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Biological Control of Erosion of Banana Drains in Côte D'ivoire

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Abstract

The erosion of drains is a major limitation of the quality, the increasing of banana production and the environmental protection of industrial banana in Côte d'Ivoire. It leads inundations, death of banana trees and significant loss of production. Thence, the construction and the maintenance of drain costs too much and causes injure, snake bite, physical traumatisms, many diseases, … These events compromise the sustainable production of banana by reducing seriously worker's the activities and finally increase the cost of production. The aim of the present work is to contribute to the sustainable development and human capacity building in the third world nations as far as banana production is concerned. The methods used so far to address this phenomenon proved inefficient. The technology innovation in this area has been to grow grass on the outer edges of the channels drained water. This resulted in a systematic reduction of erosion. Better still, it helped fertilize the soil, reduce the deportations of fertilizer and improve the quality of landscape of the plantations. *Stenotaphrum secondatum* is the best vegetable specie adapted to the biological control against water erosion of drains.

Keywords

Banana, Biological Control, Ivory Coast, Drain, Environment

1. Introduction

The studies took place in the south of Ivory Coast forest region in the department of Agneby and the outskirts of Abidjan district (**Figure 1**).

The study on biological control against erosion of drains from the industrial banana plantations (**Figure 1**), deals

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with the general context of food security mainly northern countries, large consumers banana dessert. They are increasingly concerned about the quality and quantity of bananas but also by the quality of environmental conditions, production systems of the South. In that one, good management of soil, water and agricultural inputs can guarantee an abundant production, durable and quality. In addition, the liberalization of the banana market requires a very increased competition between small Africans producer and Caribbean and Pacific (ACP) countries and those of Latin America's largest producer [1]. Southern countries, such as Côte d'Ivoire, rely on the quality of their products to increase their income in this new market. To do this, it emphasizes research in sustainable land management and the fight against pollution of soil and water by fertilizers and other agrochemicals and erosion of drains [2] [3]. This latest phenomenon causes inundations, death of banana trees and significant loss of production. Thence, the construction and the maintenance of drain costs too much and causes injure, snake bite, physical traumatisms, many diseases in the low grown the tropical area, like Nieky valley in Côte d'Ivoire where the studies toot place [4]. For these reason, soil erosion is a major problem in banana production system around the world partially in Côte d'Ivoire. This work is initiated by the Company of Bananas of Côte d'Ivoire (CDBCI), in his conquest of the required certification since 2006 and leads under the "Better Banana" Program (BBP) by The Rainforest. The main objectives are the environmental and workers' lives. The quality of the drainage system determines the value of the fruits. In that, the obstruction of drainage channels is due to flooding of plots congestion rot roots, loss of banana leaves and finally the production of poor quality diets low commercial values. Also, after a systemic approach to the problem of drainage systems of industrial banana, through sampling, and health economic study of the activity of drainage plantations [4], we proceed here in the implementation and evaluation of a biological control method against water erosion of drains.

2. Materials and Methods

2.1. Materials

Drains are particular channel of draining water from soil, realized in banana plantation (**Figure 2**). The means

Figure 1. Banana area of CDBCI. Source: Google Earth Sat, 2005 [box] Study Area [oval] Local codes of plantations from the national organization of banana and pineapple affaires administration in Côte d'Ivoire called OCAB (Organisation Centrale de la Commercialisation des ananas et des bananes) Four banana plantations (Agnéby, N'gaty, Songon-Agban and Songon-M'bratté).

and methods formerly used against water erosion are very limited (**Figure 3**). Currently, the struggle is to use biological material to prevent erosion of drains in all its forms. We chose three bent grass species plants which have the ability to fix the edges of the floor drains, with their root system and ensure smooth descent of the water drains through the roots and stolon. These plants are sensitive to conventional herbicides and their seeds are not viable. They are therefore controllable in terms of their mode of reproduction. This is *Cynodon dactylon*, *Paspalum pensacicola* and *Stenotaphrum secundatum*, all from the family of Poaceae. The seeds of the first two plants were purchased, the third local plant is obtained by cutting (**Figure 4**).

2.2. Methods

The biological control method against water erosion drains required the establishment of an experimentation device, maintenance tests, make observations and statistical analysis.

2.2.1. Observing Device

Three plots were selected from three different banana plantations (**Figure 1**): Parcel M-21 (sand, much eroded) at Songon M'brathé (plantation 66), E-7 (peat, eroded) at Songon Agban (plantation 40) and N-10 (very clayey soil) at N'gatty (plantation 50). They were chosen on the basis of soil type and extent of erosion on these plots. On each of them, a completely randomized design with 4 columns and 4 rows was established on 12 boards of the same size banana at 3 per block. Each block was thereafter divided in length by 4 rows of small dimensions the same, forming four repetitions. We get thus 16 basic plots of banana which is a Latin square design, 4 columns (4 blocks 3 boards of the same width) and 4 replicates (4 rows of 3 boards of the same length). 16 squares were divided into four treatments in a completely randomized design: T_0: unprotected drains; T_1: Drains protected by *Cynodon dactylon*; T_2: Drains protected by *Paspalum pensasicola* and T_3: Drains protected by *Stenotaphrum*

Figure 2. Overview of a physical drain under banana.

(a) Plastic bags (b) Mulching the banks of drains

Figure 3. Some methods used in planting against erosion drains.

(a) Young plants of *Paspalum pensacicola* (E-7)

(b) Young seedlings under banana *Stenotaphrum secundatum* high recovery rate (80%), M-21

(c) Young Plants of *Cynodon dactylon*

(d) F: Lines of sowing of grass seeds on the drains

(e) Young seedlings *Paspalum pensacicola* on the edge of a secondary drain (parcel M-21)

Figure 4. Planting and cultivation of grain and grass cuttings along the drains.

secundatum. On the first two turfs, seeds were sown along the drains, 30 cm on edge. Cuttings of the third were cut between nodes and planted at the same distance on the edge drains, oriented to the light drainage channels (**Figure 4** and **Figure 5**).

2.2.2. Maintenance

Maintenance has been in regular plucking weeds and dead banana leaves left carelessly on the grass seedlings. Furthermore, the main rods *Stenotaphrum secundatum* were sometimes cut to cause bud shoots and promote secondary tilling and drains around the edges.

2.2.3. Comments

1) Observations growth of selected plants

Comments focused on the germination time or recovery rates exercise or successes, height, length and speed of growth of stolon.

2) Observations and statistical analysis

The impact of erosion on the drains after seeding lawns, the assessment of the type and level of erosion suffered by the edges and walls of the drains were made from a scale that we have initiated: O: no erosion; 1: (very rare) very low erosion, soil slightly planed; 2: low erosion, soil planed, just traces of less than 20 cm; 3: erosion important enough ground planed with some hollow ravines, 20 to 40 cm; 4: very important erosion, soil degraded enough with many deep valleys (within one meter); 5: spectacular erosion, many hollow or very deep gullies several meters. This operation is carried out before the establishment of the anti-erosion means on the edges of the tiles. The results had been statistically treated by [5].

3. Results

Stenotaphrum secundatum is the grass that gives the best success rate (55.4%). This rate may be much higher if the runners are planted on the same day of their pulling or 3 days later. In addition, the viability of buds becomes

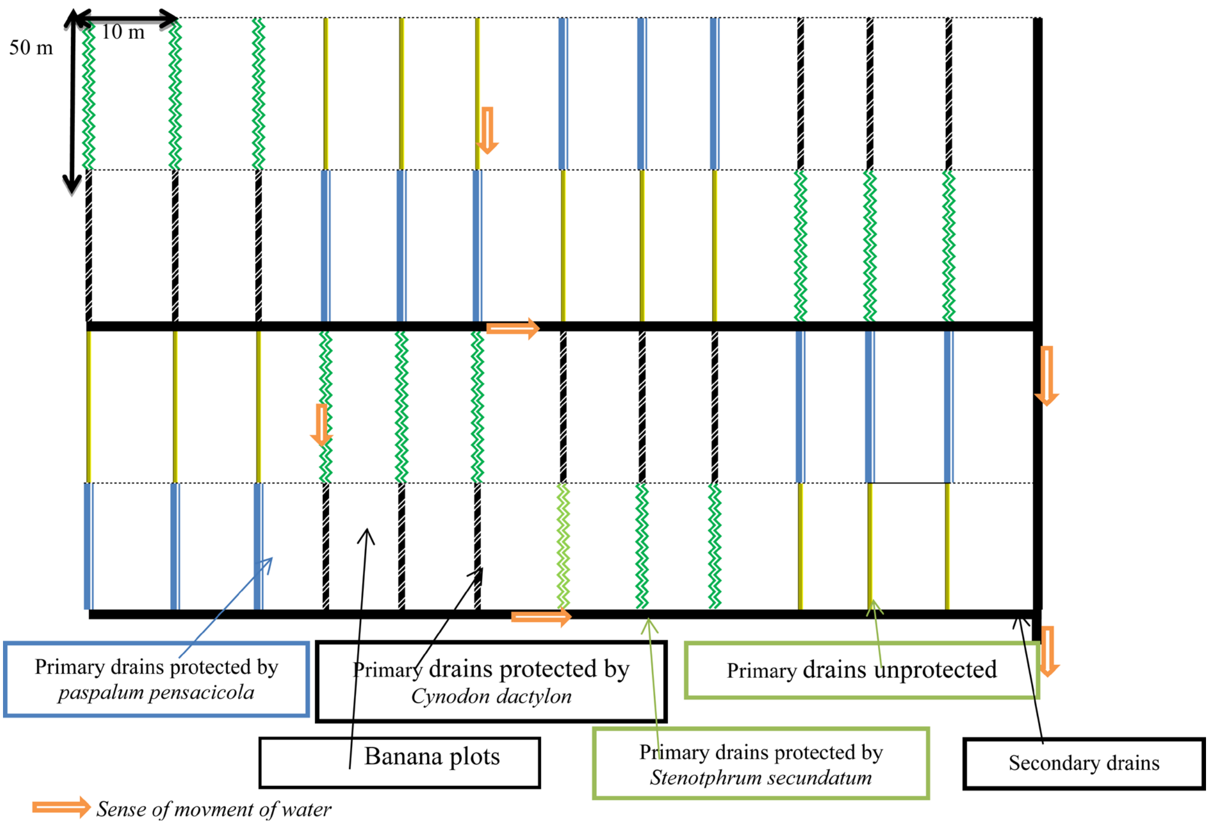

Figure 5. Dispositive of implementation.

weak. The low rate of emergence observed in other types of turf is primarily shading banana leaves. For recoveries of these leaves were 60% to 90% at planting. This delayed the levees that were observed as soon as the seeds have received germination energy, following the intensification of cutting regimes, which reduced the recovery of leaves between 40% and 45%. Moreover, *S. secundatum* moved faster than other grasses: higher growth rate, two or three branch per node. Its height is lower than the other with an average of 5.91 cm above the floor (**Tables 1-4**). Also, *S. secundatum* effectively protects drains against erosion (**Figure 6** and **Table 4**). Its presence on the edges and faces of drains eliminates or reduces the intensity of the gully, the impact erosion, gravity erosion, surface erosion, landslides and collapses. The effectiveness of other turf could not be assessed because these species do not survive to the agronomic activities including, herbicides. Furthermore *S. secundatum* is controlled by herbicides at usual doses and abundant straw fertilizes and maintains soil fertility.

Table 1. Rate of or rate of success 15 days after sawing or planting (%).

	Parcel E-7				Parcel M-21				Parcel N-10			
	Treatments				Treatments				Treatments			
Repetitions	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3
R1	0	30	60	80	0	20	60	95	0	10	30	40
R2	0	30	50	20	0	20	60	90	0	5	20	20
R3	0	40	60	20	0	20	60	95	0	5	25	25
R4	0	30	80	80	0	20	60	90	0	10	10	10
Average	0	32.5	62.5	50	0	20	60	92.5	0	7.5	18.75	23.75

N.B.: T_0—Drains unprotected, T_1—Drains protected by *Cynodon dactylon*, T_2—Drains protected by *Paspalum pensasicola*, T_3—Drains protected by *Stenotaphrum secundatum*.

Table 2. Length of stolons 90 days after sawing or planting (cm).

	Parcel E-7				Parcel M-21				Parcel N-10			
	Treatments				Treatments				Treatments			
Repetitions	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3
R_1	0	22	20	210	0	300	80	350	0	90	25	40
R_2	0	30	20	145	0	30	30	350	0	70	20	130
R_3	0	90	30	140	0	60	25	310	0	20	25	50
R_4	0	55	40	280	0	240	50	450	0	100	20	100
Average	0	50	27.5	168.75	0	157.5	46.25	365	0	70	22.5	80

Table 3. Height of plants 90 days after sawing or planting (en cm).

	Parcel E-7				Parcel M-21				Parcel N-10			
	Treatments				Treatments				Treatments			
Repetitions	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3
R_1	0	25	10	5	0	20	10	5	0	20	20	5
R_2	0	10	10	10	0	25	20	5	0	20	5	5
R_3	0	15	15	3	0	22	25	8	0	10	15	5
R_4	0	35	30	5	0	25	15	10	0	15	20	5
Average	0	21.25	16.25	5.75	0	23	17.5	7	0	11.25	15	5

Table 4. Effects of erosion on the drains after 14 months.

		Parameters of drains							Components of erosion				Consequences		
Parcels	Treatments	Wid	Wds	Dep	Dps	Dbl	Lsl	Asl	Ser	Ger	Cer	Ier	Col	Sub	Gul
E-7	Drains with SS	136	98	63.3	55.7	118.7	68.7	78.3	0	1	1.3	1.7	0	0	1.3
	Drains without SS	154.3	95	73.8	66.4	112.2	73.1	67.5	1.9	1.7	1.4	1.4	0.1	0	1.4
M-21	Drains with SS	120	72.8	71.7	60	120.6	72.2	72.2	0.4	1.1	0.7	0.4	0.5	0.2	0.7
	Drains without SS	134.2	73.1	84.3	69.4	113.8	87.7	68.9	1.7	2.2	0.6	1.3	0.3	0.2	1
Average: protected by SS		144	84	79	67.9	113	80.4	68.2	1.8	1.9	1	1.3	0.2	0.1	1.2
Average: Not protected		128	85.4	67.5	57.8	119.6	70.4	75.2	0.2	1	1	1	0.2	0.1	1

Parameters of drains: Wid—Width; Width of stability; Dep—Depth; Depth of stability; Dlb—Distance to the banana; Lsl—Length of slope; Asl—Angle of slope. Different components of erosion: Ser—Surface Erosion; Ger—Gravity Erosion; Cer—Concentric; Ier—impact Erosion; Consequences: Col—collapse; Sub—subsidence; Gul—gullying; SS: *Stenotaphrum secundatum*.

4. Discussion

S*tenotaphrum secundatum* reproduces only by cuttings. Its seeds are not viable, both in Côte d'Ivoire, in France and in North Carolina, USA. It's rapid growth, abundant straw and relatively low heights (5 - 20 cm) are the same on these three continents. In America and Europe, This plant is sensitive to low temperatures [6]. Sensitivity to shading is not quite noticeable on the drains especially its locations are generally the sunniest banana. Unlike our work, *S. secundatum* is cultivated in Europe, inhabited environment particularly in the gardens [7]. In addition, low levels of raising *pensacicola Paspalum* and *Cynodon dactylon* is explained by their high sensitivity to the shade of banana trees. The sun-loving nature of these two species is known in Mexico and North America where *Paspalum pensacicola* is used against water erosion [8]. The efficacy of *S. secundatum* on drains erosion control is greater than that of mulching and plastic bags as what proved the work of [9]. This new control method is similar to bands grass effectiveness that is recognized worldwide. It is effective against all forms of erosion. It avoids grass strips based weed most of which contribute to weed plantations and some are secondary hosts of nematodes, viruses or insects enemies of bananas. The use of *S. secundatum* in plantations, as we advocate should be enhanced by a good neighbor density of 2200 vines of banana per hectare. This is to ensure a good ground cover, which may be collected by lush foliage. Water has come along later pseudo stems and will then drain thoroughly by the roots of banana trees and lawns. Because we agree with [10] to say that covered the soil by a full plant provides excellent water retention of the soil and its influence prime on all other factors. This is why we can combine biological control against erosion drains and biological control against weeds, involving a banana density as indicated above, culturing seed of *Vigna adenanthus* (Fabaceae). This plant is sensitive to conventional herbicides, both prevents weed plots and erosion of drains; fertilized by lush foliage whose cycle is adapted to that of banana, soil, while setting its abundant roots at each node [11], the slope drains as firmly as Stenotaphrum secundatum. Hower, the using of grasses around drains contribute not only to stabilize them but is purifies and, reduce the flow of water, as well [12]. Studies of many authors like [13], [14], show that sowing of grass seed is more effective than natural weed control, or weed controlled by Glyphosat and total chemical weeding as far as soils erosion are concerned. So, it obvious that grass is the best cultural technology system, to stop soil erosion whoever in banana plantations or any other situation. More than this, grass reduces either pesticides transfer and increase stock water in soil.

5. Conclusion

Biological control against erosion turf is possible industrial banana. The use of such turf as indicated certainly contributes to lower the cost of banana production. The annual cost per hectare of labor clerk drainage was estimated at 48,661.94 FCFA in 2006 by CDBCI. It is higher than herbicides that have been estimated to 38,386/ha at the same time. Furthermore, it is possible to extend the period of maintenance of drains or without cause landslides or collapse, nor silting. The weed will be reduced to straw turf. This will require a little maintenance, no more than once a year. Health of workers will thus be preserved and the overall cost of production will lower. Moreover, the quality of bananas will be better, as they will be transported on better tracks, in good condition.

(a) & (b) *Secundatum stenotaphrum* on two primary drains before herbicide treatments, sandy soil

(c) & (d) *Stenotaphrum* on the edges of two primary drains after the first herbicide treatment

(e) & (f) *Secundatum stenotaphrum* on the edges of two primary drains after the second herbicide treatment

(g) *Stenotaphrum secundatum* borders on a primary drain after herbicides treatments on a peat soil

Figure 6. Gradual disappearance straw *Stenotaphrum secundatum* after two successive applications of herbicides (round up).

Also, Biological control against water erosion is a means to fight against the deportation of fertilizer runoff and against invasive aquatic plants. It helps to maintain water quality and ensures the survival of plant species from the banks but also that of many species of fish and other animal species, water present in the rivers of banana. In addition to the removal of erosion, it offers a very nice landscape planting and contributes to biodiversity conservation and improvement of soil fertility, thus sustainable banana production. This is our contribution to sustainable development of agriculture and human capacity building in the third world nations.

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