

Journ'ïames 2012

Technical day on yam

September, 25 - INRA Duclos, Petit-Bourg

October, 2 - CFPPA Petit-Canal

Proceedings



Texts and communications from this technical day (Journ'iamés 2012) should be cited as follows :

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Introducing the technical day about INRA's work on yams : Journ'iames 2012

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Yam is one of the main food crops in Guadeloupe and the Caribbean islands. It is cultivated by many producers in many different ways, and both consumers and producers have high expectations with regard to quality. The French National Institute for Agronomical Research (hereafter INRA) is committed since years with yam producers to improve knowledge on these plants and bring some answers and ways of improvement on agronomical and technical issues about this relatively and otherwise worldwide little studied crop.

The very first diagnostics performed with producers organizations allowed to define the strongest needs and clarify the main lines of investigation to sustain and improve yam production. Some of these are best classified as long term goals, like creating new varieties improving productivity or quality, or with lasting disease resistance. Other actions fit in with much shorter timelines when they rely on expanding upon already evaluated techniques, just like some of the agronomical practices that are discussed today.

Furthermore, some of our experiments may only be organized collaboratively with producers and their organizations. We must thus inform these collaborators on work in progress, share about our results or about yet unanswered questions. As a consequence, we are proposing this technical seminar today bearing several aims in mind: first, to provide you with our most recent findings whether they brought immediate technical liability or not; second, to share with producers that contributed to our experiments and to convey information we gained thanks to their participation; third to create debate incentives that would further help refine our research goals.

Today we will summarize latest developments on agronomical practices: yam planting date management, struggle against weeds, potential incomes of 'fertilization' and use of compost. We will also elaborate on our results on disease control and yam sanitation status, and the creation of new varieties that are both resistant to disease and adapted to local farming constraints. Eventually, we will discuss diverse economical stances on estimating and optimizing yam production costs, before we compare different results of the various market options used for yam commercialization.

Our exchange themes are indeed numerous today, but talks are kept short to allow for timely discussion and questions, and room demonstrations as well. We hope that we shall meet again for technical seminars like this on a regular basis.

Effect of planting date on *Dioscorea alata* yam yield

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1. Issue and aims

It is well known that development of *Dioscorea alata* yams is very sensitive to day length (photoperiod). Indeed, tuber growth is faster when planting is late (e.g. in July, with shortening days) than with early planting (April and May, with increasing day length). Moreover, the experience of Guadelupean producers is that « *if anything else is right, there are no differences in productivity between yams planted in April and those planted in July* »; the latter is the latest planting month in Guadelupe. In order to understand why day length is affecting the plant's development (e.g. cycle length) and does not seem to affect yields, we decided to go back to series of experiments carried out at Guadelupe INRA station in the 1980's, whose results were reanalysed with a mathematical model that included climate and its impact on plant life cycle.

2. Description and results

All assays were performed in plots (INRA de Duclos, Belep variety) with adequate watering and fertilizing to prevent constraints associated with lack of water or nutrient. In order to interpret results, we used a model from the USA to study Potato crops and we adapted it to Yam (CropSyst-Igname).

Figure 1 illustrates 3 examples of yam cycles for contrasting planting dates. We note that the model explains growth well, and that growth does not vary too much for planting dates in May and July, but that it decreases dramatically for September. Yam cycle is one month shorter in July compared to May, but since growth is faster in July, yields do not differ between these two planting dates. This implies that *alata* yams adapted to compensate a shorter cycle with a faster growth: there are fewer leaves in July but they are more efficient in producing biomass.

This ability to adapt these conditions does not exist in very late planting dates (after July) because tubers occur too quickly and leaves are not numerous enough to sustain both growth and tuber filling. **Picture 1** illustrates the impact of day length on plants 150 days after planting.

We used the model to estimate yam yields during 15 years (between 1991 and 2005) using climate data for INRA station at Duclos. The concordance for mean yield as estimated with our model and actual yields is good except in March (**Figure 2**). Yield for this last experiment was very low and possibly due to low sunlight, because of the strong rains that fell over 40 days following planting. It first impacted leaf production and then later affected tuber filling. Indeed, results from model demonstrate that variability in yields is strongest for early planting dates (compare variability in **Figure 2**), which is a consequence of strong rains just after planting. Year 2011 was a good example of this kind of situation.

3. Limits and perspectives

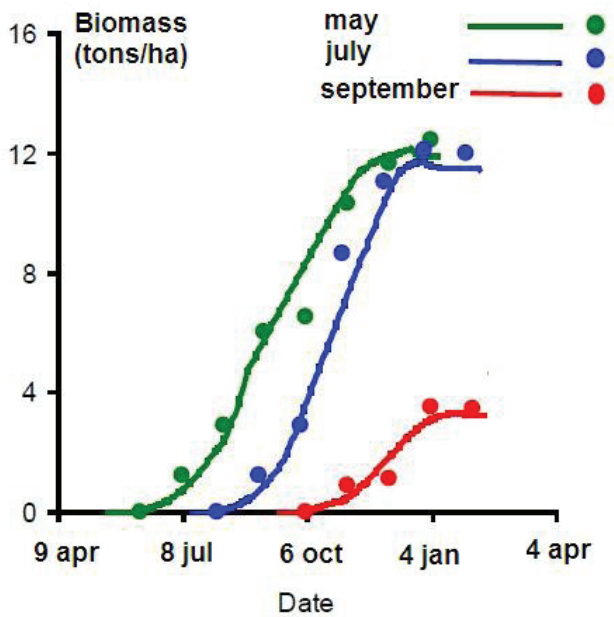
We showed that the *lack of effect* of planting date on yield in *alata* yams implies an adaptation of the crop, at least for the classical planting dates in Guadelupe. We will then investigate sensitivity to photoperiod in different varieties to assess their ability to vary the planting date. We also demonstrated that early planting can be affected by low sunlight during rainy years. Next steps will consist in evaluating the impact of fertilization at different planting dates and thus move on the question as to why response of yam to fertilizer application looks random (see « Response of Yam to fertilizing and compost »).

4. To learn more...

INRA Antilles-Guyane, 2006. Recherches sur l'igname en Guadeloupe. Synthèse et Inventaire bibliographique. 75 p. Rapport. Lacoite A., Zinsou C., 1987. Effet de la date de plantation sur la croissance et le développement de plantules d'igname (*Dioscorea alata* L.) produites par culture in vitro. Agronomie, 7 : 475-481. Article.



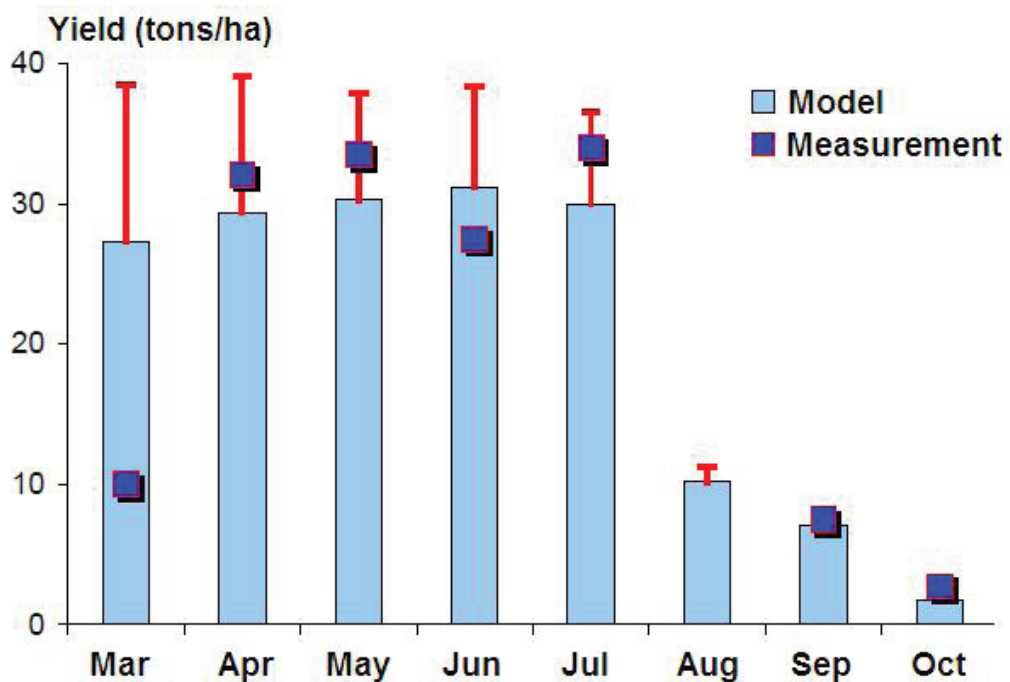
Figure 1 : Growth of *alata* yam (variety Belep) at three planting dates in Guadelupe. Full lines are the result of CropSyst-Igname model and circles are actual measures.



Picture 1 : Impact of day length on growth in *alata* yam (variety Belep). Picture was taken 150 days after planting (15 september). Right plant has grown under natural conditions (short days), left plant has grown with artificial light after sunset in order to get a 16 hours photoperiod.



Figure 2 : Yields of *alata* yam (variety Belep) as a function of planting date : measured and estimated results (model CropSyst-Yam). Red lines represent yield variability for the 1991-2005 period.



Yam response to fertilization and compost addition

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1. Issue and aims

It is frequently said that yams (all species and varieties alike) are crops needing high fertility soils. Experience of farmers in Guadelupe nevertheless shows that response to fertilization looks random and is extremely diverse from one year to the other. The aim of this study was to investigate the effects of mineral and organic fertilization on yam yields in farmer's plots and thus to identify factors that impact how plants react to fertilization.

2. Description and results

In 2009 we followed field trials in Basse-Terre (20 assays, ferralsols, humid climate) and Grande-Terre (28 assays, vertisols, subhumid climate). Nitrogen (N), phosphorus (P) and potassium (K) fertilizer rates used by farmers were very diverse (**Figure 1**). No relationship between fertilization levels and yields were found though, confirming observations by numerous farmers. The diversity of varieties used by farmers or the characteristics of the region (e.g. soil and climate) do not explain the great variability of yields (e.g. from 3 to 43 tons/ha). It is possible that other nutrients, such as magnesium in the ferralsols of Basse-Terre and iron in the calcareous vertisols of Grande-Terre, are limiting factors controlling yam response to fertilization.

Table 1 presents a summary of available information from international literature about yam response to fertilization. This information involves 218 field trials carried out in the tropics, mainly in Africa. It is interesting to notice that most trials (64%) did not present any response to fertilization. Moreover, for the trials with positive response, the effect was more frequent for *D. alata* (44%) than for *D. cayenensis* (36%). Also, the effect was more frequent for N and for NPK fertilizers than for P and K. These results show that lack of a clear response of yam to fertilization is a general observation and not a Guadelupean specific trait.

Furthermore, we tested during two years the effect of compost addition (15 tons/ha) with or without further fertilization (in kg/ha: 100 N, 80 P, 120 K) in two farmer plots, one in Basse-Terre and the other in Grande-Terre.

Figure 2 presents an example of result for each region. Fertilization or compost alone had no significant effect compared to the control. Both treatments applied together presented the greater yields. This effect may be associated with mycorrhizae in the compost, which would help plant nutrient uptake from fertilizer, mainly P.

3. Limits and perspectives

All these results confirm that yams have a low response to mineral nutrient addition. The reason is probably that yams were selected for resistance to diseases (e.g. anthracnose) but not for their ability to use nutrients in rich soils. Even if the hypothesis of an effect of mycorrhizae must be verified, our results with compost addition open interesting perspectives to improve yam response to fertilization. For example, composts could be used at low rates at planting in order to improve nutrient uptake. In this study, a rate of 120 kg N + 30 kg P + 150 kg K would be large enough to ensure good N nutrition and restore soil P and K exported by tubers. Nitrogen and K fertilizers should be splitted during the yam cycle to reduce nutrient losses by leaching.

4. To learn more...

Cornet D., Hammouya D., Bonhomme R., 1995. Etude du fonctionnement physiologique d'un couvert de *Dioscorea alata* pour une utilisation plus rationnelle des engrais chimiques. In : Farant M., Anaïs G., Ozier-Lafontaine H., Zebus M.F., Diman J.L., Hammouya D. (Editeurs). 41th Annual Meeting of the Caribbean Food Crops Society 31: 398-416. Communication.

Sierra J., 2011 Effet de l'apport de matière organique sur le rendement de l'igname : cas du compost Biogwa.

http://www.antilles.inra.fr/la_documentation/dossiers_et_documents/dechets_et_composts. *Diaporama*.



Figure 1 : Effect of the rate of NPK fertilizers on yam yields. The results correspond to 48 field trials carried out on farmer's plots in Guadeloupe.

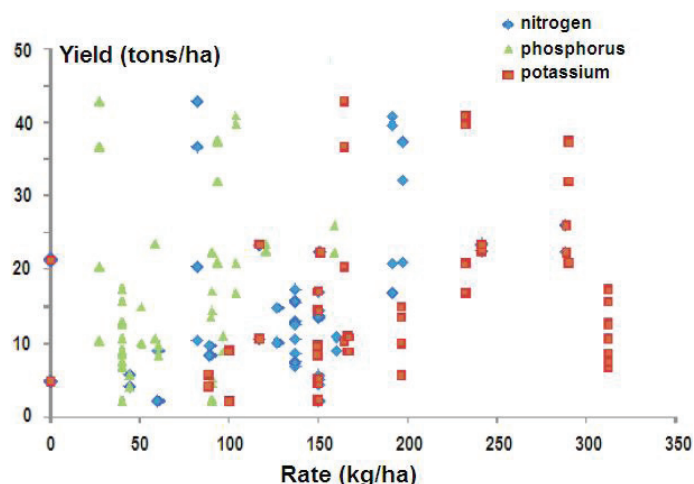
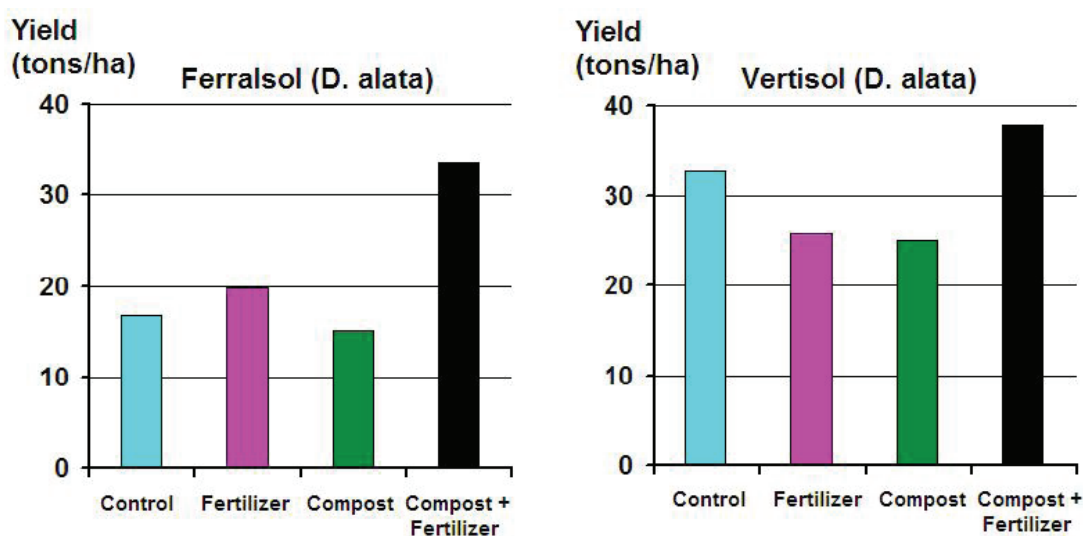


Table 1 : Effect of NPK fertilizer application on yams yields. The results were obtained from 218 field experiments reported in the available scientific literature. Results are expressed as % of the number of trials performed for each nutrient and yam species.

Yam species	Nutrient	Positive effect	No effect
		%	
Alata	N	42	58
	P	40	60
	K	36	64
	NPK	49	51
	total	44	56
Cayenensis	N	43	57
	P	21	79
	K	23	77
	NPK	44	56
	total	36	64

Figure 2 : Effect of mineral and organic fertilization on yam yields



Controlling weeds in yam crops : advantages of different mulching methods

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1. Issue and aims

Because of the lack of homologated molecules, weed control in yam crops is done by hand. This way to control weeds is time consuming (between 250 and 750 hours of work by ha), hard and often difficult to plan because of climate conditions that do not always allow work be done in a timely fashion. Mulching is thus an interesting alternative to hand control to prevent competition between yams and weeds. It is traditionally worked out with sugar cane crop residue, plastic film or even craft paper, the latest being a new technical innovation that we thought of and evaluated in Guadeloupe. We present here our first comparative experimental results, some of which were directly experienced by yam producers.

2. Description and results

Experiments on paper and plastic covers (from 2009 to 2011) were done in INRA Duclos and in fields from Lycée Agricole, both with irrigation and fertilization. Indeed, mulching techniques need drop a drop irrigation and fertilization be set up prior to mulching plots. We measured out weeding time, total weed biomass, yam upcoming rate and yield.

Plastic mulch is characterized by a decrease in plant emergence due to scalding and a consequently significant decrease in yield (**Table 1**). Moreover, plastic films need to be collected back at the end of crop cycle to conform to legislation, which increases the cost of use.

With paper mulch, emergence rates are similar to those of crops without mulch and weeded by hand. In the first assays, mulching had occurred by hand, and further fixing with crossing threads was sometimes needed (**Picture 1**). These steps required about 15 work days per ha. Labor balance was nevertheless still positive, because it allowed reducing weeding time by 60% (i.e. by about 18 to 55 days). Yield with paper mulch was equal to or even sometimes greater than traditional cropping system (by up to 40% in situations with low fertilizing). This increase in yield results from the lower competition for nutrients when fewer weeds are growing.

Paper mulch duration span is proportional to rains (**Figure 1**) but was always sufficient to control weed development (**Picture 2**). Paper may need maintenance in order to replace torn parts. At the time of harvest, the paper incorporated to the soil is degrading very fast and our chemical analyses demonstrate that there is no polluting with kraft paper, which can thus be left in place or buried without affecting soil quality.

Currently the cost of paper mulch is about 4000 € per ha, thus between cost of plastic film and biodegrading film (1000 € and 7000 €, respectively). It could even beneficiate from Agro-environmental measures that could go up to 900 €/ha.

Last, sugar cane leaves mulching also demonstrate very high protecting qualities against weeds, with an even lower setting time (10 hours/ha), though with a lower duration time. Experiments with sugar cane leaves bales are under prospect (Agricultural Chamber). Technical and economic analysis will allow us to a more complete evaluation of this mulching method by the end of the year.

3. Limits and perspectives

Some issues still need special investigation before we may conclude on the economics of natural mulching. Our IGNAMARGE software, as explained elsewhere in this booklet, would take into account analysis of the different mulching strategies in the diversity of producers situations once correctly calibrated. Finally, the study of mechanization for paper mulching is carefully considered (with EPLEFPA).

4. To learn more...

Tournebize R, 2011. Mulch papier ; Antilles Agricole 26 : 44-45.
Tournebize R, 2011. Mulch papier. Fiche Transfaire
<http://transfaire.antilles.inra.fr/spip.php?article86>.



Table1 : Emergence rate, labour time and yield for 2009 experiment at Lycée Agricole.

Mulch type	Without mulch	Without mulch	Plastic mulch
Emergence rate	95%	95%	69%
Weeding time (J/ha)	60	24	20
Yield (T/ha)	9	10.2	6.2

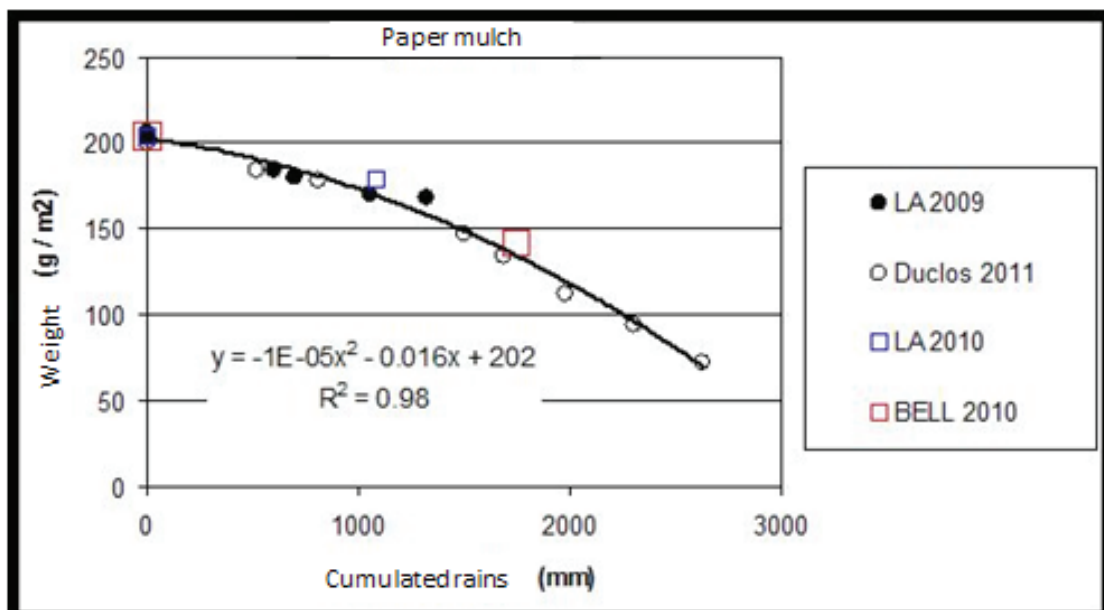
Picture 1 : Left: paper mulch prior to planting



Picture 2 : Right: mulch state at harvest



Figure 1 : Evolution of paper biomass as a function of cumulated rains.



Are yam plant residues a source of infecting spores leading to new anthracnose epidemics?

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1. Issue and aims

Anthracnose, resulting from the attack of the fungus *Colletotrichum gloeosporioides*, is one of the main disease of yam species *Dioscorea alata* in Guadeloupe and tropics. Infected plant residues are a plausible source of fungus spores, which can further be dispersed by rain. Here, we investigated whether residues were a potential infectious source and if it was, the post-harvest time lapse after which residues would keep infectivity risk high enough to allow for further dispersal and disease.

2. Descriptif et résultats

We set a field experiment to 1) Measure leaf and stem decay in yam (in variety Pacala) left on the ground or buried below 10 cm in the soil (**Picture 1**), and 2) Assess survival and pathogenicity of the fungus surviving on decaying residues. Plant residues were infected with high doses of *Colletotrichum* spores in order to follow survival kinetics. Pathogenicity was evaluated with infecting healthy leaves (from variety Sainte-Catherine) with spore suspensions collected from decaying residues.

Leaves degraded 2 times faster than stems, and buried residues degraded 1.5 faster than those left on the ground (**Figure 1**). For example, while after 5 months since the beginning of the experiment leaves were completely degraded, stems were still found at the site, ranging from 40% (buried) to 50% (surface) of initial biomass. These results are explained on one hand by the greater fragility of leaf tissues compared to stems, and by a more intensive decay when residues are buried and with a greater contact area with soil microbes.

Fungus spore population on residues decreases quite rapidly to reach about 10% of initial population on surface and 3% of buried residues only one month after the experiment begun. Four month later (at the offset of experiment), only 1% was still found on residues. Pathogenic ability also decreased quite dramatically during the experiment to reach very low levels after 2 months (**Figure 2**). Both decrease in spore number and pathogenic ability are linked to the state of plant residues, since the fungus only develops on living tissues. The very low survival can also be associated with the strong competition by soil microbes that are degrading the remaining tissues.

3. Limits and perspectives

Our results demonstrated that five months after harvest, only stems left at soil surface could still initiate a new epidemy whenever yams would be planted again on the same plot. This risk is quite reduced due to the very low remaining biomass and very low number of surviving spores. It would nevertheless seem wiser not to plant yams from a non-resistant variety on a plot that had declared the disease during the previous year..

4. To learn more...

INRA 2005 Anthracnose (maladie fongique des parties aériennes).

http://www.antilles.inra.fr/la_documentation/dossiers_et_documents/igname



Picture 1 : Experimental plot to study decaying rate of yam residues



Figure 1 : Yam residues decay over time (variety Pacala).

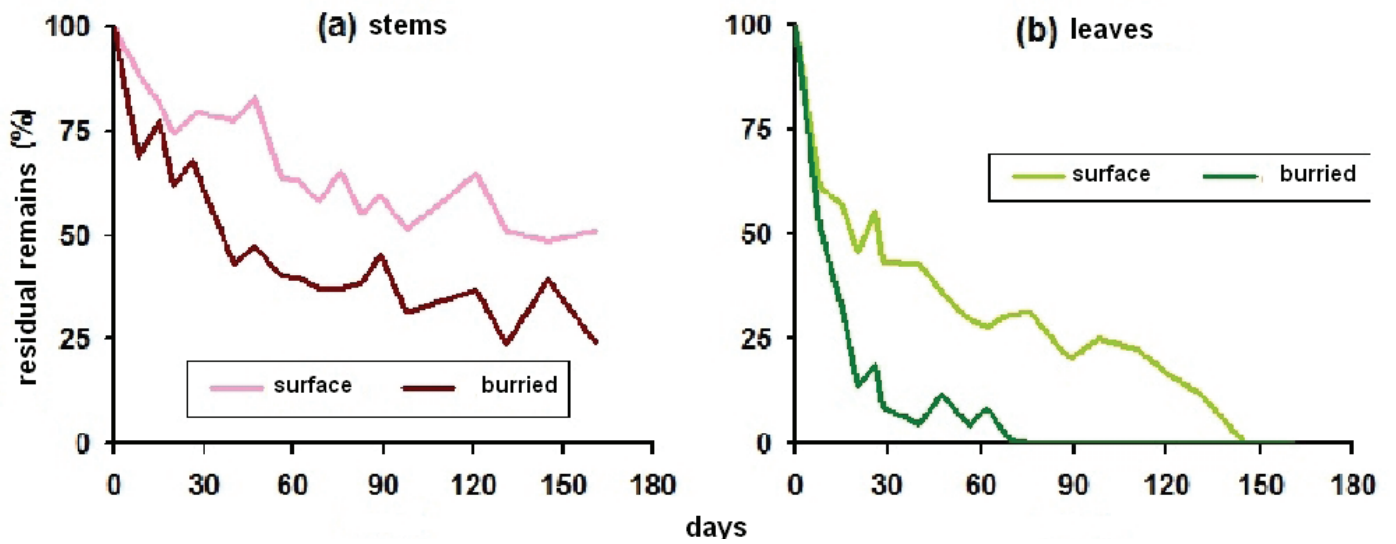
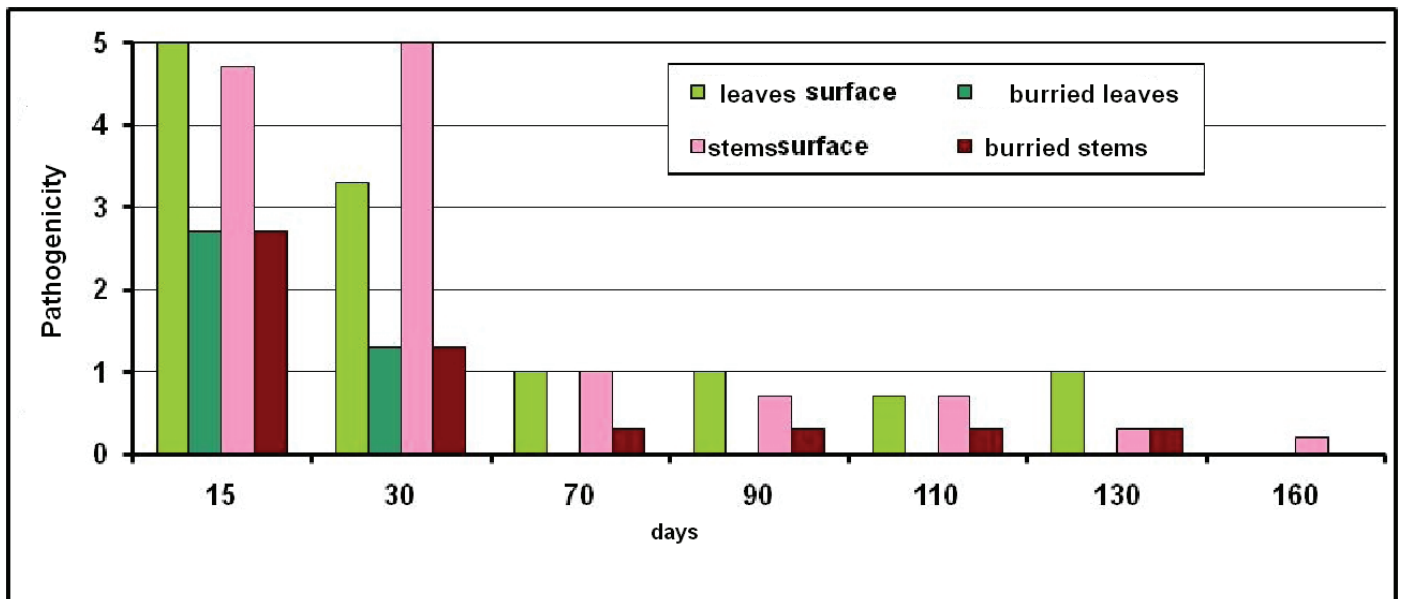


Figure 2 : Variation of pathogenic ability of residues over time: Pathogenic Indices 5: >75% of leaf has necrosis, 4: from 51% to 75%, 3: from 21% to 50%, 2: from 6% to 21%, 1: from 1% to 5%, 0: without necrosis..



Creating new varieties in yam (*D. alata*): from abiotic and biotic identified constraints to new cultivated hybrid variety.

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1. Issue and aims

Despite an important nutritive, economic and socio-cultural value of yam in tropics or more specifically in Antilles, this crop is affected by strong constraints resulting in a regression of cultivated surfaces.

Major agronomic constraints as cited by producers themselves are phytosanitary concerns, weed control and water availability in some area, but also the availability of more diverse quality seeds.

Because of a lack of certified pesticide and herbicide in yam farming and with the current trend to reduce the use of synthetic inputs, breeding programmes may solve these new challenges to improve yam crops. The issue at stake is to create yam varieties from various species that are adapted to different agro-pedo-climatic farming zones, resistant to diseases (anthracnose, curvularia, viruses) and appealing to consumers tastes.

2. Description and results

Facing these challenges, INRA created a Biological Resource Center with a collection of over 500 clones from different species :

- *alata* (igname blanche),
- *cayenensis* (igname jaune),
- *cayenensis rotundata* (grosse caille),
- *trifida* (cousse couche),
- *bulbifera* (adon),
- *esculenta* (pas possible)

from different geographical origins (New Caledonia, South America, Caribbean area, Nigeria, Ivory Coast, collection from Porto Rico).

A direct use is possible...

Clones from this collection can be used directly for production after field evaluations. So was the case of Bélep, Kinabayo and Oriental varieties which were suggested to producers because they were resistant to anthracnose. This strategy is still amenable especially for species like *esculenta* and *bulbifera*.

Variety Creation

Clones from the collection may also be used in breeding programmes to create new varieties.

3. Limits and perspectives

Perspectives Hybrids that are selected with producers as participative selection will be multiplied and put at producers' disposal. Hybrids from *alata* and *rotundata* from new breeding programmes are currently at the pre-selection phase at INRA.



Female flowers



Male flowers



Seeds



Breeding offspring



Tubers from hybrids



Adapting selection criteria

Selection criteria given known crop constraints

COMMON CRITERIA		SPECIES	SPECIFIC CRITERIA
Yield	Quantity, Regularity	<i>alata</i>	Resistance to anthracnose
Soil Cover	Quantity, Growth	<i>cayenensis-rotundata</i>	Tolerance to viruses
Tuber quality	Taste Flesh colour Shape Cooking behaviour		Tolerance to curvularia

Hybrid cultivated in Guadeloupe :

Boutou (good productivity, vigour, late, taste that is appreciated but flesh is coloured, producing bulbils, resistant to anthracnose).

Hybrids under evaluation in Guadeloupe :

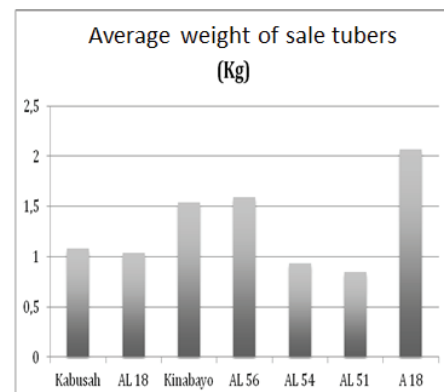
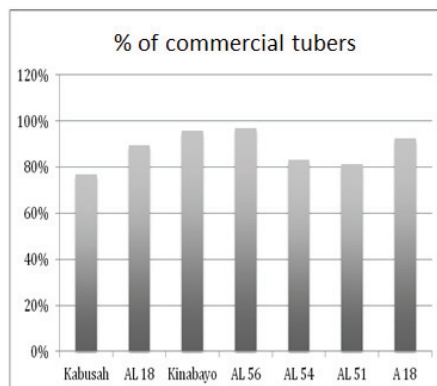
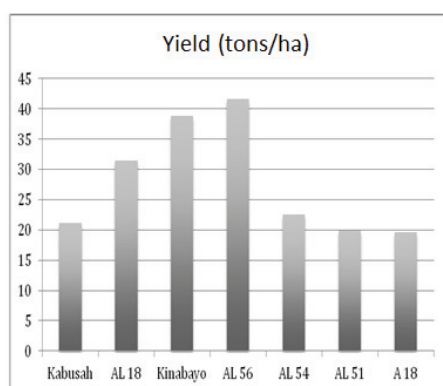
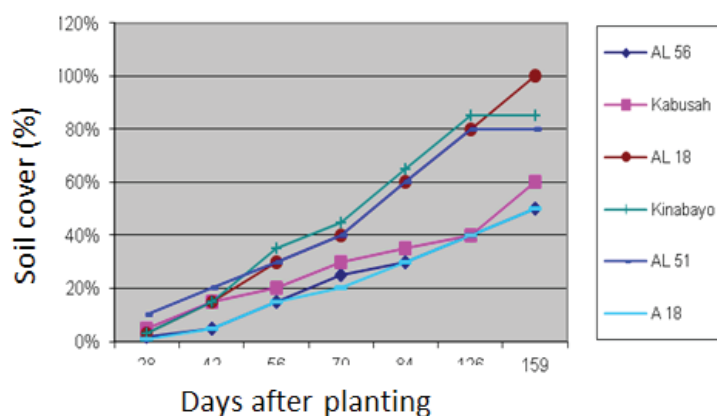
Tested at least four years in multiple locations in collaboration with the Agriculture Chamber.

4 hybrids from *alata* and 2 from *rotundata* were evaluated for their soil cover ability and yield.



Variety trial at Anse Bertrand, 4 months after planting

D. Alata cover evolution



Perspectives

Hybrids that are selected with participative choice will be multiplied and put at producers' disposal.

Hybrids from *alata* and *rotundata* from new breeding programmes are currently at the pre-selection phase at INRA.

Contamination of yams by Chlordecone: How and where?

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1. Issue and aims

Yam production is heavily impacted by Chlordecone soil pollution. Chlordecone is a highly persistent organochloride pesticide widely used against banana weevil between 1972 and 1993 in Guadeloupe. The recent discovery of Chlordecone in tubers grown in contaminated areas dramatically decreased agricultural diversification in the Guadeloupean "banana belt". The distribution of this pollution in soils and its persistence evaluated at a few decades at best to a few centuries at worst raised many questions: Are contaminated soils unsuitable for any yam farming for that long? Are there means to produce yams while reducing contamination risk? What is the link between soil contamination and further plant and tuber contamination? Are there processes to potentially increase speed of soil restoration? All these questions first need an understanding of how the molecule is absorbed and stocked in plants and more specifically in yams.

2. Description and results

Experiments were designed to study the relationship between soil Chlordecone concentration and concentrations in different plant organs. Plants were grown in fields either in contact to polluted soils or in containers with healthy soils with roots allowed to grow in polluted soils. Other greenhouse experiments allowed characterizing water absorption by plants grown in soils with various degrees of pollution in order to further measure the subsequent distribution of Chlordecone in the different tissues. Chlordecone quantity in soil is a function of initial pollution, soil's nature, and its organic matter composition since the molecule has strong association rates with organic matter. Rainwater leaching systematically dissolves only a tiny fraction of soil fixed Chlordecone, and this is the only known process for soil decontamination to date. Pollution will last much longer and environmental fluxes will be lowest for andisols, which strongly retain the pesticide, while nitisols have a lower initial stock but are leaking 5 times more easily water fluxes (**Figure1**).

This very low fraction of Chlordecone in soil solution can then be absorbed by plants. As a consequence, contamination of below ground organs is only dependent upon soil contamination levels and pollutant transfer in plants can only occur via root absorption and contact between integument and soil (**Figure 2**). There is no preferential process of Chlordecone extraction that would lead to Chlordecone accumulation in plants.

In plants, Chlordecone is quickly fixed on hydrophobic tissues (lignin, suberin) of epiderm and bark and tracheids and vessels. In yams, Chlordecone is thus adsorbed in tubers just below the epiderm and along roots and stems. Tuber peelings have Chlordecone concentrations that are 20 times higher than tuber flesh. In roots and stems, the molecule is fixed quickly in tissues for which it has the greatest affinity and subsequent xylem sap has lower and lower Chlordecone concentration: most of the plant contamination does not flow after the very first meter of stem

3. Limits and perspectives

These first results give us a better understanding of Chlordecone contamination process in yams, but they should be further investigated with specific studies of interactions between lignin and the pollutant, aiming to a general modeling of plant contamination. Moreover, new directions for remediation studies are undertaken by international research teams.

4. To learn more...

Cabidoche, Y.M., Lesueur-Jannoyer M., 2012. Contamination of Harvested Organs in Root Crops Grown on Chlordecone-Polluted Soils. *Pedosphere* 22(4), 562-571

<http://transfaire.antilles.inra.fr/spip.php?article103>



Figure 1 : Maps for a) soil pollution risks by Chlordecone in Guadeloupe (DAAF-SA Guadeloupe, INRA-ASTRO, 2006): higher risk in red to negligible (grey) ; and b) General scheme for Guadelupean soils.

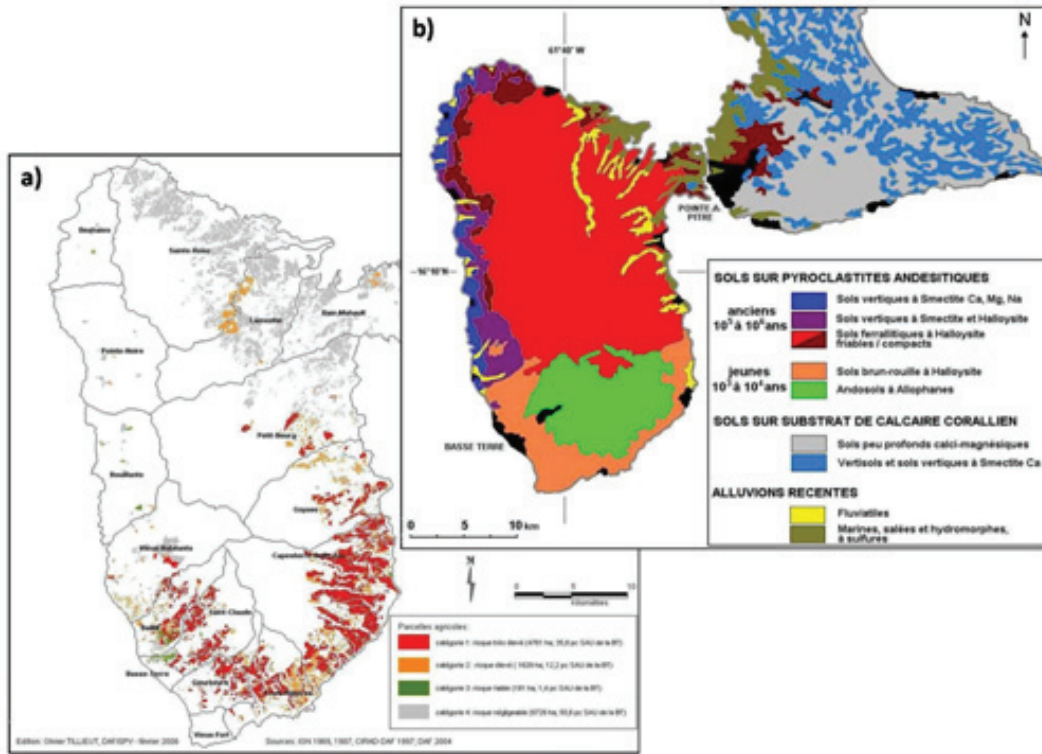
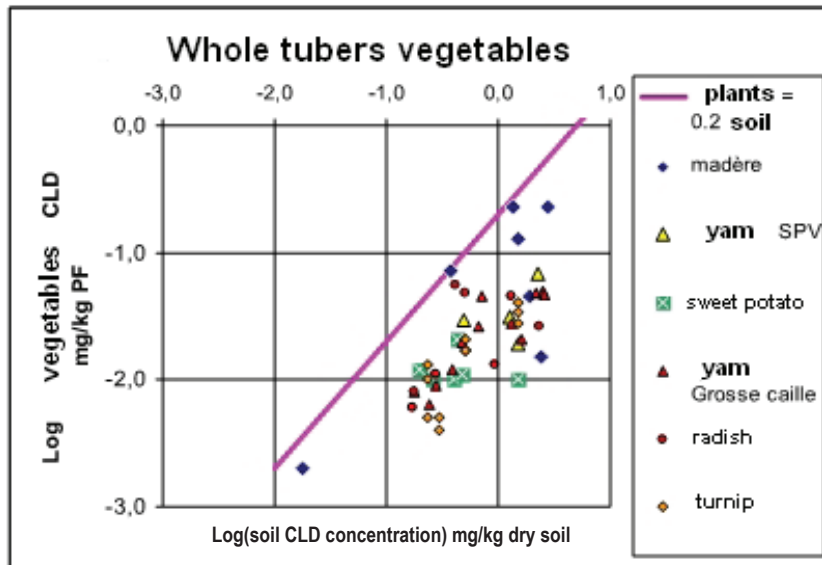


Figure 2 : Relationship between Root Chlordecone(CLD) concentration and peelings and the soil concentration.



Ignamarge: a technical and economic evaluation tool of yam production

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1. Issue and aims

Ignamarge creation answered two needs: first, we needed a model to analyze and simulate the economics of yam production (yam is the first food crop in Guadeloupe but is barely studied there); and second, we wanted a tool that farmers could use to choose technical practices that would help them optimize the economic performance of their cropping system.

2. Description: Ignamarge: What is it for? Who is it for?

Ignamarge is a software (cf. **Figure 1**) occurring as an Excel sheet that enables one to :

- i) Characterize yam production within farms while calculating technical and economic performance (labor time requirements, costs, benefit margin, break-even point, etc.).
- ii) Simulate the impact of technical or economic changes (changes in production modes, cultural innovations, evolution of market prices, etc...).

Input parameters :

- i) Yam production mode : cultivated area, labor cost, selling price, yield, etc...
- ii) Crop management system : each cultural operation is defined by its technical modality and described by its frequency, input quantities whenever applied and subsequent time load.

Output results:

- i) Production costs and their distribution (allocation between labor and inputs, allocation along the different steps in the crop management system);
- ii) Gross margin, net margin;
- iii) Total labour needed ;
- iv) Break-even point (the yield being the adjusted parameter), total cost per kilo of the final product.

2.1 Characterizing crop management systems and their economic performance

Six typical situations are suggested (cf. **table 1**). They do not cover the whole range of ways to grow yams in Guadeloupe but they do correspond to the most frequent cases and were assessed by surveys and expert knowledge. For each situation, baseline results are estimated.

Whenever a crop management system does not fit a suggested situation, any user can create its own type and investigate its own technical and economic performance. Simulating different crop management system is possible by redefining the initial situation.

2.2 Assessing the impact of different technical or economic changes on economic performance

As illustrative examples, here are a few scenarios that can be tested with Ignamarge :

- Changes in crop management system: transition from hand weeding to mulch, changes in cultivated variety, changes in fertilization strategy.
- Changes in cost of labor, fluctuation in yam selling price or input purchase price.
- Increase or decrease in labor time requirements or total yield.

2.3 Ignamarge simulator is directed at :

- Farmers and farm managers, farmers' organizations, extension services...
- Policy-makers, R&D institutes, etc ...

3. Limits and perspectives

The survey used for model calibration currently has a narrow base. Consulting with more farmers and professional from agricultural extension services will enable better parameters adjustment and analysis of new situations.

4. To learn more...

Causeret F., Barlagne C., Blazy JM., 2012. Ignamarge©: a technical and economic evaluation tool of yam production for decision making. Operating instructions. Version 1.01. September 2012, 8p. (In French)

Bertrand, C., 2011. Technical and economic evaluation of yam cropping systems in Guadeloupe. Master report (1st year) l'ENSAIA Nancy, 21 pages. (In French).

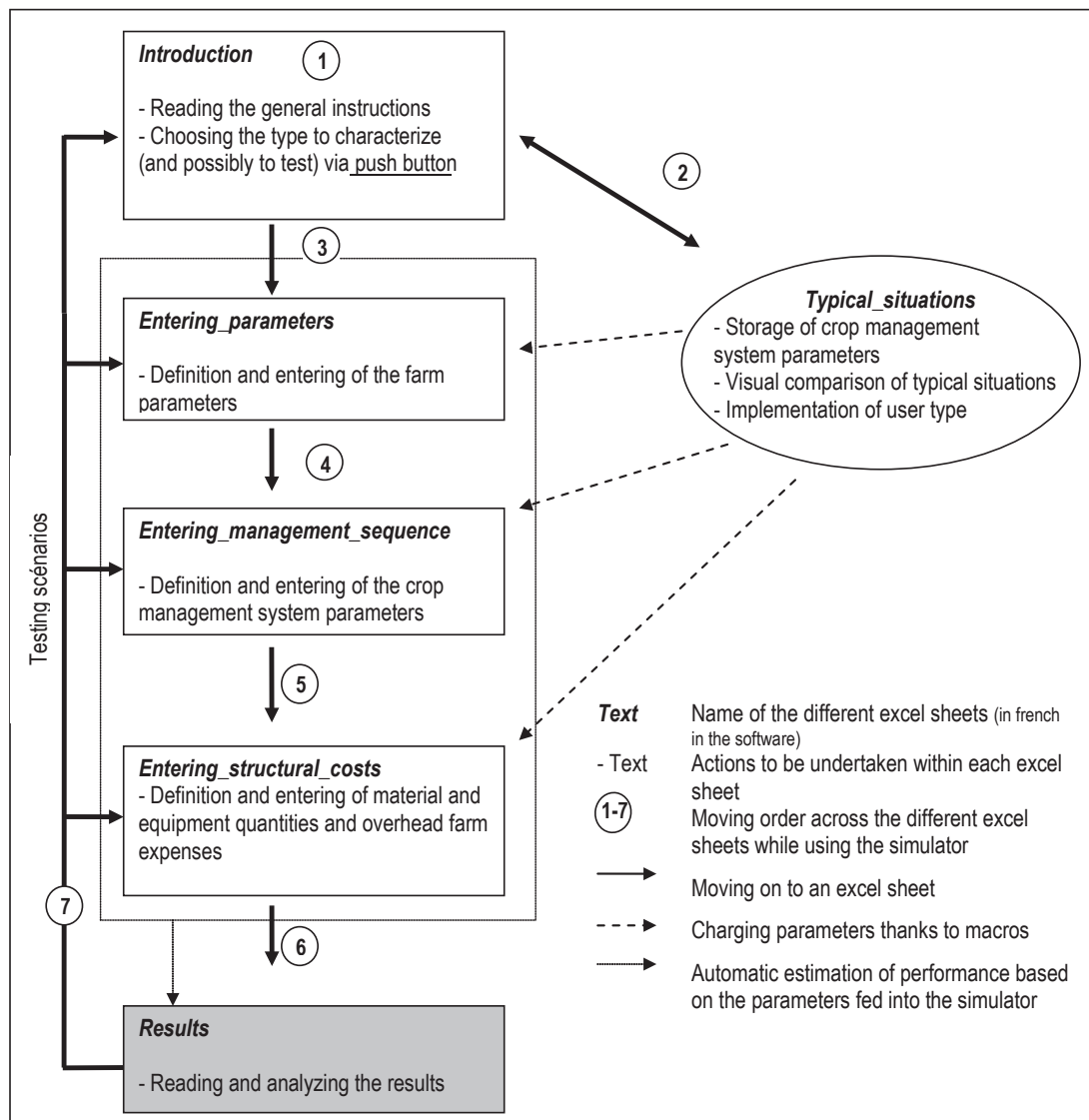


Table 1 : Characteristics and typology of six common yam management systems

*A double harvest implies that farmers first collect the tubers that meet market standards and then seed tubers providing that the leafy part of the plant has not been removed in between the two harvests.

	T1	T2	T3	T4	T5	T6
Cropping area	Basse-Terre	Basse-Terre	Grande-Terre	Grande-Terre	Grande-Terre	Basse-Terre
Species	<i>D. cayenensis</i>	<i>D. alata</i>	<i>D. cayenensis</i>	<i>D. alata</i>	<i>D. esculenta</i>	<i>D. esculenta</i>
Staking	Yes	No	No	No	No	Yes
Irrigation	No	No	Yes	Yes	Yes	No
Type of harvest	By hand Double*	Half-mechanized	Half-mechanized	Half-mechanized	Half-mechanized	By hand
Weight of seed tubers (g)	130	120	90	70	70	70
Tillage	Mechanized	Mechanized	Mechanized	Mechanized	Mechanized	Mechanized
Type of harvest	Manual Double*	Half-mechanized	Half-mechanized	Half-mechanized	Half-mechanized	Manual

Figure 1 : Overall structure, functioning and steps to implement as modeled in Igmamarge simulator.



Growing yam in Guadeloupe : How much does it cost and how much does it pay?

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1. Issue and aims

Yam is a long cycle (6 to 12 months) annual crop that is usually considered profitable in Guadeloupe as long as growing conditions are favorable. Nevertheless one has to invest a lot in the cropping system before one can make a benefit from yam farming. Additionally, the great diversity of plot locations and cropping systems in Guadeloupe result in quite different technical and economic performances. We illustrate them here with six typical crop management systems and further analyze their outcome under average price and yield estimates.

2. Description and results

The six crop management systems here were built with Ignamarge, a tool which enables characterization and simulation of technical and economic performance of yam production. These situations are delineated by cropping area, cultivated yam species, seed weight, staking of the crop, irrigation system and type of harvest. These characteristics are summarized in **Table 1**.

There is a great variability in technical and economic performance within these six situations (Table 1). Gross product is always high (22 500€ to 30 000€) with a relatively low rate of change among situations (+33% between lowest and highest performance). Production costs are very important (11 496€ to 21 002€) and with a greater rate of change between situations (+83% between lowest and highest). This cost is due to contrasted farming practices. As a result, gross margin (gross product – production costs) ranges from high (8 631€) to very high (17 130€) with a high variability between situations (+98% between lowest and highest).

Situations T1 & T4 have the most contrasted technical characteristics in our typology. Gross margin for T4 is greater than gross margin for T1 by 6506 €/ha/cycle. This difference is best explained by higher costs for T1 because of staking (+4 042 €), preparing of seed tubers (+3 778€), harvesting (+994€) and weeding (905€), despite a higher gross product for T1 (+30 000€). These steps are the most expensive in yam management systems (**Figure 1**). With regard to the other technical and economic parameters, we notice three main points :

→ i/ Break-even point (minimum yield for which production costs are balanced by benefits) in T1 is about 11 tons/ha/cycle rather than 8 in T4 situation. Therefore T4 situation is fully balanced with a lower yield.

→ ii/ Unit cost of production for T1 is about 1.46 €/kg and 0.68 €/kg for T4. So T1 needs a greater selling price to balance production cost than does a T4 situation (selling price has to exceed 1.46 €/kg in T1 against 0.68 €/kg in T4).

→ iii/ Labor time required in T1 equals 1115 h/ha/cycle against 564 in T4 (**Figure 2**). The difference is due to staking, type of harvest (by hand and double¹ in T1), and weeding (lower out-weeding in T4 because of faster ground cover with *D.alata* varieties).

In summary, situation T4 is economically more efficient than situation T1. Some geographic location indeed allows for more favorable technical choices.

3. Limits and perspectives

In the light of this technical and economic analysis, yam is a demanding crop with regard to cash investment and labor time requirements, but whenever yields expectations are met (between 7 and 11 tons/ha/cycle) it is raising benefits whatever the situation considered. Nevertheless, some situations are more favorable compared to others (T3 has the highest gross margin). Moreover, it is especially important to consider that the different combinations of practices cannot be implemented in all farming locations. Those locations have indeed diverse constraints and potentialities (soil fertility, topography, rains, and pathogen contamination risks). It is only with a full and wise consideration of these parameters and their own economic goals that farmers will be able to make the best technical choices.

4. To learn more...

Causeret F., Barlagne C., Blazy JM., 2012. Ignamarge©: a technical and economic evaluation tool of yam production for decision making. Operating instructions. Version 1.01. September 2012, 8p. (In French).

¹A double harvest implies that farmers first collect the tubers that meet market standards and then seed a tuber providing the leafy part of the plant has not been removed in between the two harvests.



Table 1 : Characteristics of the 6 common yam management systems

*A double harvest implies that farmers first collect the tubers that meet market standards and then seed a tuber providing the leafy part of the plant has not been removed in between the two harvests.

Type	T1	T2	T3	T4	T5	T6
Cropping area	Basse-Terre	Basse-Terre	Grande-Terre	Grande-Terre	Grande-Terre	Basse-Terre
Species	<i>D. cayenensis</i>	<i>D. alata</i>	<i>D. cayenensis</i>	<i>D. alata</i>	<i>D. esculenta</i>	<i>D. esculenta</i>
Staking	Yes	No	No	No	No	Yes
Irrigation	No	No	Yes	Yes	Yes	No
Type of harvest	By hand, double*	Half-mechanized	Half-mechanized	Half-mechanized	Half-mechanized	Manual
Weight of seed tubers (g)	130	120	90	70	70	70
Yield (t)	15	15	15	18	13	13
Labour cost (€/h)	11.31	11.31	11.31	11.31	11.31	11.31

Table 2 : Main technical and economic results for the 6 situations

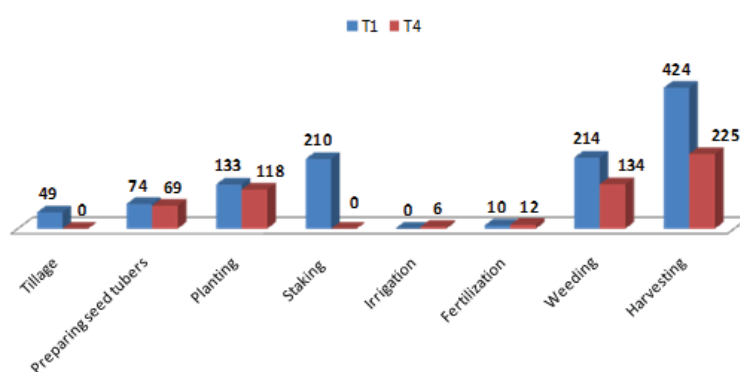
*Costs without structural costs and depreciation.

Type	T1	T2	T3	T4	T5	T6
Gross income (€/ha/cycle)	30 000	22 500	30 000	27 000	26 000	26 000
Gross margin (€/ha/cycle)	8 998	9 777	17 130	15 504	13 317	8 631
Break-even point (kg/ha/cycle)	10 979	9 119	6 791	8 189	6 819	9 162
Labor time requirement (h/ha/cycle)	1 115	710	574	564	613	976
Unit cost* of production (€/kg)	1.46	0.91	0.91	0.68	1.05	1.41
Cost* of production (€/ha/cycle)	21 002	12 723	12 870	11 496	12 683	17 369

Figure 1 : Distribution of costs for a crop cycle (8 months) for situations T1 and T4.



Figure 2 : Labor time requirement (hours/ha/cycle) for a crop cycle (8 months) for situations T1 and T4



Strengths and weaknesses of the different yam marketing chains in Guadeloupe

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1. Issue and aims

Yam is mostly sold via informal distribution chains in Guadeloupe (FWI). In order to devise options for an improved structuring of the sector, we needed to identify the current distribution chains and understand how they work and the reasons for their existence. We inquired yam farmers and retailers and characterized the different marketing chains. We also assessed their advantages and inconveniences. Consequently we identified the marketing strategies adopted by the different actors.

2. Description and results

6 300 tons of yam are produced yearly in Guadeloupe for a total of 8 200 tones consumed, resulting in a coverage rate of 78% (Chambre d'Agriculture Guadeloupe, 2011, data of 2009). The complementary 1900 tons of yam mainly come from Costa Rica and Dominica.

Local production is mostly sold through short distribution chains (chains that count a maximum of one intermediary). We extrapolated data from our inquiries and estimate that 3000 tons of yam are sold on retail markets either by yam farmers themselves (farmer-retailer) or by retailers (cf. **figure 1**). 3200 tones are distributed between itinerant sale, direct farm sale, sale to small retailers (small supermarkets, green-groceries and restaurants) and sale to wholesaler-collectors (collection of the harvest at the farm-gate). Part of the harvest is dedicated to household consumption. Only a small proportion of the production (100 tons) is sold through cooperatives. Given these facts, we identified 5 marketing methods used by local farmers to first-stage market their production. These chains are characterized by a varying number of intermediaries, ranging from no intermediary at all (direct sale) to two intermediaries (wholesaler-collectors and retailers) between farmers and consumers (refer to **figure 1**).

Direct sale (itinerant sale and direct farm sale) is informal. It is characterized by no specific contract, a higher price paid to the farmer than in any other chain, zero payment terms and lower quality requirements regarding the product. On the other hand, it implies that farmers dedicate a large part of their activity to marketing and they need to be properly organized between production and marketing activities.

On the opposite, longer distribution chains (two intermediaries)- and particularly those involving cooperative- imply contracting on price, volumes and quality of the tubers. These chains appear to have a high level of constraints from the farmer's point of view, which can explain that only small volumes of yam are marketed these ways. Yet, cooperatives guarantee the sale of the production and give the insurance to sell it all and at a price known in advance. Additionally they provide access to marketing subsidies and help to save time that can be reallocated to production activities.

Other chains are characterized by contrasted levels of commitment between farmers and intermediaries. Whenever there is a contract, it is generally an oral contract based on mutual trust. Those chains have diverse characteristics regarding selling of the production. Those are represented in **Table 1**. Imported Costa Rican yam is marketed through long chains that count with wholesale firms as the main intermediaries while wholesale-collectors and retailers are involved in the marketing of Dominican yam (cf. **figure 1**).

3. Limits and perspectives

Properly speaking, there is no ideal marketing method for yam. Being aware of advantages and inconvenience of each marketing method (level of remuneration, marketing risk, time dedicated to marketing, quality requirements) is what makes farmers decide the strategy that best suits their objectives and production factors endowment.

4. To learn more

Le Roux, C. (2011). Study of yam marketing network in Guadeloupe. Master thesis. Petit-Bourg, Guadeloupe, ISTOM, School of International Agro-development and French National Institute for Agricultural Research. Research Unit: Tropical Agrosystems: 77p. + appendices. (In French).



Figure 1 : Yam marketing chains in Guadeloupe

*Small retailers = Green groceries, small supermarkets, restaurants

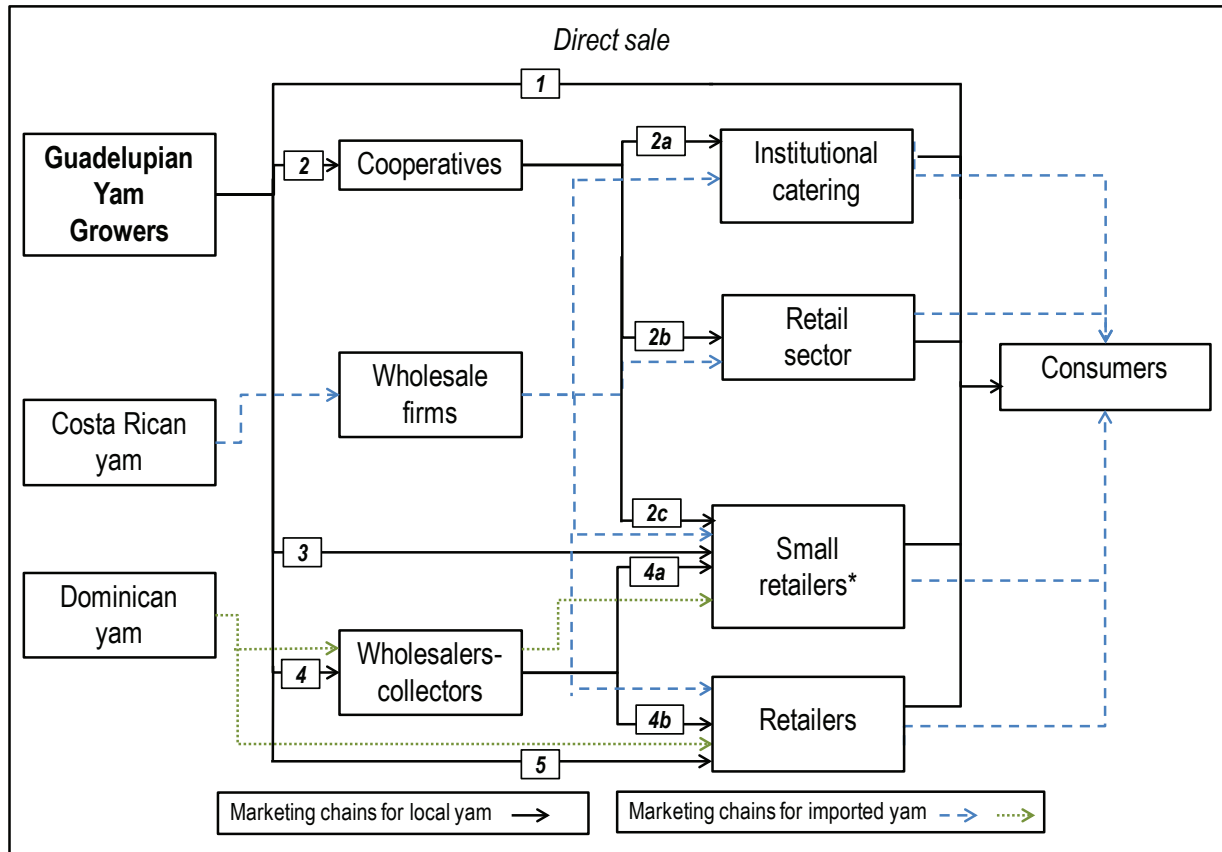


Table 1 : Assets and constraints of the different marketing chains according to yam farmers

Marketing chain	Characteristics of the marketing chain
1/ Direct sale	Low to medium guarantee on sales. High remuneration. Big amount of time dedicated to marketing and short payment terms. Small to medium volumes sold. Low quality requirements regarding marketed tubers.
2/ Farmer ↓ cooperative	High guarantee on sales. Low remuneration but access to subsidies on marketing. Small amount of time dedicated to marketing and long payment terms. Big volumes sold. High quality requirements regarding marketed tubers.
3/ Farmer ↓ Small retailers	Low to high guarantee on sales. Medium to high remuneration. Small amount of time dedicated to marketing and short payment terms. Small to big volumes sold. High quality requirements regarding marketed tubers.
4/ Farmer ↓ Wholesaler- collectors	High guarantee on sales. Low remuneration. Small amount of time dedicated to marketing and short payment terms. High volumes sold. Low quality requirements regarding marketed tubers.
5/ Farmer ↓ retailers	High guarantee on sales. High remuneration. Small amount of time dedicated to marketing and short payment terms. Small volumes sold. Low quality requirements regarding marketed tubers.

Strengths and weaknesses of yam sector and prospects for improvement

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1. Issue and aims

Yam is the first crop grown in Guadeloupe in both terms of area (450ha) and production (3600 t). Local production covers 78% of the needs and contributes among other products to food self-sufficiency in Guadeloupe (Chambre d'Agriculture, 2009). However, this high potential sector faces difficulties at different levels (production, distribution and consumption) that hamper its competitiveness. In order to understand better its strengths and weaknesses we inquired yam producers, retailers, consumers as well as extension services. The present work is an assessment of the strengths and weaknesses of the sector from the point of view of different stakeholders. We also suggest options for improvement.

2. Description and results

A cross-analysis of the sector revealed that actors' expectations and proposals are numerous and diverse, which highlights the fact that there is a great potential for improvement (Table 1). Consumers are generally willing to eat more yams, which they usually consider as a quality product. They would like to have access to a greater varietal diversity. Other consumers, who are also less knowledgeable about the crop, consider that yam is long to prepare and is not tasty, especially for children. For everybody yam is still an expensive product that can only be afforded depending on family budget. Therefore, it could be interesting to offer increased varietal diversity to consumers as well as different forms of processed products (ie. peeled or pre-cooked yams), thus providing competitive product supplies compared to other stark foods (pastas, rice, etc...). Intermediaries support consumer demand and are also interested in more varietal diversity. Additionally, they would like yams to be of more homogeneous quality and the supply to be more regular. On the production side, farmers' expectations are currently difficult to satisfy because of important phytosanitary constraints affecting varieties that consumers appreciate a lot but that prove difficult to grow. Prospects for improvement of the sector are: counter-season production of non-photoperiodic cultivars, stretching of production taking advantage of the fact that there are short and long cycle cultivars, storage facilities, improvement of cultural practices. Also, the production could be more diverse and of higher quality (production of seed tubers of rare varieties, taking advantage of the diversity of soil and climate conditions in Guadeloupe).

Additionally, the marketing value of products could also be improved through more attractive marketing varieties and by increasing consumers' awareness of the existing varietal diversity. Our results also suggest that a prospect for development could be improving the fit between demand and supply. To do so, we need to characterize consumers' expectations and identify the drivers of their own choices (i.e., the guarantee on the origin and production type, taste criteria, price...).

3. Limits and perspectives

Our proposal was built from a representative sample of the diversity of stakeholders. It enables us to draw prospects for the development of the yam sector in Guadeloupe, in accordance with stakeholders' expectations.

4. To learn more...

Defêche, C., 2005. Diversity of yam growers' agronomic and technical practices in Guadeloupe. Petit-Bourg, Guadeloupe, INRA AG APC: 57p + appendices. Report produced within the frame of a voluntary civil service for technical support. (In French).

Le Roux, C. (2011). Study of yam marketing network in Guadeloupe. Master thesis. Petit-Bourg, Guadeloupe, ISTOM, School of International Agro-development and French National Institute for Agricultural Research, Research Unit: Tropical Agrosystems: 77p. + appendices. (In French).

Merlot, J.-C., 2007. Yam growers' marketing strategy and consumer demand in Guadeloupe. Diagnostic elements for the drafting of a marketing policy. Masterthesis. ENITA (French National School of Agricultural Engineers), UPROFIG, ARECA : 43p + appendices. (In French).



Stakeholders views of the strenghts and weaknesses of the yam sectors and proposals for their development

	Producers	Retailers	Consumers
Strenghts and weaknesses	Profitable crop but with important labour time requirement and high risks on production	Yam, « a product that sells good » but whose supply has to be regulated and commercial quality enhanced	Yam is an appreciated local product but it is too costly for some consumers while for others it does not fit with the new patterns of food consumption
	Sensitivity to fungal diseases and pests High sensitivity to weed infestations and droughts Lack of healthy seed tubers Imported yam is responsible for the decrease of local yam price and it can potentially cause phytosanitary problems	Local production irregular due to constraints at the production level and lack of technical advice and planning Lack of quality and homogeneity of local production: twisted and dirty tubers, lack of calibration Lack of organization and endorsement among farmers Local yam too costly	Hurdles at the consumer level:: price, lack of interest from children, time and difficulties at cooking stage, lack of knowledge about the identity of yam and lack of taste Drivers of consumption: taste, willingness to eat local products, quality of products
Proposals	Producing more Seeking solutions against diseases Improving access to seed tubers Organizing producers into groups Subsidizing local yam Developing linkages with consumers Regulating yam importations Avoiding cultivation of non competitive yam cultivars compared to imported yams Developing yam processing	Encouraging yam consumption Offering processed products to consumers Improving linkages between producers and retailers Homogenizing the quality of production Increasing the provision of different cultivars Increasing commercial outlets for cooperatives	Providing new forms of product conditioning and processing? Spreading new recipes ? Improving the knowledge of the different cultivars ? Offering more calibrated products fitted for family consumption ? Offering more cultivars and more often ?

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