Plantain/maize intercropping

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Plantain is a staple foodstuff for large numbers of people in lowland areas in sub-Saharan Africa. It is grown in traditional cropping systems and often intercropped with other food crops, and especially maize. This crop combination is a subject for controversy as maize is considered to be an excellent host for the nematode *Radopholus similis* (Rivas and Roman 1985), a pest that can cause serious damage to lowland banana crops in some places and lead to substantial yield loss (Sarah, 1989). In spite of this pest problem, the two crops are always found in farms where mixed cropping is practised. Combined cropping systems that include plantain were reviewed by Rao and Edmunds in 1984. The work on intercropping of the two plants by Devos and Wilson (1979 and 1983) did not take this pest aspect into account. A trial was therefore undertaken to obtain more information about this combination which is widespread in Cameroon. The main objectives were (1) to study the influence of intercropping with maize on plantain health and production, and (2) to determine the optimum densities for this kind of combination in a semi-intensive cropping system.

Material and methods

The trial was set up in land left fallow after being used to grow food crops for many years. 'French sombre' plantain suckers were planted on 25 August 1994 in holes 40 cm deep using an experimental layout in Fisher blocks with 6 treatments, 3 replicates and 25 significant plants per elementary plot. The following different treatments were examined:

- T1: plantain monoculture, 1,667 plants/ha (3m x 2m)
- T2: maize monoculture, 53,333 plants/ha (0.75m x 0.50m)
- T3: plantain (1,667 plants/ha, 3m x 2m) + maize (one row)
- T4: plantain (1,667 plants/ha, 3m x 2m) + maize (two rows)
- T5: plantain (1,250 plants/ha, 4m x 2m) + maize (two rows)
- T6: plantain (1,250 plants/ha, 4m x 2m) + maize (three rows).

The maize used for the study was "Cameroon Maize Selection 8704" (CMS 8704), a hybrid bred by the Institut de la Recherche Agronomique. It is a yellow flint maize suited to humid forest lowlands and with a yield potential of 5-7 t/ha-1. It was sown (4 seeds per hole) between the rows of plantains about three weeks after the planting of the latter (15 September 1994). The maize was then thinned to two plants per hole, i.e. a density of 53,333 plants per ha.

A second maize crop was sown between the rows of plantain in treatments T5 and T6 and in treatment T2 in March 1995. The shade given by the banana plants in treatments T3 and T4 because of the planting distances (3m x 2m) was not favourable for sowing maize again.

The crops were managed under rainfed conditions with reduced inputs. The plantains received applications of 200 g urea and 100 g potash during the first cycle. Banana borer was controlled with insecticides (chlordecone and fipronil). No treatment was applied for black Sigatoka. Maize fertilisation consisted of the application of 2 g urea per hole after emergence and 5 g per hole when the plants were 50 cm high. NPK 20:10:10 was also applied in the second season.

For observation of the dynamics of infestation of the plots by nematode populations, counts were performed at the nematology and entomology laboratory of the CRBP *(Centre de recherches régionales sur bananiers et plantains)* at different periods on plantain and maize roots and in the soil using the 'maize test' (the same hybrid was used for this test). The 'maize test' consists of collecting a soil sample from the test plots, placing it in a 2-litre plastic bag and growing maize in it. Five weeks after emergence, all the roots grown by the plant are removed for estimation of the nematode population in the soil concerned. Production data were collected for the first plantain cycle and analysed statistically using the STATITCF program.

Results and discussion

Plantain harvest data

The observations made when the plantain bunches were picked did not reveal significant differences in the average weight of the bunches (Table 1). It is noted however that the figures were lowest for the plantains in treatments T1 and T6. The presence of a maize intercrop significantly increased the planting to harvest time. The shortest cycle was in the control plot, whereas treatments T4 and T6 were sometimes over 30 days longer. These high figures were observed with both planting densities when the number of rows of maize was highest. Devos and Wilson (1979) observed similar effects in the study of plantain/maize, plantain/cassava and plantain/taro combinations.

Production of the two crops

The production data for the two crops are shown in Table 2. The maize yield is expressed in real grain quantities at 12-13% moisture content after drying, without taking post-harvest losses into account.

It is noted that because of the rapid covering of the ground by the foliage of the plantain planted at the classic spacing of 3m x 2m, no maize was sown in the second season (24/3/95) in the plots used for treatments T3 and

Table 1. Some data on the cycle length and harvest of plantain intercropped with maize

	Treatments				
Parameters	T1 (control)	T3	T4	T5	T6
Flowering to harvest time (days)	79ns*	78ns	76ns	78ns	74ns
Planting to harvest time (days)	387b*	406ab	424a	402ab	421a
Average bunch weight (kg)	11,83ns	12,93ns	12,23ns	12,6ns	11,73ns
Harvest percentage (%)	98,4	96,27	98,53	96,97	91,13

**: ns: not significant at 5 %.*
The figures followed by the same letter on the same line are not significantly different to the 5% significance threshold according to the Newman-Keuls test.

T4. At this date, the plantains had been growing for 7 months.

Cumulated maize production for the two seasons gave a yield of over 6t/ha-1 in monoculture and approximately 2 to 3t/ha-1 when it is grown with plantain. It is possible to grow some one to two tonnes (and more) per ha of maize between plantain set out at 3m x 2m. The yield thus doubles when the number of rows of maize is increased. It is noted that at least two maize crops can be grown between plantain set out at 4m x 2m.

Plantain production was high (over 20t/ha-1) in the plots planted at the classic density and combined with maize (T3 and T4) and low in the plots planted at a lower density (T5 and T6, approximately 15t/ha-1). Plantain in monoculture (T1) gave a slightly smaller yield than plantain intercropped with maize. This superiority of T3 and T4 in comparison with T1 can be explained by the gain in minerals for the plantain resulting from fertiliser applications for the maize.

It was noted that the equivalent area ratio (EAR) was always greater than 1 (1.19 to 1.74) in all the intercropping treatments, resulting in higher productivity of plantain/maize than in monoculture. With regard to the densities of the two crops grown as a combination, the classic treatments (3m x 2m) were much more productive that the low density treatments (4m x 2m) in spite of the fact that it was only possible to grow one maize crop. In a study of intercropping of plantain and food crops, Devos and Wilson (1979) concluded that reducing plantain density to enhance the development of maize and cassava resulted in a low return for the farm. The highest production for all the plants was given by the classic treatment with two rows of maize between the rows of plantain (EAR = 1.74).

Table 2. Average maize (2 crops) and plantain (first cycle) production.

Treatement	Production (t/ha^{-1}) M1	M2	M1+M2 cumulate d	Plantain	EAR*
T1 (plantain monoculture, 3x2)	-	-	-	19,72	-
T2 (maize monoculture)	2,98	3,20	6,18	-	-
T3 (plantain 3x2 + 1 row of maize)	0,90	-	0,90	21,55	1,38
T4 (plantain 3x2 + 2 rows of maize)	2,20	-	2,20	20,39	1,74
T5 (plantain 4x2 + 2 rows of maize)	1,27	1,10	2,37	15,75	1,19
T6 (plantain 4x2 + 3 rows of maize)	1,87	0,9	2,77	14,66	1,2

M1: first maize crop: 15/9/94

M2: second maize crop: 24/3/95

**: equivalent area ratio*

Table 3. Results of nematode counts for soil, plantain roots (p) and maize roots (m) in the plantain/maize intercropping trial

Date	Treatments	Nematodes per 100 g roots *R. similis*	*Hoplolaimus*	*Meloidogyne*	*Helicotylenchus*	*P. zeae*
29/08/1994	T1 (s)	0	400	1 543	0	22 529
After planting	T2 (s)	0	714	14 151	0	23 044
	T3 (s)	0	0	2 659	0	4 367
	T4 (s)	0	0	8 380	0	5 949
Maize sown	T5 (s)	0	0	5 128	0	18 264
15/09/1994	T6 (s)	0	0	4 146	0	7 145
27/10/1994	T1 (p)	11 733	0	933	133	0
2 m.a.p.*	T2 (m)	0	400	0	0	800
	T3 (p)	5 133	0	4 933	0	0
	T4 (p)	1 067	0	2 667	0	0
	T5 (p)	6 533	667	2 867	0	0
	T6 (p)	3 467	0	8 267	0	0
30/11/1994	T1 (p)	0	0	467	0	133
3 m.a.p.*	T2 (m)	67	133	800	0	**9 667**
	T3 (p)	2 400	0	67	0	1 200
	T4 (p)	533	0	0	0	200
	T5 (p)	1 533	0	1 000	0	0
	T6 (p)	67	0	467	0	0
23/03/1995	T1 (p)	67	0	1 000	0	0
7 m.a.p.*	T2 (s)	2 267	0	1 600	0	**269 533**
	T3 (p)	0	0	67	0	333
Maize sown	T4 (p)	0	0	1 333	0	133
24/03/1995	T5 (p)	0	0	1 333	0	0
	T6 (p)	433	0	2 933	0	0
11/05/1995	T1 (p)	267	0	2 533	0	0
9 m.a.p.*	T2 (s)	0	0	3 066	0	**80 000**
	T2 (m)	0	0	0	0	**36 667**
	T3 (p)	0	0	0	400	0
	T4 (p)	0	0	0	400	0
	T5 (p)	133	0	533	0	0
	T6 (p)	133	0	0	0	0

** : map : months after planting*

Nematode infestation dynamics

The results of the nematode counts in the soil and in plantain and maize roots performed throughout the first plantain production cycle are shown in Table 3. A maize trial was performed after the setting out of the plantain trial using the same hybrid CMS 8704. This showed the absence of *R. similis* in the soil. However large quantities (from 4,000 to over 23,000 per 100 g of soil from the plots) of *Pratylenchus zeae* (a maize nematode) were found. This is not surprising as the test site was previously used for food crops and especially tuber plants.

The presence of *R. similis* in banana roots at populations exceeding the threshold of 10,000 nematodes per 100 g roots was already observed two months after the plantains were set out and slightly more than a month after the maize was sown. As *R. similis* was not present in the maize, its introduction was related to the plantain material. However, *P. zeae* was found–in very small quantitites–in the maize roots but was not present in banana roots. Three months after planting, the roots of maize were invaded by *R. similis* and the roots of plantain by *P. zeae*. However, this infestation was relatively slight in both directions. This would appear to show that *P. zeae* attacks plantain roots very weakly and is probably not a danger for the crop as it is no longer found in plantain after seven months of vegetation. The presence of CMS 8704 hybrid maize between the rows of plantain did not appear to affect the sanitary state of the latter. Inoculation tests in pots should be performed to confirm the ‘non pathogenicity’ of *R. similis* for this hybrid maize. Other maize varieties should also be tested. Fogain

and Gowen (1995) studied the pathogenicity for maize and plantain of four isolates of *R. similis* from Africa and Asia. The CMS maize cultivar used was found to be an excellent host for this nematode. However, the number of the CMS maize used was not specified.
The nematode counts also showed the existence of significant populations of *Meloidogyne* spp. in the roots of the plantains. It would be desirable to examine the impact of the species on plantain accessions and define the nuisance threshold.

Conclusions

This study performed on plantain cropping cycle showed the economic benefit of combining the cultivation of CMS 8704 hybrid maize and 'French Sombre' plantain (EAR>1). With regard to plant health, it is noted that maize does not seem to be a host for the nematode *R. similis*. These results obtained for only one plant cycle must be confirmed since small quantities of the nematode were observed in maize roots after three months of vegetative growth of plantain. The behaviour of this hybrid maize with regard to *R. similis* should also be investigated by growing it in infested soil where the risk of root infestation is greater. The study did not reveal a significant effect of the presence of maize on plantain yield. With regard to the density of the two crops, it was observed that the sowing of two rows of maize between plantains planted at the classic spacing of 3m x 2m in the early stage of the vegetative growth of the latter gives the highest productivity with an equivalent area ratio of 1.74. Increasing plantain spacing to enhance the growth of maize results in a low return for the farmer even though it is possible to grow more than two maize crops between the rows of plantain. These results should nevertheless be confirmed by subsequent studies on different maize varieties and on more than one cycle of plantain using healthy plant material (grown using *in vitro* culture) on cleansed soil (fallow).

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A gold star for FHIA-01

Agronomic evaluation and Fusarium wilt resistance of the hybrids FHIA-01 and FHIA-03 in Burundi

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Introduced in Burundi within the framework of the International *Musa* Testing Programme (IMTP I), the tetraploid hybrids FHIA-01 et FHIA-03 confirmed their partial resistance to black Sigatoka (*Mycosphaerella fijiensis*) in a varietal trial at Mageyo at an elevation of 1,250m.

According to the results obtained in Honduras and Australia, FHIA-01 ('Goldfinger') is resistant to races 1 and 4 of Fusarium wilt (*Fusarium oxysporum* f. sp. *cubense*), displays resistance to burrowing nematodes and is appreciated as a dessert banana. It is both resistant to black Sigatoka and drought-tolerant (Rowe 1990; Rowe & Rosales 1993a, b, c; Daniells *et al.* 1995).

This article provides preliminary results concerning the resistance of FHIA-01 and FHIA-03 to wilt and their agronomic characteristics at different evaluation sites in Burundi.

Agronomic evaluation

The characteristics of the hybrids FHIA-01 and FHIA-03 are compared with those of the highland cooking banana Nyakitengwa (AAA-Mutika) tested at Cibitoke, Burundi, in soil not infested by wilt (Table 1). The site is at an elevation of 850 m north of lake Tanganyika, where the two tetraploids also displayed partial resistance to black Sigatoka.

Plant height of the hybrids FHIA-01 and FHIA-03 is 15% less than the reference cultivar 'Nyakitengwa'. The hybrids are robust, which is an important advantage in East Africa where bananas are often grown on slopes in hilly country. At Cibitoke, the two tetraploids gave heavier bunches than 'Nyakitengwa'. This difference was also observed in medium fertile soil (at Mageyo). In contrast, at Mashitsi (elevation 1,650 m) in relatively poor soil, the tetraploids produced bunches weighing some 15 kg, which is fairly similar to the bunch weight of highland bananas.

Fusarium wilt resistance of FHIA-01 and FHIA-03

The hybrids FHIA-01 and FHIA-03 were evaluated in the Moso region (Burundi) at an elevation of 1,200 m, where the cultivar 'Kayinja' (ABB-'Pisang Awak') is seriously attacked by wilt. External and internal symptoms were observed respectively during plant growth and at maturity using the scoring method proposed by INIBAP (Jones 1994):

External symptoms:

- 0 : no yellowing, plants in good health,
- 1 : slight yellowing limited to lower leaves,
- 2 : yellowing spread to upper leaves,
- 3 : severe symptoms and death of the plant.

Internal symptoms:

- 0 : corm completely clean,
- 1 : isolated points of discoloration,
- 2 : discoloration of up to 1/3 of vascular tissue,
- 3 : discoloration of between 1/3 and 2/3 of vascular tissue,
- 4 : discoloration of between 2/3 and 3/4 of vascular tissue,
- 5 : total discoloration of vascular tissue.

The scores for the hybrids and controls are shown in Table 2.

FHIA-03 is very susceptible to Fusarium wilt in the Moso region,