for '30456-3' and '29525' in the plant crop, though in the ratoon crop, '30456-3' significantly ($P < 0.05$) retained more leaves than the other genotypes. The genotype '29525' produced the heaviest bunch and highest number of fruits but Agbagba had heaviest fruits than the other genotypes in both the plant and ratoon crops (Table 6).

Fertilizer type effect: The application of fertilizer influenced the yield and black sigatoka disease parameters at harvest in the plant crop only (Table 6). In the plant crop, higher number of leaves, leaf weight, leaf retention index, number of fruits and heavier bunches were produced by the application of organic (poultry) manure. All the parameters measured were statistically similar in the ratoon crop (Table 6). However, it was notable that the application of poultry manure produced extra 4.2 and 3.7-t/ha fruit yield than the control (no fertilizer) and inorganic fertilizer treatments, respectively, in the ratoon cycle.

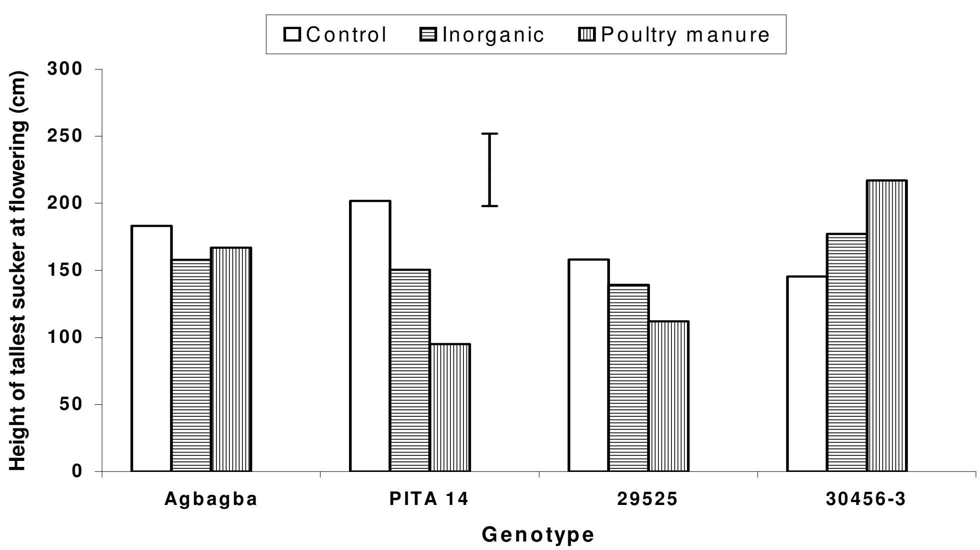

Fig. 1: Genotype and fertilizer type interaction effect on the height of tallest sucker at flowering of the plant crop. Vertical bar represents $LSD_{0.05}$

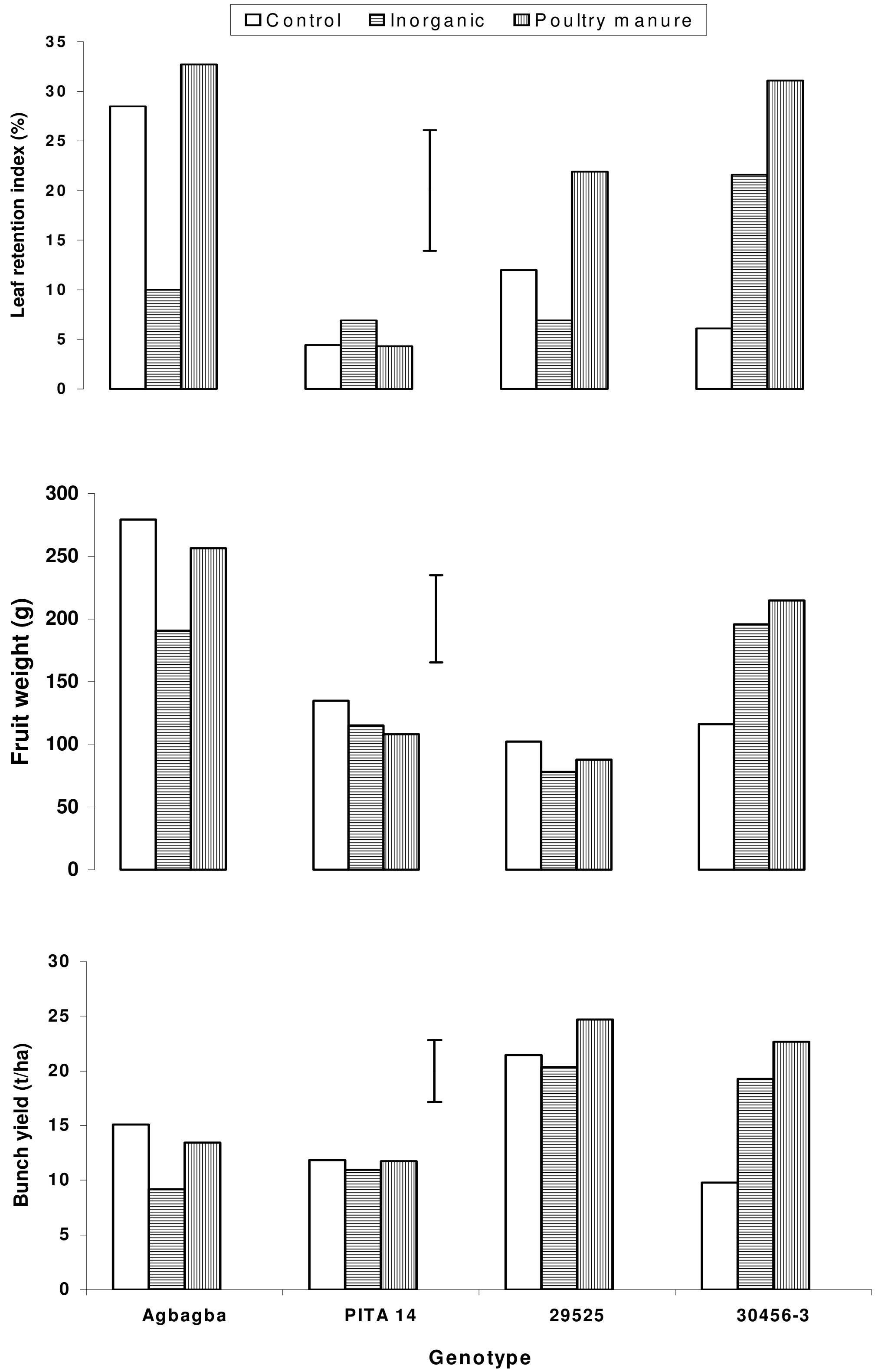

Fig. 2: Genotype and fertilizer type interaction effect on (a) leaf retention index (b) fruit weight (c) bunch yield. Vertical bars represent $LSD_{0.05}$

Interaction effect: The leaf retention index, fruit weight and bunch yield per hectare were influenced by the combined effects of fertilizer type and genotypes (Fig. 2). The landrace, 'Agbagba' had higher value for leaf retention index than the hybrids when it received organic fertilizer or no fertilizer. Similarly heavier fruit weight was associated with 'Agbagba' irrespective of the fertilizer type. Among the hybrids, leaf retention index and fruit weight increased with the application of fertilizer in '30456-3'. The values were greater when the plant received organic fertilizer. However, '29525' produced higher bunch yield per hectare than the other genotypes irrespective of the fertilizer type.

Effect of Cropping Cycle: The black sigatoka disease resistance/tolerance traits (index of non-spotted leaves, youngest leaf spotted and number of standing leaves at harvest) were higher in the plant crop than the ratoon crop (Table 7). However, plant height and girth (at flowering), bunch yield per hectare, number of fruits per bunch and fruit weight were higher in the ratoon crop than the plant crop. The height of tallest sucker at flowering, total leaf weight at harvest and leaf retention index were similar in the two cropping cycles (Table 7).

Correlation analysis of index of non-spotted leaves at flowering and some growth and yield parameters at harvest: In the plant crop, index of non-spotted leaves at flowering had positive and significant correlation with all the growth and yield parameters at harvest (Table 8). The yield parameters - bunch yield/ha, number of fruits/bunch and fruit weight had relatively higher relationship with the index of non-spotted leaves than the growth parameters. However, the bunch yield/ha (r = 0.756**) had stronger association with the index of non-spotted leaves than number of fruits (r = 0.560**) and fruit weight (r = 0.523**). In the ratoon crop, the bunch yield/ha and total leaf weight had positive and significant association with the index of non-spotted leaves. The fruit weight was negatively associated with the black sigatoka disease response parameter.

Table 3: Main effects of genotype and fertilizer type on growth at 3 and 6 MAP of the plant crop

	3 MAP				6 MAP			
	PHT (cm)	PG (cm)	NSL	TLA (m^2)	PHT (cm)	PG (cm)	NSL	TLA (m^2)
Genotype								
Agbagba	115.00	26.04	12.11	1.43	186.90	35.64	8.20	2.72
PITA 14	131.70	28.14	11.02	1.95	201.70	38.29	8.71	3.07
29525	117.90	28.82	10.62	2.22	190.40	39.99	9.36	3.99
30456-3	97.30	22.27	8.44	1.16	154.10	28.90	7.27	2.06
$LSD_{0.05}$	13.22	1.61	Ns	0.32	15.73	2.44	0.83	0.39
Fertilizer source								
Control	98.20	23.16	9.47	1.29	158.90	32.48	8.13	2.46
Inorganic	117.30	25.77	9.80	1.77	193.90	36.45	8.34	3.20
Organic	130.90	30.02	12.38	2.02	197.10	38.19	8.64	3.22
$LSD_{0.05}$	11.45	1.39	Ns	0.27	13.62	2.11	Ns	0.34

PHT= Plant height; PG= Plant girth at 50 cm (3MAP) and 100 cm (6MAP) above the ground level; NSL= Number of standing leaves;
TLA= Total leaf area of the three most photoactive leaves; ns= Non-significant; $LSD_{0.05}$= Least significant difference at 5% probability level.

Table 4: Main effects of genotype and fertilizer type on the growth and black sigatoka disease at flowering of the plant and ratoon crops.

	Plant crop					Ratoon crop				
	Plant height (cm)	Plant girth (cm)	INSL (%)	Youngest leaf spotted	Height of tallest sucker (cm)	Plant height (cm)	Plant girth (cm)	INSL (%)	Youngest leaf spotted	Height of tallest sucker (cm)
Genotype										
Agbagba	321.30	53.11	66.28	8.30	169.30	373.00	62.16	54.60	5.86	112.50
PITA 14	265.50	44.65	78.08	9.74	149.10	365.50	62.87	69.53	8.36	184.10
29525	236.70	45.79	77.74	9.15	136.50	315.90	63.19	61.71	7.05	177.00
30456-3	277.60	42.84	74.65	8.77	179.90	302.90	48.42	67.16	7.01	120.10
$LSD_{0.05}$	18.05	5.15	4.75	Ns	31.23	16.25	3.77	4.52	0.93	36.50
Fertilizer source										
Control	281.80	45.85	69.86	7.79	172.10	325.40	55.91	62.69	6.66	136.30
Inorganic	273.20	46.52	74.45	8.74	156.20	341.50	59.61	61.67	6.97	162.70
Organic	270.90	47.43	78.25	10.44	147.70	351.00	61.96	65.39	7.58	146.30
$LSD_{0.05}$	ns	ns	4.11	1.17	Ns	14.08	3.26	Ns	ns	ns

Table 5: Genotype and fertilizer type interaction effect on plantain growth at 3 and 6 MAP of the plant crop.

		3 MAP				6 MAP			
Fertilizer type	Genotype	PHT (cm)	PG (cm)	NSL	TLA (m^2)	PHT (cm)	PG (cm)	NSL	TLA (m^2)
Control	Agbagba	102.00	23.22	9.73	1.18	175.00	33.07	8.47	2.46
	PITA 14	121.00	25.87	10.93	1.71	181.00	36.82	8.80	2.85
	29525	91.70	23.57	9.47	1.45	153.30	34.91	8.47	2.99
	30456-3	78.00	19.98	7.73	0.82	126.30	25.14	6.80	1.55
Inorganic	Agbagba	110.00	25.12	9.60	1.33	189.00	35.60	8.00	2.73
	PITA 14	134.00	27.70	10.67	1.93	216.00	38.80	8.47	3.32
	29525	129.70	30.13	10.27	2.68	209.70	42.47	9.80	4.69
	30456-3	95.70	20.13	8.27	1.12	160.80	28.92	7.08	2.08
Organic	Agbagba	133.00	29.78	17.00	1.78	196.70	38.27	8.13	2.97
	PITA 14	140.00	30.85	11.47	2.22	208.00	39.27	8.87	3.04
	29525	132.30	32.75	11.73	2.52	208.30	42.60	9.80	4.31
	30456-3	118.30	26.70	9.33	1.55	175.20	32.63	7.92	2.57
$LSD_{0.05}$		Ns	2.79	ns	Ns	Ns	Ns	ns	0.68

INSL= Index of non-spotted leaves; ns= Non-significant; $LSD_{0.05}$= Least Significant Difference at 5% probability level.

Table 6: Main effects of genotype and fertilizer type on bunch yield and some other parameters at harvest of the plant and ratoon crops

	Plant crop						Ratoon crop					
	No. of standing leaves	Total wt of standing leaves (kg)	Leaf retention index (%)	No. of fruits/bunch	Fruit weight (g)	Bunch yield (t/ha)	No. of standing leaves	Total wt of standing leaves (kg)	Leaf retention index (%)	No. of fruits/ bunch	Fruit weight (g)	Bunch yield (t/ha)
Genotype												
Agbagba	2.72	1.78	12.57	26.60	239.00	12.57	1.27	1.08	14.10	26.80	312.60	15.15
PITA 14	0.63	0.29	11.52	62.50	119.30	11.52	0.86	1.00	7.60	108.00	173.60	28.10
29525	1.47	1.06	13.60	161.80	89.30	22.17	1.04	1.38	10.70	188.80	152.70	41.92
30456-3	2.14	1.99	19.60	59.40	175.50	17.24	2.14	2.29	25.80	71.20	186.20	22.54
$LSD_{0.05}$	0.63	0.21	7.02	9.48	40.26	3.28	Ns	Ns	9.46	8.15	27.80	4.81
Fertilizer source												
Control	1.22	0.70	12.70	69.80	155.70	14.54	1.16	1.04	15.50	96.60	198.90	25.38
Inorganic	1.36	1.18	11.30	78.20	144.80	14.94	1.04	1.18	10.10	98.40	196.70	25.87
Organic c	2.65	1.96	22.50	84.70	166.70	18.14	1.78	2.09	18.10	101.10	223.20	29.53
$LSD_{0.05}$	0.55	0.18	6.08	8.21	Ns	2.84	Ns	Ns	Ns	ns	ns	Ns

PHT= Plant height; PG= Plant girth at 50 cm (3MAP) and 100 cm (6MAP) above the ground level; NSL= Number of standing leaves; TLA= Total leaf area of the three most photoactive leaves; ns= Non-significant; $LSD_{0.05}$= Least significant difference at 5% probability level

.Table 7: Effect of cropping cycle on the growth parameters at flowering and yield parameters at harvest.

	At flowering					At harvest					
Cropping cycle	Plant height (cm)	Plant girth (cm)	INSL (%)	Youngest leaf spotted	Height of tallest sucker (cm)	Bunch yield (t/ha)	No. of fruits /bunch	Fruit weight (g)	No. of standing l eaves	Total wt of standing leaves (kg)	Leaf retention index (%)
Plant crop	275.20	46.58	74.17	9.03	157.90	9.44	76.8	155.90	1.79	1.32	14.79
Ratoon crop	339.30	59.16	63.25	7.07	148.40	16.14	98.6	206.30	1.33	1.44	14.57
$LSD_{0.05}$	2.83	0.75	0.77	0.19	Ns	1.20	4.28	15.88	0.45	Ns	ns

INSL= Index of non-spotted leaves; ns= Non-significant; $LSD_{0.05}$= Least Significant Difference at 5% probability level.

Table 8: Relationship between some growth and yield parameters at harvest and the index of non-spotted leaves at flowering in the plant and first ratoon crops

Parameter	Plant crop	Ratoon crop
Bunch yield (t/ha)	0.756**	0.341*
Number of fruits/bunch	0.560**	0.266^{ns}
Fruit weight	0.523**	-0.372*
Leaf retention index	0.426**	0.261^{ns}
Number of standing leaves	0.436**	0.323^{ns}
Total leaf weight	0.414**	0.369

*, **= Significant at 5% and 1% probability level, respectively

DISCUSSION

The host plant resistance to the black sigatoka disease of the hybrids, especially '29525' and 'PITA 14' compared to the control, 'Agbagba' at 3 MAP, 6 MAP and at flowering was confirmed in this study. This is evidenced by their higher number of standing leaves (functional leaves) and index of non-spotted leaves. Significant fertilization effect on the growth and black sigatoka disease response parameters at 3 MAP, 6 MAP and flowering could be associated with the release of nutrients (especially nitrogen which is needed for growth by all plants) by the inorganic and organic fertilizers applied. A similar observation had been made in maize (Ayoola and Adeniyan, 2006). Organic fertilizer generally had higher performance in terms of plant height and girth, number of standing leaves and index of non-spotted leaves than inorganic fertilizer. Hue and Silva (2000) found that poultry manure provides a large quantity of nitrogen during the first four to six weeks after application. It had also been observed that the addition of manure increased the soil water holding capacity thereby enhancing sustained release of nutrients to crops where manure had been added to the soil (Costa *et al.,* 1991). The height of tallest sucker was higher for '30456-3' than the other genotypes irrespective of the fertilizer type. As it was observed during the experiment, the other genotypes produce higher number of suckers per stool than '30456-3' (data not shown). Hence there might be greater competition for nutrient, light, moisture between the several numbers of suckers of the other genotypes than the few suckers produced by '30456-3'.

As expected, the higher the number of functional leaves at harvest the higher the conversion of photoassimilates for dry matter production. The number of standing leaves and leaf retention index were highest for '30456-3' yet it did not produce higher bunch yield per hectare. Genotype '29525' produced higher bunch yield per hectare. Obiefuna (1986) observed that rapidly growing banana fruits utilised nitrogen reserves for protein synthesis faster than they could be replenished resulting in reduced leaf longevity. Poultry manure retained higher number of leaves and had more total leaf weight and leaf retention index. These characteristics might have resulted in the higher bunch yield per hectare and heavier fruit weight as more photoassimilate should have been converted to dry matter. Leaf retention index increased with the application of fertilizer especially poultry manure. This means that leaf retention index is not only genotype specific but could be influenced by soil fertility dynamics. Mobambo *et al*. (1993) reported that organic nutrients from the disposal of household wastes might play a role in lowering black sigatoka severity on backyard plantains and bananas. Among the hybrids, the application of fertilizer to '30456-3' increased the leaf retention index and fruit weight. The values were greater when the plant received organic fertilizer.

The plant crops performed better in terms of index of non-spotted leaves at flowering, youngest leaf spotted at flowering and number of standing leaves at harvest. Oluma *et al.* (2004) observed that the severity of black sigatoka disease increased with age. Also the ratoon crops had their productive cycle in the same field with the plant crop hence, the virulent *Mycosphaerella fijiensis* must have been multiplied during the development of the ratoon crop which should have resulted in higher percentage of leaves (index of non-spotted leaves at flowering) with the fungal spores. However, plant height and girth (at flowering), bunch yield per hectare, number of fruits per bunch and fruit weight were higher in the ratoon crop than the plant crop. The ratoon crop benefited from the organic matter turnover of the plant crop in addition to the fertilizers received. This explains why the ratoon crop produced higher bunch yield, number of fruits per bunch and average fruit weight. Obiefuna (1990) observed the same result while working with a false horn plantain (*Musa* AAB cv Agbagba); Baiyeri and Tenkouano (2007) also reported similar result with ten *Musa* genotypes grown for two cropping cycles in south-eastern Nigeria.

Foliage traits and black sigatoka disease resistance status of plants at flowering were found to be strong and positively associated with bunch weight in high yielding *Musa* genotypes (Baiyeri *et al*., 2008). This explains why there was a strong and positive relationship between the index of non-spotted leaves at flowering and bunch yield/ha. This suggests that increased percentage of non-spotted leaves increased the yield and yield components of the crops.

The results of the experiment suggest that none of the hybrids, especially the newly developed ones were severely infected by the black sigatoka disease since the value for their index of non-spotted leaves ranged between 62 to 78% across the two cropping cycles. The earlier finding that the black sigatoka disease severity could be reduced by soil fertility improvement was also confirmed. The two newest hybrids '30456-3' and '29525' had comparatively good agronomic traits that could warrant their recommendation for on-farm adaptive trial.

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