Improving technical support for vegetable production in Mayotte through the creation of Recommended Technical Itineraries

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Master Thesis 30 credits 2013

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Master thesis

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To obtain a master in Agroecology and a diploma in Agronomy Engineering

Trainee's supervisor: Elodie Savignan

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SUMMARY

The Network for Innovation and Transfer in Agriculture (RITA) of Mayotte is piloting a project on Recommended Technical Itineraries (ITR). The agricultural school of Coconi is the intermediary of the project. The aim of this project, among others, is to improve technical support given to vegetable producers. The vegetable sector of Mayotte is marginal but in constant progress. The producers are seeking technical support but there are only two technicians for the entire island. The creation of three ITR documents on dwarf bean production, organic amendments and sustainable plant protection would improve technical support and sustainability of the sector. The tools used to create the documents were: establishing experimentations on dwarf beans and organic amendments but also interviewing farmers and gathering all results on research specific to Mayotte. The results of the experiments on dwarf beans showed that Contender is the most reliable variety that can be cultivated in Mayotte. The Primel and Cora varieties presented good yields but unfortunately it is not possible to purchase Primel in Mayotte and the Cora variety needs to be tested again because of the large dispersion of its yields. The dwarf bean production seems more adapted to the dry season. However the vegetable producers of Mayotte are not very enthusiastic about cultivating this crop because of the amount of labor needed during the harvesting period. The experimentation on organic amendments has not yet produced analyzable data. The experimentation will be conducted until June 2017. Out of the 20 farmers interviewed, 19 of them are using phytosanitary products to control pests but also dried chicken manure to fertilize their crops. Most of them do not collect any data of their productions. The three ITR documents created were distributed to technicians and are available on the internet web site of the RITA of Mayotte. These new tools will help improve technical support for the vegetable production sector in Mayotte.

Key words: Mayotte, vegetable production sector, technical support, ITR.

Le Réseau d'Innovation et de Transfert en Agriculture (RITA) de Mayotte pilote un projet d'Itinéraires Techniques Recommandés (ITR). Le lycée agricole de Coconi est l'intermédiaire du projet. L'un des buts de ce projet est d'améliorer le conseil technique auprès des producteurs maraîchers. Le secteur du maraîchage à Mayotte est marginal mais en constante évolution. Les producteurs sont très demandeur de conseil technique mais il n'y a que deux techniciens pour l'ensemble de l'île. La création de trois documents sur la production de haricot vert nain, sur les amendements organiques et la protection durable des cultures peut améliorer le conseil et la durabilité du secteur. L'établissement d'expérimentations sur les haricots verts nain et les amendements organiques mais aussi interviewer des fermiers et rassembler toutes les résultats de la recherche spécifique à Mayotte sont les outils utilisés pour créer les documents. Les résultats des expérimentations sur les haricots verts nains montrent que Contender est la variété la plus fiable qui peut être cultivé à Mayotte. Les variétés Primel et Cora présentent de bon rendements mais il n'est pas possible d'acheter Primel à Mayotte et Cora a besoin d'être à nouveau testée compte tenu de la large dispersion de ses rendements. La production de haricot vert nain paraît plus adaptée à la saison sèche. Cependant, les producteurs maraîchers de Mayotte ne semblent pas très enthousiastes en ce qui concerne cette culture du fait des besoins en main d'œuvre important lors des récoltes. L'expérimentation sur les amendements organiques n'a pour l'instant pas produit de données exploitable. L'expérimentation va être conduite jusqu'en Juin 2017. Sur les 20 fermiers interviewés, 19 utilisent des produits phytosaintaires pour lutter contre les bioagresseurs des cultures mais aussi des fientes de poules séchées pour fertiliser leurs cultures. La plupart d'entre eux ne collecte pas d'informations sur leurs productions. Les trois documents ITR créaient ont été distribués aux techniciens et sont disponible sur le site internet du RITA de Mayotte. Ces nouveaux outils peuvent être utiles pour l'amélioration du conseil technique du secteur maraîcher de Mayotte.

Mots clés : Mayotte, maraîchage, conseil agricole, ITR.

THANKS

I would like to thank everyone that helped me during the elaboration of this master thesis.

First I would like to thank my supervisor, Elodie Savignan, who has supervised this mission.

Then I would like to thank Emilie Perreard, agricultural engineer from ISA. Thanks for your good mood, your help and your advice on the elaboration of the experimentation carried out at the farm of the agricultural school of Coconi.

Thanks to Mister Sitraka Andrianarisoa, researcher and teacher at ISA who was my school supervisor. He gave me important advices on the elaboration of this master thesis and he did a final read-through of it.

I would like to thank Mathilde Brignoli, a student from Agroparitech. We did our internship together at the agricultural school of Coconi. She was very supportive and joyful throughout the work we did together, which helped considerably in the realization of the mission.

Thank you to all the professionals of the agricultural institutions of Mayotte who spared me their time to discuss and to elaborate the final ITR documents. I would like give a special thanks to Luc Vanhufel, vegetable crop technician for his good mood, his advice and for taking me around the island to meet farmers. Thomas Chesneau, researcher, thanks for his review of protocols of experimentations and for bringing me back seeds from La Réunion.

Thanks to Bernard Gagniardot, vegetable producer, for providing me with a piece of land, essential for the establishment of experimentation. Special thanks to Charles, head of exploitation for Mr Gagniardot, he helped me during the process of experimentation.

Thanks to Philippe Payet, vegetable producer, for giving me seeds.

I would like to thank Jelan and Gerard, agricultural workers at the farm of the agricultural school, for their availability, their great sense of humor, their strength and their advice on vegetable crop cultivation.

Thanks to Mélissa Galleron, for your patience, your support and your help.

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INTRODUCTION

The island of Mayotte is the 101st Department of France since 2011. This tiny territory of 374km² is located between Africa and Madagascar and is 9000 km away from mainland France. It is a world biodiversity hot-spot. It is an ancient volcanic island with rugged reliefs and lush tropical vegetation. There are two seasons: a hot and humid rainy season and a cooler dry season.
In 2012, the population of Mayotte was evaluated at 212 645 inhabitants and the first agricultural census of Mayotte carried out in 2010, showed that 1/3 of the population living on the island rely on agricultural production.

In 2010, the national institutions created the catch-up plan for Mayotte 2015. Its aim, among others, is to improve all agricultural sectors of the island. That is why sector based programs were established. The Chamber of Agriculture, Fishery and Aquaculture of Mayotte (CAPAM) was designated to supervise the program on vegetable production. Yet this sector is marginal, only 1250 farmers are producing vegetables and only a few individuals are specialized in this production. Nevertheless they are all seeking technical support but with only two technicians affiliated to this sector, improving it seems to be a difficult task. So how is it possible to improve technical support for vegetable production in Mayotte?
A project on Recommended Technical Itineraries (ITR) was established in order to facilitate the improvement of each sector of production. The Network for Innovation and Transfer in Agriculture (RITA) of Mayotte is supervising the project. It has for objectives to gather all research and information proper to Mayotte and to facilitate their transfer to farmers.
The agricultural school of Coconi, one of the few institutions of Mayotte providing agricultural education, is the intermediary of the project. It hires interns and gives them missions to create documents designated to technicians and farmers. These documents are the tools dedicated to improve the technical support of agricultural sectors of Mayotte. The farm of the agricultural school, which is supposed to be a model for all the farmers of Mayotte, is hosting various experimentations which will help in the creation of the documents.

First is described the study framework. Secondly the context and the problematic in which the mission takes place are presented. Then analyses of experimentations, interviews and bibliographic research follow. Finally the results are discussed.

A. STUDY FRAMEWORK

The agricultural school of Coconi is one of the few institutions providing agricultural education in Mayotte. The school is part of a project on Recommended Technical Itineraries and is the reception structure of trainees hired to work on different subjects of the project.

1. The agricultural school of Coconi

1.1. A singular history

The singularity of this institution, located in the centre of the island is that it started from being a local associative centre to becoming a public school of agriculture (Figure 1). At the end of 1977 a Pre-vocational Education Centre for Agriculture in Coconi (CFPA) was created, spurred on by the Association for Rural Development in Mayotte (ADRUMA). The CFPA used to welcome twenty students and had for objectives to support them in their establishment in agriculture. The center is recognized as a private institution for agricultural education and is under contract with the State, which gives it funds to create a Certificate of Professional Competences in Agriculture (CAPA).
The Association for Initial and Day Release Education of Farmers of Mayotte (AFICAM) created the 4th of April 1980 becomes the legal support of the CFPA. It is under contract with the Ministry of Food, Agriculture and Fishery (MAAP) as a non-affiliated private institution for agriculture. The AFICAM develops actions of training in agriculture while considering the specificities of Mayotte.
In 1991 the Department of Mayotte asked the Ministry of Agriculture to create a public school of agriculture. In return the Ministry ordered a mission of expertise that concluded the possibility of transforms the AFICAM into a public school of agriculture. The decree n°94-1058 of the 8th of December 1994 established the creation of the agricultural school of Coconi with the status of National Public Institution (EPN). The creation in 2002 of the Centre of Professional Training and Agricultural Promotion (CFPPA) completed the offers of training.
The transfer of classes from AFICAM to EPN would never be complete. Nowadays the agricultural school of Coconi has the specific singularity of unifying a public school (EPN) and a private school (AFICAM) to provide a mission of public service. They are grouping together their resources in order to optimize the efficiency of the institution. All EPN and AFICAM are designated by the term school of agriculture of Coconi (Eugénie, 2009) (DAF-SFD, 2010).

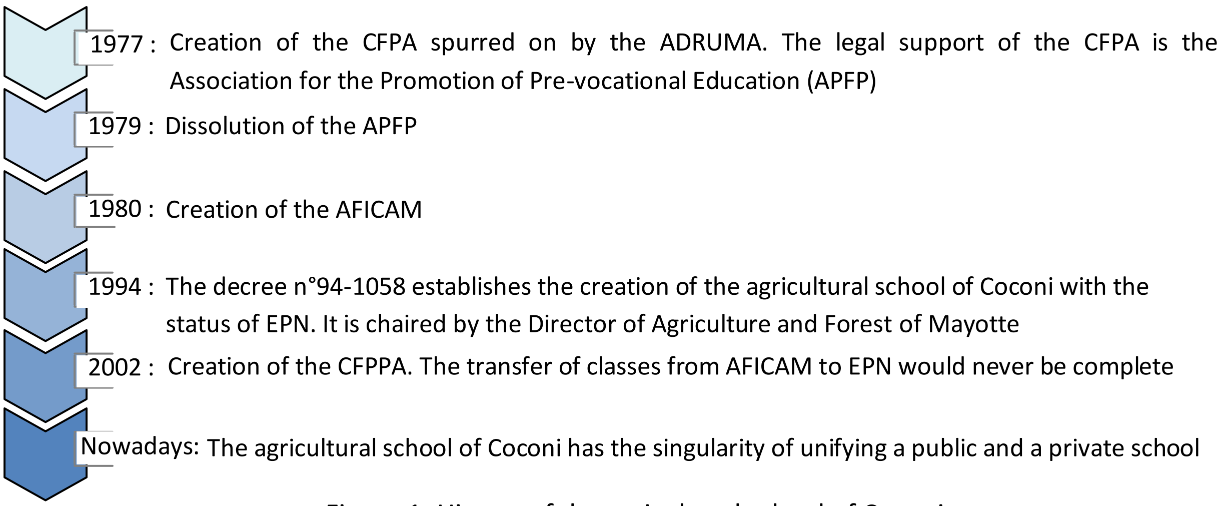


Figure 1: History of the agricultural school of Coconi
Source: (Eugénie, 2009) (DAF-SFD, 2010)

1.2. Sectors of activities

The agricultural school of Coconi is characterized by six sectors of activities (Figure 2).

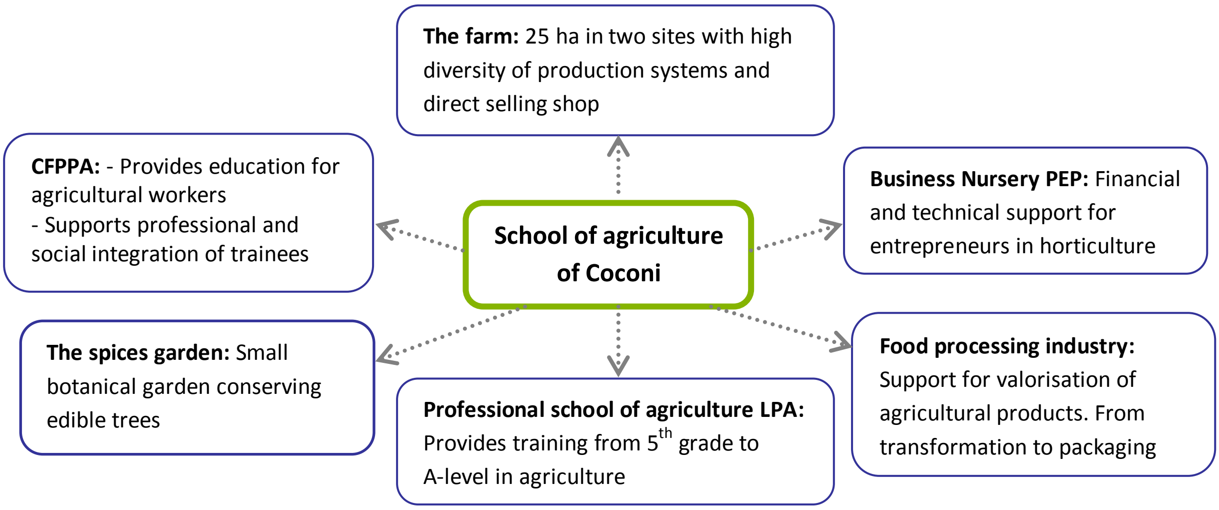


Figure 2: Sector of activities of the agricultural school of Coconi
Source: (Lycée agricole de Coconi, 2011a) (Lycée agricole de Coconi, 2011b)

The farm, the food processing industry and the Business Nursery (PEP) are structures providing real life situations of local agriculture. These structures are pedagogical supports used by teachers and trainers for the education of their students and trainees. Practical workshops are held weekly.

The agricultural school of Coconi ensures five missions according to the law of modernization of agriculture and fishery of the 27th of July 2010 (articles M811-1 and L813-1 of the rural code and fishery code). Those missions, reinforced through the six sectors of activities of the agricultural school, are:

- Initial and day release education, in general, technological and vocational training,
- Animation and development of rural territories,
- Scholar, social and professional integration of youths and adults,
- Development, experimentation and innovation in agriculture and food industries,
- Actions in international cooperation, especially promoting exchange of students, trainees and trainers (Lycée agricole de Coconi, 2011c).

1.3. Focus on the farm

The farm of the agricultural school of Coconi presents a high diversity of production, symbol of the agricultural diversity of Mayotte:

- Vegetal production: vegetable crops on open field and under greenhouse, food crops (banana and manioc), fruit trees (citrus, pineapple, papaya, jack fruit, breadfruit and coconut), vanilla, pepper and forage.
- Animal production: rabbit and duck breeding, battery-farming of chicken and dairy livestock.

All the products are sold directly on the spot at the “Banga des Délices” located at the entrance of the school or at the farmer’s market that takes place at the agricultural school once a month.
The mission concerns the vegetable production. The school’s farm dedicates 5000 m² of greenhouses and open fields for this type of production. The responsibility of the vegetable production was transferred from the head of exploitation to the person in charge of the PEP: Emilie Perreard (who is

also in charge of experimentations in vegetable production). There are also two workers employed annually.
No chemical inputs are used at the farm: fertilization of the soil is done by using exclusively duck and chicken manure from the breeding systems and the only treatments used for plant protection are macerations of plants. The six greenhouses, present on the farm, allow the development of off-season productions. Three of them were built in 2012 in order to promote the exemplarity of the farm. They are all equipped with shade nets and automatic drop by drop irrigation systems.

Besides its functions of production and commercialization and support for education of students and trainees, the farm is associated with research and development programs in collaboration with the International Centre of Agricultural Research for Development (CIRAD), the Department of Mayotte and the agricultural institutions. Research is carried out on the regeneration of the coconut plantation of Mayotte through the production of hybrids. It is also carried out on zootechnic support for dairy farming with the production of technical and economical references for the management and rationing of cattle. Experimentations on vegetable production are also regularly carried out at the farm in order to improve the production of this sector; some recommended technical itineraries were created (DAF-SFD, 2010).

2. The project on Recommended Technical Itineraries

2.1. Creation of RITA

The agriculture of Mayotte is in mutation. The sector is characterized by a dominance of pluri-active households that practice subsistence farming. Nowadays, farmers are starting to professionalize and hundreds are recognized as professionals by the Direction of Food, Agriculture and Forest (DAAF). These farmers are making a living from their activity. They are deeply involved in the dynamic of the development of the agricultural sector and are seeking support from the agricultural institutions.
In 2009, the General States of the UltraMarine (EGOM) reinforced the dynamic of professionalization of the agriculture in Mayotte. One measure takes at this assembly was to do a catch up plan for Mayotte 2015 with the aim of answering the needs of new markets (supermarkets, canteens, restaurants, etc.). The goal of this plan is to improve the actions of training, research and development in agriculture, in order to increase the efficiency of support in agriculture.
In 2009, the President of the Republic of France confirmed this plan, favoring the diversification of agriculture in Ultramarines Domains (DOM). He asked a Pilot Committee (COPIL) to work on this issue. The committee has enabled the creation of the Network for Innovation and Transfer in Agriculture (RITA). There is one RITA in each DOM. The RITA of Mayotte has for objectives to organize the dialogue between agricultural institutions in the assembly and the implementation of any projects on research-development-training in Mayotte (Savignan, 2011).

2.2. Presentation of the project

The RITA has organized a project on Recommended Technical Itineraries in order to answer to the catch up plan for Mayotte 2015. The main objectives of this project are to collect data of the agricultural performances for each sector of production and to improve the transfer of research results to farmers, technicians of agricultural institutions and teachers and trainers of the agricultural school of Coconi (Savignan, 2011). Four agricultural sectors are subjected to research in this project: the small animal breeding sector, the food crop sector, the fruit production sector and the vegetable production sector.

There are four axes of work in this project:

- Register and identify: define technical and economical recommendations for the management of main agricultural productions in order to improve farmers' practices and profitability of farms; but also to define new projects on research-development-training on Mayotte.
- Transfer and communicate: make the agricultural school exemplary in the control of recommended technical itineraries, improve its pedagogical support and communicate on the project's actions.
- Experiment: obtain reference data proper to Mayotte and propose technical solutions to farmers in order to improve yield.
- Perpetuate: insure the perpetuation of the project after the end of the mission.

2.3. The project at the agricultural school of Coconi

The first Regional Program for Agricultural Education in Mayotte (2010-2015) entitled the identification of a number of expectations of the professionals. The agricultural school of Coconi is awaited on for its contribution to the development of the economical and social agricultural sector. It is also looked-to for the visual and technical exemplarity that should present its farm and its food processing industry as good pedagogical support. It is working this way in collaboration with the DAAF, with the Direction of Agriculture, Terrestrial and Maritime Resources (DARTM), with the CIRAD and with the Chamber of Agriculture, Fishery and Aquaculture of Mayotte (CAPAM). The agricultural school of Coconi is deeply involved in the project on ITR: it is the intermediary for its progress. Indeed, the school's farm provided equipment and agricultural land for the benefit of the project. The main experiments of this mission took place at the farm (Appendix 1).

B. Context and problematic

1. The vegetable crop production in Mayotte

1.1. Overview of the actual situation

The vegetable production in Mayotte started with the creation of the first group of producers in 1981. It was composed exclusively of women with the objective of commercializing their production (Varnaudon, 1994).

In 2010, the first agricultural census of Mayotte revealed that there are 1250 vegetable producers. They represent 8% of the 15627 farmers censed in Mayotte. The land dedicated to vegetable cultivation is 133 hectares (about 2.4% of the total cultivated land) (DAAF-SISE, 2011a). The vegetable sector has kept on increasing until today but nevertheless remains marginal. The vegetable production is the principal activity for only 1.3% of producers. Moreover, the adverage size of production land is low: 0.11 ha per farm. However, 118 farmers have a production surface above 2000 m² (DAAF-SISE, 2011b).

Most of the land dedicated to vegetable production is located in the centre of the island (Figure 3), due to the good pedoclimatic conditions (flat ground and access to water) and the proximity of Mamoudzou (capital of the island), central zone for the commercialization of products.

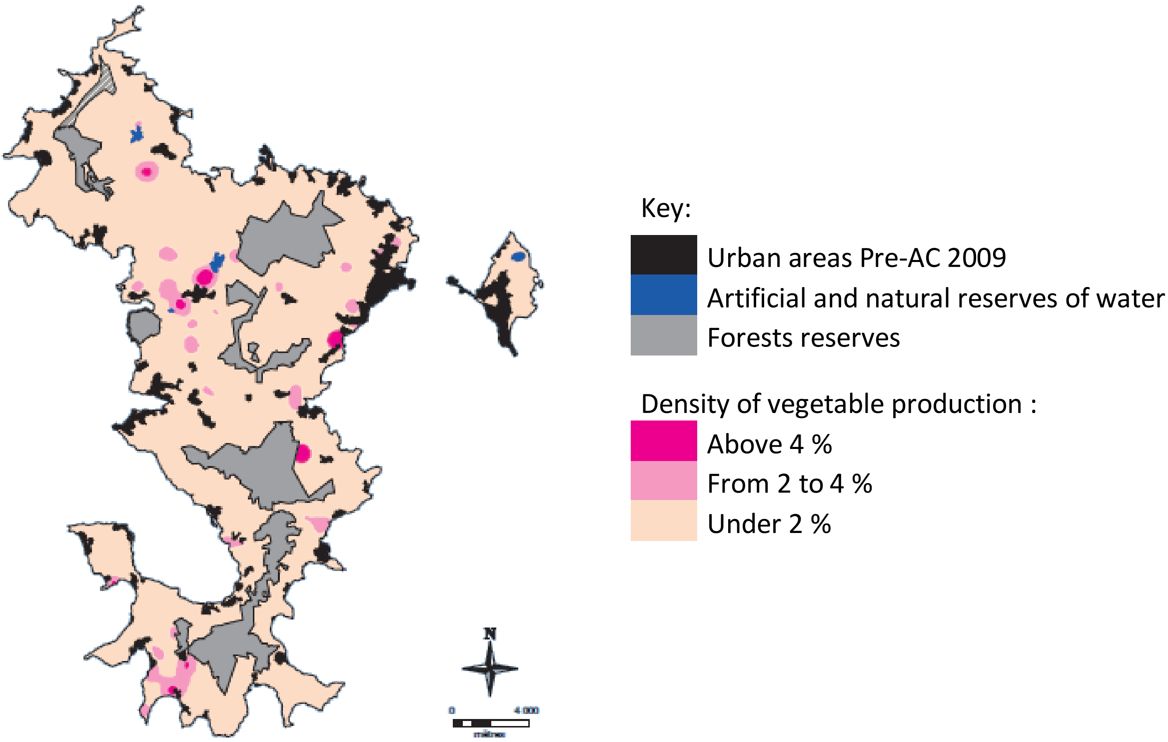


Figure 3: Geographical repartition of the vegetable production
Source: (DAAF-SISE, 2011a)

1.2. Production

In 2012, the vegetable production was estimated[1] at about 5126 tons (Table 1). The consumption of vegetables on the island is still dependent on imports: in 2010, there were 9275 tons of fruits and vegetables imported (of which 157 tons of tomatoes and 6 tons of lettuce) (ODEADOM, 2010) (DAAF-SISE, 2012).

Table 1: Production of vegetables (in tons)

Vegetables	tons
Tomato (under greenhouse)	2000 (240)
Cucumber (under greenhouse)	1820 (50)
Lettuce	428
Cabbage	360
Eggplant	194
Pumpkin and squash	132
Brèdes	117
Chili and bell pepper	46
Zucchini	29
Total	5126

Source: (DAAF-SISE, 2012)

Those vegetables could be produced in Mayotte. But there are some difficulties in doing so such as little land available for the growing of vegetable crops (considering the topography), the costs of production (especially investments in irrigation systems) and the rainy season. This season is synonymous of high temperature, high humidity and high pest pressure (IEDOM, 2012).

There are twenty species of vegetables cultivated during the dry season whereas only a few species are cultivated during the rainy season. Farmers mostly grow chili, tomato and eggplant in open field (DAAF-SISE, 2011b). The production is very seasonal. The dry season from May to October is the time where labor is available and is synonymous with overproduction whereas there is a lack of production during the rainy season (Vanhuffel, 2013). In order to de-seasonalize the production, funding is dedicated to the creation of greenhouses and tunnels. In 2010, 17 farmers cultivated vegetables under greenhouses for a total surface area of 2.2 ha (DAAF-SISE, 2011a).

The diversity of production is low and there is a willingness of the agricultural institutions to promote the diversification. Also the main constraints for the development of the vegetable sector are water availability and market proximity (DAAF-SISE, 2011a).

1.3. Commercialization

Most of the vegetable producers do not have for principal objective to commercialize their production. In 2010, 62% of vegetable producers where practicing donations or exchanges and 58% of farmers where selling them. There are various ways of selling the products: direct selling (at the farm or at the market) or to a middleman (Table 2).

[1] All numbers considering tonnage of production are based on estimations and have to be considered carefully because the majority of the vegetable producers do not collect data about their production.

Table 2: Type of commercialization

Commercialization (% of farms) *			
Direct selling at the farm	Direct selling at the market	To the final addressee	To a middleman
24%	14%	7%	27%

* Multi-answering possible Source: (DAAF-SISE, 2011a)

The organization of the commercialization was developed through the creation of the farmers cooperative (COOPAC) that was created in 2009. In 2013, the COOPAC counted 11 farmers and one group of producers. It has for objective to commercialize the production by managing the volume and the buyers. The importance of the COOPAC is increasing year after year. A new platform for transformation and comercialization will soon be created. The project is supported by the catch up plan for Mayotte 2015 and financed by the Service of Development of the Overseas Agricultural Economics (ODEADOM) (Aufman, 2013).

The plan for Mayotte 2015 has also initiated a campaign for the valorization of local products entitled "Let's eat local" (Appendix 2) (DAF, 2009).

2. Need for support

2.1. Evolution of the sector

The agricultural census of 2010 highlighted an increase in the attractiveness of the vegetable sector. This is the sector farmers would like to get involved in the most (Figure 4): 31 % of the 15627 farmers would like to create that activity and 31 % of them would like to increase their production surface for vegetables (DAAF-SISE, 2011a). It can be explain by the return on investment and development of new markets (direct selling, collective catering and supermakets). This trend is likely to continue and to further increase in the years to come.

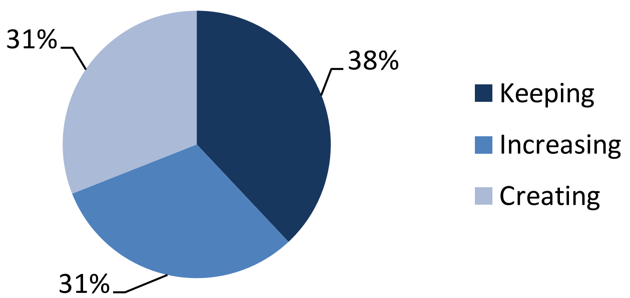


Figure 4: Dynamics of farmers in vegetable production
Source: (DAAF-SISE, 2011b)

The catch up plan for Mayotte for 2015 had established a methodology of sector based programs. The program in vegetable prouction is coordinated by the CAPAM. This program regroups all structures (DAAF, CAPAM, CIRAD, DARTM, and School of agriculture of Coconi) of the sector and has for objective to professionalize and structuralize the vegetable production sector. Its aim is also to improve the quantities and qualities of the products (IEDOM, 2012).

The main goals to achieve are (DAF, 2009):

- The realization of 2 ha of new irrigated vegetable fields, producing at least 40 tons per year,
- The realization of 5000 m² of new greenhouses.

The will to develop the vegetable production sector could be the starting point for the modernization of agriculture and the progressive specialization of agricultural exploitations on those productions that were previously developed just in complement of the traditional food crop system.

Technical support for vegetable producers and more generally for the agricultural sector of Mayotte is very low. While there was one technician per municipality specialized in vegetable production during the time of the Association for Development and Agricultural Valorization (ADVA), there are only two technicians at the CAPAM today, for the entire island (Abdou M. , 2013). In 2010, they were providing regular support to 35 producers. Nevertheless, a lot of farmers are requesting technical support but without more technicians it is not possible to answer their expectations (DAAF-SISE, 2011a).

2.2. Creation of Recommended Technical Itineraries

The stakeholders of the project on ITR wanted to focus on three topics in the vegetable production sector: the production of dwarf bean, the use of organic amendments and the sustainable management of pests and diseases.

- ITR on dwarf bean:

The dwarf bean (*Phaseolus vulgaris*) cultivation in Mayotte was observed for the first time in 1981. Varnaudon (1994) mentioned that 3014 m² of land was dedicated to dwarf bean cultivation. In 2004, the area was only 2500 m² (DARTM, 2010). Between 1999 and 2004, the ADVA observed that around 40 vegetable producers have cultivated that dwarf bean. There are no numbers available after 2004 because of the dissolution of the ADVA institution that was in charge of collecting data and supporting farmers.

However this specie presents several interests. The dwarf bean belongs to the *Fabaceae* family which has the ability to fix the nitrogen of the atmosphere (Carroue & al., 1999). Moreover, introducing a different botanical family in crop rotations helps to avoid phytosanitary problems (Messiaen, 2012). Promoting the cultivation of the dwarf bean is an integral part of the politic of diverisification of the sector based program (Vanhuffel, 2013).

Two sets of research on dwarf bean cultivation was established during the rainy season at the experimental station of Dembeni (Departement of Mayotte) in 1993 and 2006. Results of both trials showed that Contender was the most productive variety (DAF, 1993) (Gimenez & Huat, 2006). It has the particularity of being adapted to a tropical climate (Messiaen, 2012). Nowadays it is the major variety cultivated in Mayotte (Abdou A. , 2013).

However experimentations on dwarf bean production during the dry season never take place. It will be interesting to test other varietes to see their behaviour compared to Contender and to establish if there are differences in yield between seasons. An economic study of this production will lead to a better management of this production and will increase the dynamic around this crop.

- ITR on organic amendments:

At the beginning of the nineties, public authorities started to subsidize the purchase of chemical fertilizers and phytosanitary products in order to counter yield decrease (Varnaudon, 1994). With this policy, chemical inputs started to be used by farmers in Mayotte (Abdou M. , 2013). The promotion

of mineral fertilizers was addressed to vegetable producers in priority. However, only 3% of total farmers of Mayotte (467 farmers) used chemical fertilizers in 2010 (DAAF-SISE, 2011a).
At the same time, some battery farming of chicken appeared on the island. Chabalier (2006) observed the general vulgarization of the use of hens' manure that allows an intensification of the production. Vegetable producers got manure for a cheap price or even for free if they collected it themselves. According to the agricultural census of 2010, there are only 2% of farmers of Mayotte that use manure and 5% that use compost or plant residues. Still, most of the farmers who adopt these techniques are vegetable producers.

The agricultural institutions have the willingness to vulgarize the utilization of organic amendments (instead of chemical fertilizers) necessary to maintain long term fertility of the soil. Experimentation on organic amendments was carried out at the farm of the agricultural school of Coconi from 2010 until 2011. They used Ramial Chipped Wood (RCW) to produce maize, sweet potatoes and bell peppers. In all experimentations, yields were increased with the incorporation of RCW into the soil (Maignien, 2011). The fast growth of trees in tropical area makes this technique interesting for the maintenance of the fertility of the soil in Mayotte.
During the time of the ADVA, the institutions sought to vulgarize the creation of composters with groups of producers. The number of composters increased until the dissolution of the ADVA. Then they have progressively been abandoned due to the lack of technicians to support them. The various changes of institutions have broken the efforts made by the technicians (Abdou M. , 2013). Even the DAAF that had established a special agri-environmental measure (AEM) in favor of composting did not make it. The only two vegetable producers that adopted this measure did not respect the criteria for subsidy (Develter, 2013).

Considering this statement it seems interesting to perpetuate experiments on organic amendments. The school of agriculture has the materials for the establishment of experimentation on different types of organic amendments and the possibility to make compost. These topics will be source of research during the mission.

- ITR on plant protection:

There are regularly stock shortages in Mayotte. Farmers have to anticipate the problem of supply of inputs by themselves. It appears that often they do not find solutions and do not have the needed products in time (Huat J. , 2008). The fight against pests is characterized by farmers systematically using phytosanitary products or by farmers not doing anything. Only 3 % of the total number of farmers uses phytosanitary products to protect their crops. Out of these 467 farmers, 71 of them have a sprayer and 85 have sprayers in co-ownership (DAAF-SISE, 2011a). Only a few farmers have a shelter to store the products and most of them are not equipped to use chemical pesticides safely. They are therefore subject to health risks.
Moreover there are only a few controls on the handling of the phytosanitary products. The plant protection section of the DAAF made a campaign of sampling in order to observe the quantities of residues contained in vegetable products. It appears that only 3% of the samples were presenting a too high quantity of phytosanitary products (Ben Ali, 2008). However, technicians have revealed a case where a producer was carrying out 30 treatments during the cultivation of tomatoes (Liachouroutu, 2013). The assessment on pesticides of 2007 showed that the molecule chlorpyriphos ethyl (organo phosphate family) was present in two water reservoirs in Mayotte (Amalric, 2007). A

presentation document of the utilization of pesticides was published in 2001 by the DAAF for the farmers. It is in French but also in Shimaoré, which is the local language of Mayotte (DAF, 2001).
The problematic of the utilization of pesticides in Mayotte is characterized by the high level of analphabetism of the population who has no clue about the safe handling of pesticides (no dosage and no equipment). The DAAF regularly organizes training for farmers but because they do not speak French or they cannot read, only a few farmers come to the meetings (Liachouroutu, 2013). Moreover, for some species of vegetable such as brède mafane (*Acmella oleracea*) and brède morelle (*Solanum nigrum*) there are no legal phytosanitary products for the treatment; it is technically impossible for farmers to stay within the law if they protect their crop with chemical products (Ben Ali, 2008).

According to this statement it is necessary to improve the management of chemical plant protection. The stakeholders of the project on ITR would like to facilitate a modal shift towards more environmentally friendly plant protections.

2.3. Problematic of the mission

The context of the vegetable production sector developed above lead to a question:

How is it possible to improve technical support for the vegetable production in Mayotte?

The creation of Recommended Technical Itineraries (ITR) specific to Mayotte will be helpful tools improving the work of technicians. The technical support that provides these documents will be welcome in their toolbox. Also these documents will be available to all farmers. They will be useful tools especially for farmers who are not subject to support from technicians. They will have reference documents to work with.
During this mission, three ITR were created on the three topics developed above. Experiments and interviews of farmers were carried out in order to obtain reference data proper to Mayotte. The knowledge transfer and the communication on the experiments were done at the agricultural school of Coconi in order to improve its exemplarity and its pedagogical support. Technical and economical recommendations for the management of the dwarf bean cultivation were defined in one ITR in order to improve farmers' practices and profitability of farms. The perpetuation of the experiment on organic amendments was assured by transferring its management to the person responsible of experimentation at the school's farm.

C. MATERIALS AND METHODS

To answer the problematic it was necessary to coordinate actions of research and demonstration.

1. Process of creation of ITR documents

1.1. 1st sequence

The creation of three ITR documents needed to follow some conditions that characterized all ITR documents produced in Mayotte. First, the software Publisher had to be used to work on the documents. Second, the same layout had to be used for all ITR created in Mayotte. Third, the color green had to be used; it characterizes ITR from the vegetal sector.

The first sequence was from March 6th to July 3rd. In the middle of the mission (July 3rd), a meeting with stakeholders and farmers was set up in order to present the progress of the project and the first drafts of the ITR documents. Discussion focused on how information would be presented in the final documents. The objective was to make sure that information meets the expectations of professionals. It was decided that the ITR were to be sent to all stakeholders for review on August 20th.

1.2. 2nd sequence

The second sequence was from July 4th to September 6th. Considering the reviews of the stakeholders on the drafts, the ITR documents were improved. From August 21fr to September 2nd all technicians presented their feed-back on the documents. All considerations were taken into account. Corrections were made on the ITR after each meeting in order to present added documents to the technicians at the next meetings.

A final restitution meeting took place on September 3rd at the agricultural school of Coconi to present to all stakeholders the process of the mission and the final ITR. Last recommendations were made at this meeting and a few changes were made to the documents. The ITR documents on vegetable crops production in Mayotte were published to all stakeholders and farmers of the agricultural community of Mayotte on September 6th.

All documents were created from a compilation of the results of experimentations done in Mayotte before and during this mission. They are also made from the bibliography found in Mayotte in the different institutions and from the results of the questionnaire. Some more information came from the CIRAD from La Réunion and from the Agropolis foundation.

2. Preliminary researches

A literature review helped us to get an overview of the vegetable production sector in Mayotte. It was necessary to obtain access to all the literature available in the different institutions. This research was carried out in various documentation centers such as the library of the agricultural school of Coconi, the library of the CIRAD, the library of the CAPAM and the one of the DARTM. Also, research was carried out on the net, looking for scientific papers on the ScienceDirect web site.

Visiting and interviewing the stakeholders of the agricultural institutions gave us a better understanding of the situation (Appendix 3). Those visits and interviews were done to get maximum information about vegetable production in Mayotte and to discuss the establishment of different experimentations. A report of each interview was written in order to keep advices and all information needed for the future work.

3. ITR of dwarf bean

Following the major points of discussion between stakeholders and the history of research done in Mayotte, it appears that there was a lack of knowledge about the dwarf bean culture. That is why it was decided to establish experimentations on this topic. Also, meeting some farmers before doing experimentations gave us an overview of how to cultivate dwarf bean in Mayotte and which farmer would be willing to establish a varietal trial on his farm.

At the end of experimentations, an economic study of the crop was done. This study flowed from an analysis on costs and benefits of the experimentations.

3.1. Localisation of experimentations

Doing multi-sites experimentations provides more significant results (Gouet, 1991). That is why it was decided to establish two varietal trials on dwarf bean production: one trial at the school farm of Coconi (experimental site) and one trial at the EARL Lucile's farm located in Ironi Bé, municipality of Dembeni (real world situation site).

The rainy season was not totally finished during the establishment of both experimentations so it had been decided to grow dwarf beans under greenhouse to prevent any excess of water in the field. The meteorological station at the agricultural school was out of order so there was no control of temperature and humidity in the trial.

In 2012 the CAPAM did soil analyses of both sites used for experimentation (

Table 3). The soils contained clay and had a stable structural cohesion. But they were heavy and dried slowly with significant risk of asphyxiation, so good drainage was required. The pH was slightly more acidic at the school's farm (from 6.8 to 7.1) whereas it was alkaline at the EARL Lucille's farm (from 7.2 to 7.6). The stocks of organic matter (MO) are satisfactory and large. But the evolution of the MO was low and very low. The cation exchange capacity (CEC) was also low compared to the clay content. Soils were saturated in calcium, had a high content of magnesium and a very high content of phosphorus and potassium. The nitrogen content was high at the agricultural school and satisfactory at the EARL Lucille (Chambre d'agriculture de l'Aude, 2012a) (Chambre d'agriculture de l'Aude, 2012b).

Table 3: Soil analyses of both experimentations

		School of agriculture soil		EARL Lucille’s farm soil	
		0-15 cm depth	15-30 cm depth	0-15 cm depth	15-30 cm depth
Physical properties	Texture	Sandy clay loam	Clay	Clay	Clay
	Structure	Stable structural cohesion	Stable structural cohesion	Stable structural cohesion	Stable structural cohesion
		Heavy soil slow drying with significant risk of asphyxiation	Heavy soil slow drying with significant risk of asphyxiation	Heavy soil slow drying with significant risk of asphyxiation	Heavy soil slow drying with significant risk of asphyxiation
	Drainage	Good drainage required	Good drainage required	Good drainage required	Good drainage required
Chemical properties	pH	7.1	6.8	7.6	7.2
	Organic matter (MO)	Large stock of MO	Large stock of MO	Large stock of MO	Large stock of MO
		59 g/kg	44 g/kg	38 g/kg	31 g/kg
	Nitrogen	2,96 g/kg	2,16 g/kg	1,66 g/kg	1,3 g/kg
	C/N ratio	11.5	11.9	13.3	13.7
	Evolution of MO	Slow	Slow	Very slow	Very slow
	Phosphorus (P) and Potassium (K)	Very high content	Very high content	Very high content	Very high content
		P_2O_5: 1340 mg/kg K_2O: 647.6 mg/kg	P_2O_5: 626 mg/kg K_2O: 462.5	P_2O_5: 1265 mg/kg K_2O: 1081.9 mg/kg	P_2O_5: 436 mg/kg K_2O: 591.1 mg/kg
	Magnesium (MgO)	High content	High content	High content	High content
		1941.7 mg/kg	1354.5 mg/kg	1448.4 mg/kg	1369.4 mg/kg
	Calcium	Saturated	Saturated	Saturated	Saturated
	CEC	Correct	Low	Low	Low
		209 meq/kg	172 meq/kg	220 meq/kg	232 meq/kg
	Conductivity	0.28 mS/cm	0.25 mS/cm	0.26 mS/cm	0.27 mS/cm
	Sodium (Na_2O)	Traces of Sodium, possibility of local damage	Traces of Sodium, possibility of local damage	Traces of Sodium, possibility of local damage	Traces of Sodium, possibility of local damage
		117.18 mg/kg	92.07 mg/kg	108.81 mg/kg	117.18 mg/kg
	Zinc	39.3 mg/kg	28.4 mg/kg	18.4 mg/kg	12 mg/kg
	Copper	19.4 mg/kg	16.9 mg/kg	7.5 mg/kg	7.3 mg/kg
	Manganese	15.5 mg/kg	32.4 mg/kg	11.3 mg/kg	21.8 mg/kg

Source: (Chambre d'agriculture de l'Aude, 2012a) (Chambre d'agriculture de l'Aude, 2012b).

3.2. Varietal choice

It could be interesting to compare the variety Contender with new varieties that have never been experimented in Mayotte. The objective of the varietal trials was to evaluate the behavior of six varieties of dwarf bean (Table 4) cultivated under greenhouse during the dry season in order to promote a diversification of production of vegetable crops in Mayotte. Contender and Cora are the only two varieties of dwarf bean available for purchase in Mayotte. Four other varieties that are for sell in La Réunion were imported by the CIRAD.

Table 4: Characteristics of six varieties of dwarf bean

Variety	Breeder	Type	Pods	Nb of seeds / 50 g
Contender	Technisem	Mangetout	Oval green pods, 14 - 15 cm	110 - 120
Cora	Technisem	Mangetout	Shiny green pods, 13 - 14 cm	205 - 215
Gourmandel	Vilmorin	Stringless	Round green pods	270 - 290
Rocdor	Vilmorin	Mangetout	Shiny butter pods	200 - 210
Primel	Vilmorin	Mangetout	Long green pods	130 - 140
Delinel	Vilmorin	Stringless	Long green pods	170 - 180

Source: (Gimenez & Huat, 2006)

3.3. Establishment of trials

The varietal trial on dwarf bean at the agricultural school in Coconi took place from May 3rd to July 8th. The greenhouse, built in March 2012, is covered by a Celloclim 4S agronomic thermal greenhouse film and equipped with shade nets. It is a 234 m² greenhouse of 2.5 m high plus 1.5 m in half-moon. Only one bed of 30 m² was available.
The varietal trial on dwarf bean at the EARL Lucille's farm took place from May 29th to August 5th. The half moon plastic tunnel has a total surface of 125 m² and is 3 m high. Although even the soil of the greenhouse is flooded during the rainy season. Two beds were available for the experimentation for a total surface of 46 m² of cultivated land. In both experimentations the planting density was 23.3 plants/m².
Experimentations were established with the same objective and experimental framework but with a different way of management. The plan of the trial taking place at the farm's school and its characteristics are described in (Appendix 4). The EARL Lucille's trial plan and its characteristics are mentioned in (Appendix 5). Also the technical itineraries of both trials are located in (Appendix 6). There were four rows of dwarf bean at the agricultural school whereas there were three rows of dwarf bean per bed at the EARL Lucille. At the school's site the source of fertilization was duck manure whereas it was chemical fertilizers at the EARL Lucille's site. The trial at the agricultural school followed a randomized complete block framework with three repetitions of one factor (variety); whereas at the trial at EARL Lucille's farm, four repetitions were done. The 'variety' factor had six modalities.

3.4. Observed and measured variables

The observed variables were the dates of sowing and harvests (from the first to the last harvest). The measured variables were the earliness (from sowing to harvest), the yield of pods / m² and the number of pods / m² (only for the experimentation taking place at the agricultural school). Yield and earliness of each variety were integrated to the ITR on dwarf bean cultivation in Mayotte.

3.5. Data treatments

Data was treated with the software R (R Core Team, 2013) (De Mendiburu, 2013) (Deepayan, 2008) (Warnes & al, 2013). The study of the data has started by looking at the eventual interaction between yields and blocks in order to verify if experimentations were well conducted. In order to show statistical differences between yields of dwarf beans it was necessary to begin by testing the equality of variances of samples. The statistical model could be non correct because of an unknown factor of variability which has not been taken into account. It is possible to test graphically the normal distribution of residues through a histogram of residues to find an eventual bias. Once the normality was confirmed, it was possible to do statistical tests for the analysis of the variances. However, to complete the test on the residues it was interesting to verify their independence. Then a final graph with the possible groups was presented.

4. Additional experimentation

The dwarf bean is not the only type of bean cultivated in Mayotte. The long yard bean (*Vigna unguiculata ssp. Sesquipedalis*) and the lima bean (*Phaseolus lunatus*) are also cultivated but by food crops farmers. In order to enlarge the study on bean cultivation in Mayotte, experimentation on dry bean was established. The objective of the varietal trial is to compare seven varieties of dry bean and pea[2] in association with maize, in open field. The results were not available at the end of the mission and this experimentation did not answer to the problematic of how to improve support in vegetable production in Mayotte so it has not been described in this section (Appendix 7).

5. Other ITR

5.1. ITR on organic amendments

Only a few experiments were done in the study of organic amendments in Mayotte. That is why it was decided to establish experimentation on this topic. Experimentation on the comparison of three types of organic amendments was established at the farm of the agricultural school of Coconi. The experimentation started on June 7th 2013 and will continue till June 2017. The objective is to compare three types of organic amendments used for fertilization of vegetable crops under greenhouse. No results were available at the end of the mission so the protocol of experimentation has not been described in this section (Appendix 8).

Moreover, to establish the trial, it was necessary to create compost (Appendix 9). Because it was necessary to obtain compost rapidly it was decided to experiment the fast composting method of Berkeley. In this experimentation, two composts bins, of 1 m^3 each, were built and placed under trees to protect them from sun and rain. Then, one compost bin was filled up with several layers of green and dry materials. The new formed heap was watered during the process of creation. After three days, the heap was turned in the other compost bin. This shifting and turning of the compost heap was done every day or every two days. Then to control the temperature of the heap two special compost thermometers of 40 cm each were placed, one in the centre of the heap and one in its periphery. Temperature was measured everyday and registered in a data collection sheet on Excel and a final temperature curve of the compost was made. The compost was supposed to be ready in one to two weeks.

Also a windrow composting method was made by using manure from the animal husbandry. 6 m^3 of manure from one compartment were used to make a windrow of 1 m high, 1.5 m large and 6 m long. A geotextile trap was covering the windrow composting method from the sun and some bamboo sticks fixed the trap. The windrow was returned once a week or twice a month according to the availability of the teachers.

5.2. ITR on plant protection

There were specific research programs on plant protection done by the CIRAD so this topic has not been subject to any experimentation during the mission. The CIRAD is working on the utilization of agroecological techniques to fight the fruit and vegetable flies (*Diptera*, *Tephritidae)*. These flies are considered the main pests of vegetable crops and they can cause 90% lose of production. The brown

[2] Varieties of beans and peas were imported from the seed collection of the CIRAD of La Réunion.

rot is also a large problem in Mayotte and the CIRAD is working on varietal tolerances and grafting. During this mission, interviewing farmers and getting results of local research were the methods to create an ITR on plant protection.

6. Interviews with farmers

The stakeholders and particularly the DAAF wanted to put on the ITR information about actual practices used by the local farmers. That is why it was necessary to meet farmers. Those meetings and questions put forward to farmers came in complement of the agricultural census of 2010. It helped technicians to get a large overview of different types of farms. Notably the ones that are generally not subject to agricultural support.

The first step of the interview process was to create an interview guide (Appendix 10). Preliminary research and meeting few farmers were helpful for the process of its creation. Initially a questionnaire was written up on Microsoft Word (in ten pages) software. But finding the Sphink software set up a new deal and a shorter version of the interview guide was adopted.

The questionnaire was corrected by the internship master. Then it was tested with three farmers. Time needed to complete the questionnaire had been reduced: from one or two hours to only 45 to 60 minutes to fill the questionnaire. The interview guide was constituted of six parts:

- General presentation of the farmer and his farm: mainly focusing on the location, surface and productions of the farm. But also considering the name, age and status of the farmer. Such information was needed by the agricultural school of Coconi that is looking for internship placements.
- The vegetable production: this part is dedicated to crop rotations under greenhouses or fields, irrigation access and revenues.
- The dwarf bean production: it was necessary to look for the technical itinerary of the crop, considering practices used and time and labor needed. A final part on advantages and disadvantages of the crop concluded the section.
- The fertilization: the questionnaire was focused on organic amendments, how they were managed and used, in which quantities and how much did they cost.
- Crop protection: we were considering the main enemies present on the fields, the methods of control (conventional and alternative), the phytosanitary products used and the protection equipments of the farmers.
- The collaboration projects: this last part was looking for the will of farmers to host interns from the agricultural school of Coconi and to establish experimentations on their property. It was also interesting to learn about exchange of ideas and equipement between farmers.

There was no statistically representative sample done. The objective of the questionnaire was to get a sample that can globally take into account the various typology of vegetable producer. Most farmers spoke French and for the ones that only spoke Shimaoré, a translator was found directly on field. Several methods were used to find vegetable producers:

- By making appointments from the list provided by the technician of the CAPAM.
- By transect on field: there were some chance to find farmers on their farm.
- By word of mouth: interviewed farmers or farmers without availability were directed us to other producers.

All answers were treated with the Sphink and Microsoft Excel software. Some of these results were added to the final ITR documents. Interviews were held out with 20 vegetable producers.

D. Results

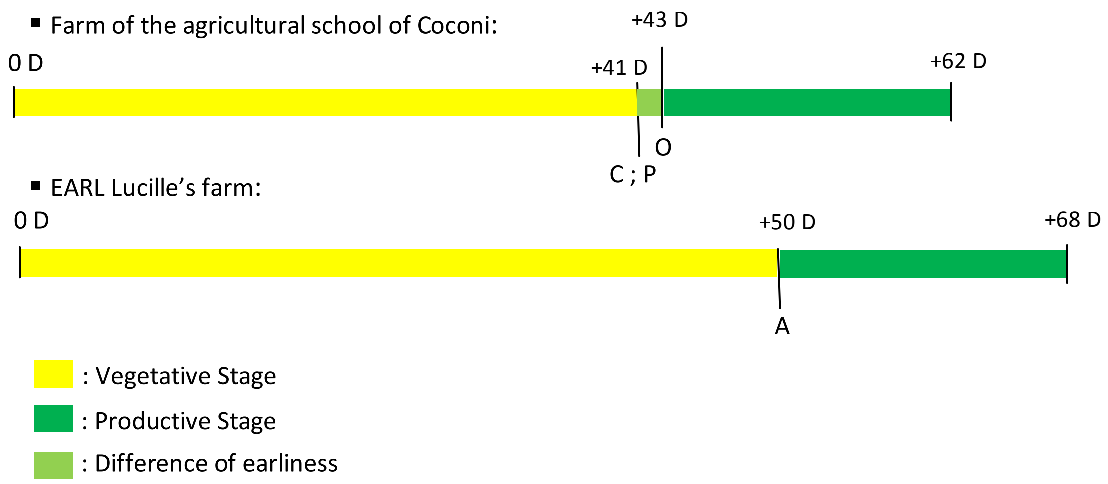
1. ITR on dwarf bean

1.1. Experimentations on dwarf bean

1.1.1. Length of the cultural cycle

1.1.1.1. Earliness of production

The six varieties were conducted together. However the Gourmandel variety did not grow even after re-sowing. It was decided to exclude this variety of the experimentations. Dates of harvest were fixed according to the development of the dwarf bean plants. The first harvests for the experimentation at the school's farm were done 41 days after sowing and continued until day 62 (Figure 5). The first harvest for the experimentation at the EARL Lucille started at day 50 and continued until day 68.



C: Contender variety
P: Primel variety
O: Other varieties than Contender (Rocdor, Cora and Delinel)
A: All varieties (Contender, Rocdor, Primel, Cora and Delinel)
D: Days

Figure 5: Length of crop cycles of the five varieties experimented

The Contender and Primel varieties are distinguished by their (relative) earliness at the farm of the agricultural school of Coconi. The first harvest at the EARL Lucille was done nine days after the first harvest at the agricultural school. However the last experimentation finished six days later. The length of harvest was reduced because of a longer vegetative stage.

1.1.1.2. Dynamic of production

The following graphics present the production of dwarf beans of each variety all along the harvest.
At the EARL Lucille, there were four harvests (symbolized by the marks on the Figure 6). The first harvest was the most important for all varieties with a peak of production for Contender, Cora and Delinel. Then the production decreased until the end of the experimentation for the Contender, Delinel and Primel varieties. There was a very small increase of production for the Cora and Rocdor after the second harvest. It seems that the plants gave their maximum for the first harvest. It might be possible that it was done too late.

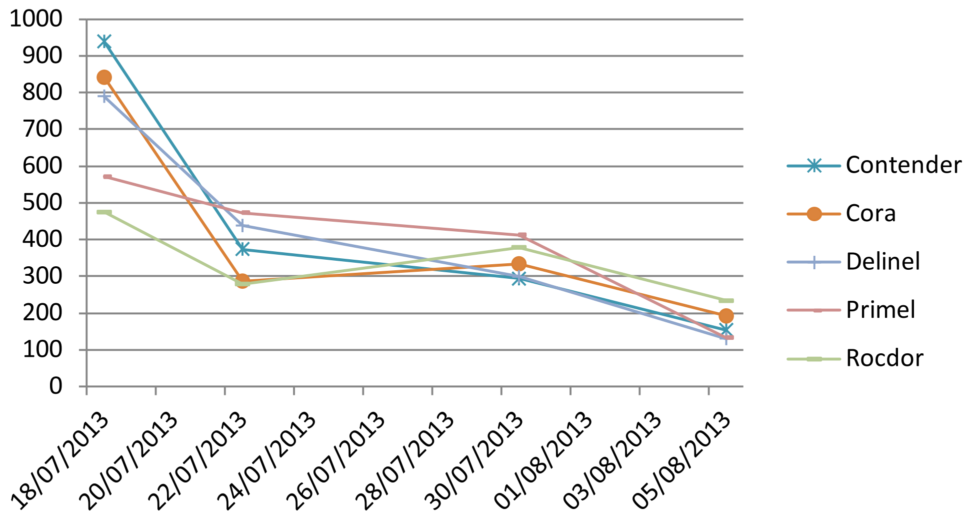


Figure 6: Harvest profile of each variety at the EARL Lucille

The profiles of the harvests done during the experimentation taking place at the farm of the agricultural school of Coconi (Figure 7) are very different from the previous profiles. The first harvest did not produce lots of dwarf beans. However there is a peak of production at the third harvest for Contender, and Primel and at the second harvest for Cora and Rocdor. There is even another peak of production for Cora at the fourth harvest, then the production decreased for all varieties. Only Delinel does not present a peak of production.

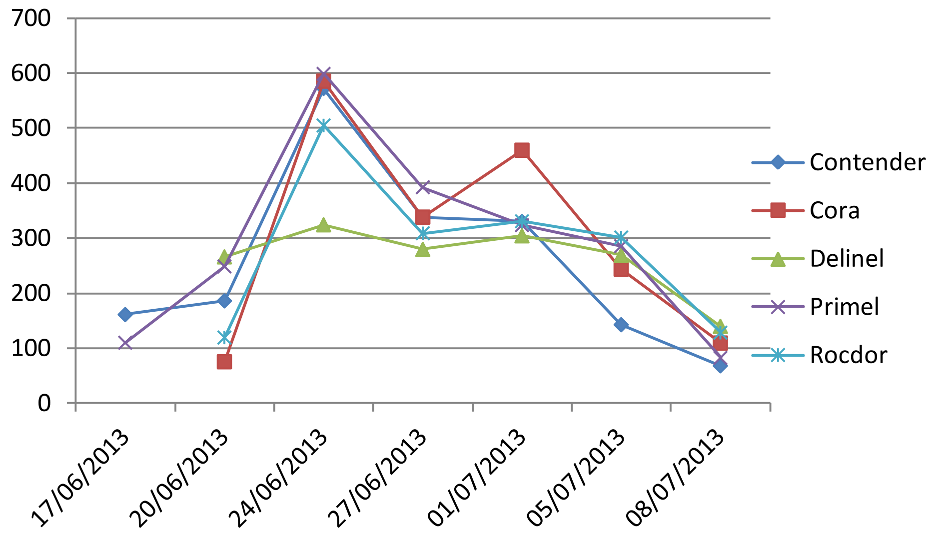


Figure 7: Harvest profiles of each variety at the agricultural school of Coconi

1.1.2. Statistical analyses on yields

The scripts of both experimentations are located in Appendix 10: Interview guide

Itinéraires Techniques Recommanés à Mayotte

2013

Présentation Générale de l'Exploitant et de son Exploitation

1. Prénom/Nom

2. Téléphone

3. Localisation

4. Agriculture seule activité professionnelle ?
○ 1. oui ○ 2. non

5. Agriculture seule source de revenu ?
○ 1. oui ○ 2. non

6. Possédez vous un numéro SIRET ?
○ 1. oui ○ 2. non

7. Quelles sont les qualités de vos terres ?
☐ 1. accès à l'eau ☐ 2. accès à l'exploitation
☐ 3. accès réseau routier ☐ 4. terrain plat
☐ 5. sol riche ☐ 6. surface de l'exploitation
☐ 7. autres
Vous pouvez cocher plusieurs cases (5 au maximum).

8. Si 'autres', précisez :

9. Contraintes de vos terres ?
☐ 1. accès à l'eau ☐ 2. accès à l'exploitation
☐ 3. sol pauvre ☐ 4. surface de l'exploitation
☐ 5. terrain en pente ☐ 6. terrain pierreux
☐ 7. autres
Vous pouvez cocher plusieurs cases.

10. Si 'autres', précisez :

11. Quelles sont les productions de l'exploitation ?
☐ 1. Maraîchage ☐ 2. vivrier ☐ 3. élevage
☐ 4. fruitier ☐ 5. autre
Vous pouvez cocher plusieurs cases.

12. Si 'autre', précisez :

13. Surface totale de production?

14. Adhérent à un groupement de producteur ?
○ 1. oui ○ 2. non

15. Lequel ?

La question n'est pertinente que si groupement de producteur ? = "oui"

Les Cultures Maraîchères

16. Principales productions maraîchères ?

17. Surface de production (ha)

18. Possédez-vous des serres?
○ 1. oui ○ 2. non

19. Souhaitez-vous en avoir (plus) ?
○ 1. oui ○ 2. non

20. Si 'oui', précisez :

21. Quelles sont les rotations de cultures sous serre?

22. Quelles sont les rotations de cultures de plein champ ?

23. Discussion choix des cultures

24. Approvisionnement en eau?

25. Quantité d'eau suffisante en saison sèche ?
○ 1. oui ○ 2. non

26. Adaptation au manque d'eau

La question n'est pertinente que si appro eau saison sèche = "non"

27. Quelles productions rapportent le plus d'argent ?

28. A qui vendez vous vos production ?

29. Où vendez vous vos productions ?

30. Collectez vous des données sur vos productions ?
○ 1. oui ○ 2. non

31. Qu'en faites vous ?

La question n'est pertinente que si Données de productions = "oui"

Le Haricot

32. Cultivez vous ou avez vous cultivé des haricots ?
○ 1. oui ○ 2. non

33. ITK_haricot_cultivar

34. ITK_haricot marque

35. ITK_haricot surface SS ou PC

36. ITK_haricot le sol

37. ITK_haricot semis/densité

38. ITK_haricot entretien

39. ITK_haricot irrigation

40. ITK_haricot fertilisation

41. ITK_haricot traitements phyto

42. ITK_haricot récolte

43. ITK_haricot les résidus de culture

44. ITK_haricot durée du cycle (mois)

45. Souhaitez vous cultiver des haricots à l'avenir ?
○ 1. oui ○ 2. non

La question n'est pertinente que si Culture de haricot = "non"

46. Avantages de la cuture du haricot ?

- ☐ 1. Entretien du sol
- ☐ 2. rotation
- ☐ 3. bonne valeur ajoutée
- ☐ 4. forte production
- ☐ 5. peu de pression des bioagresseurs
- ☐ 6. se vend bien
- ☐ 7. autres

Vous pouvez cocher plusieurs cases.

47. Si 'autres', précisez :

48. Inconvénients de la culture de haricot ?

- ☐ 1. difficile à vendre
- ☐ 2. faible durée de conservation
- ☐ 3. forte pression des bioagresseurs
- ☐ 4. coûts de productions élevés
- ☐ 5. difficulté de récolte
- ☐ 6. fréquence de récolte
- ☐ 7. durée de récolte
- ☐ 8. autres

Vous pouvez cocher plusieurs cases (7 au maximum).

49. Si 'autres', précisez :

La Fertilisation

50. Type de fertilisation ?

☐ 1. organique ☐ 2. minérale

Vous pouvez cocher plusieurs cases.

51. Nature fertilisation organique

☐ 1. bovin ☐ 2. canard ☐ 3. poule ☐ 4. lapin

☐ 5. cheval ☐ 6. BRF ☐ 7. compost ☐ 8. autre

Vous pouvez cocher plusieurs cases.

52. Si 'autre', précisez :

53. Cultures fertilisation organique

○ 1. Toutes ○ 2. autres

54. Si 'autres', précisez :

55. Quantités apportées (kg/ha)

56. Provenance (prix) ou fabrication

57. Méthodes de fertilisation

☐ 1. manuelle ☐ 2. mécanisée

Vous pouvez cocher plusieurs cases.

58. Si 'mécanisée', précisez :

59. Applications fertilisants ?

☐ 1. à la plantation ☐ 2. en cours de cycle

☐ 3. raisonnée

Vous pouvez cocher plusieurs cases.

La Protection des Cultures

60. Principaux bioagresseurs des cultures ?

61. Traitez vous vos cultures ?
○ 1. oui ○ 2. non

62. Principaux produits phytosanitaires utilisés

63. Equipements pour les traitements ?
☐ 1. gants ☐ 2. bottes
☐ 3. masques ☐ 4. combinaison
☐ 5. pulvérisateur ☐ 6. atomiseur
☐ 7. pschitt pschitt ☐ 8. rien
Vous pouvez cocher plusieurs cases (7 au maximum).

64. Remplissez vous un registre de traitement?
○ 1. oui ○ 2. non

65. Pourquoi :

66. Méthodes de luttes alternatives ? (prophylaxie, associations, produits naturels, etc)

67. Connaissance de MAE ?
○ 1. oui ○ 2. non

68. Souhaitez vous mettre en place des dispositifs MAE ?
○ 1. oui ○ 2. non

Projets de colaboration

69. Accueillir des stagiaires du LPA ?
○ 1. oui ○ 2. oui, j'en accueille déjà ○ 3. non

70. Mettre en place des expérimentations avec le LPA ?
○ 1. oui ○ 2. non

71. Echange entre agriculteurs ?
○ 1. oui ○ 2. non

72. Si 'oui', précisez :

73. VARIABLE_73
☐ 1. Thème n° 1 ☐ 2. Thème n° 2 ☐ 3. Thème n° 3
Vous pouvez cocher plusieurs cases.

Appendix 11 and Appendix 12.

1.1.2.1. Interactions

- Experimentation at the EARL Lucille

The graphic presents the means of yields per square meter, per variety and per block: the abscissa represents the four blocks of the trial and the ordinate the means of yields (grams/m²). The five curves represent the five varieties.

A quick overview shows that there is a variation of means of yields depending on the blocks and the varieties (Figure 8). There is an interaction between means of yields and blocks. Yields of each variety are at their highest in block 1 (B1), except for Primel.

Means of yield of the Contender and Delinel varieties follow the same dynamic: they are at their highest in B1, than they decrease in block 2 (B2), increase in block 3 (B3) and decrease again in block 4 (B4). Rocdor seems to follow the same dynamic except that its yield keeps slightly increasing in B3 and B4. Primel has an opposite dynamic compared to Contender and Delinel. Its yields are low in B1, increase in B2, and decrease in B3 and at last increase in B4. The yields of Cora keep decreasing from B1 to B4, with a significant decrease in B4.

Rocdor seems to be the less productive variety. Contender presents the maximum mean of yield in B1 (1915 grams/m²) and Cora the minimum one in B4 (836.7 grams/m²).

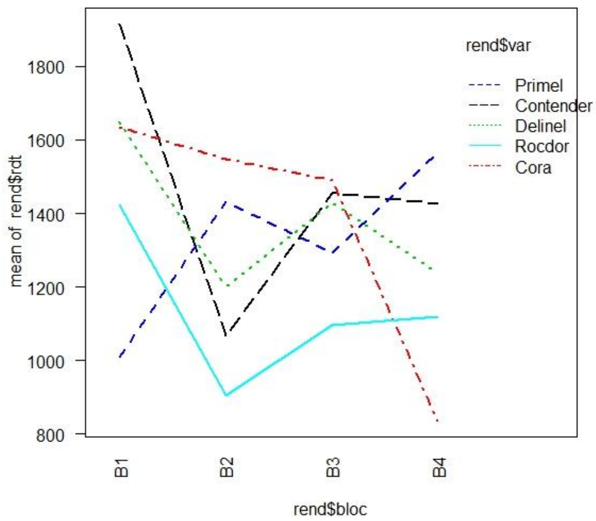


Figure 8: Interactions of yields and blocks at the EARL Lucille

- Experimentation at the agricultural school

A quick overview of the graphic shows a general decrease of means of yields from B1 to B3 for Primel, Contender and Cora (Figure 9). Yields of all varieties are at their highest in B1. There is an interaction between means of yields and blocks.

The yields decrease from B1 to B3 for Primel, Contender and Cora with a significant decrease of yields for Cora in B3. Rocdor and Delinel present means of yields decreasing from B1 to B2 but increasing from B2 to B3.

Primel presents the maximum mean of yield in B1 (1816 grams/m²) and Cora the minimum one (1150 grams/m²). Primel seems to be the most productive variety whereas Delinel seems to be the last productive (follow by Rocdor). It is difficult to distinguish yields of Contender and Cora, considering the significant decrease of Cora in B3.

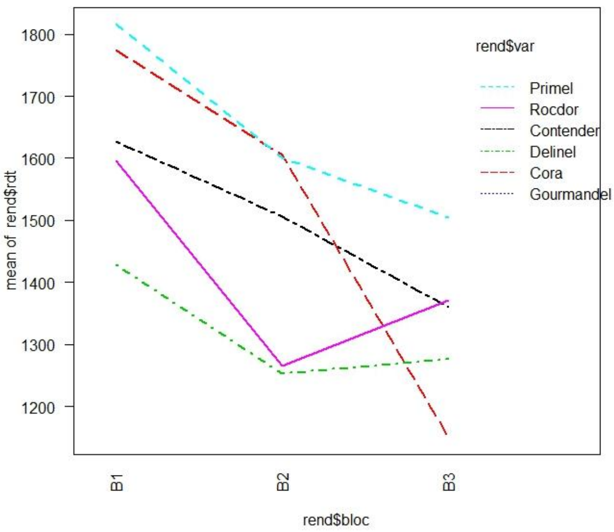


Figure 9: Interactions of yields and blocks at the agricultural school

- Comparison of both experimentations

In both experimentations, there is an interaction between means of yields and blocks. Rocdor does not seem to be a productive variety. Cora seems productive but its means of yields present sheer drops in both experimentations.

The second step of the data treatment was to create box plots in order to visualize the differences of medians and dispersion between varieties. It was done in order to get better details of the differences between varieties.

1.1.2.2. Box plots

- Experimentation at the EARL Lucille

A box plot represents graphically the dispersion of the variable ‘yield’. Medians of yields are the black lines in the boxes. There are the five varieties in abscissa and a scale of yields in ordinate (grams/m²). A first observation of the graphic show that there are no outliers in the box plots and that the medians of the five varieties are not equal (Figure 10).

The median of Cora is the most important with 1500 grams/m², followed by the median of Contender at 1450 grams/m², the median of Primel at 1350 grams/m², the median of Delinel at 1300 grams/m² and finally the median of Rocdor at 1100 grams/m². The dispersion of Contender and Cora are more important than the dispersion of Delinel, Primel and Rocdor. Contender presents a positive asymmetry (and the maximum value) whereas the asymmetry of Cora is significantly negative (and presents the lowest value). It means that there are more chances to get high yields with Contender and low yields with Cora. The dispersions of Delinel and Primel are medium with respectively a positive and a negative asymmetry. The median of Delinel is not very important but it is interesting to remark that there are only a few chances getting yields under 1200 grams/m². Rocdor seems once again the less productive variety.

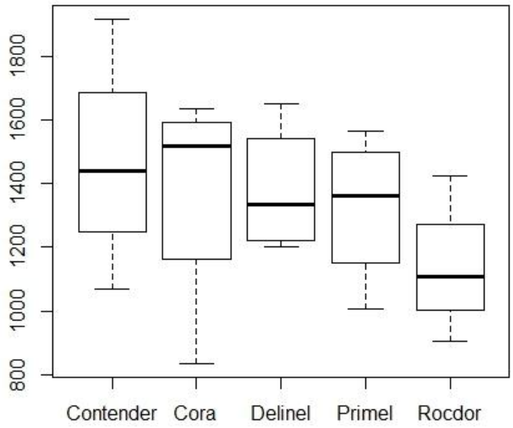


Figure 10: Box plots from the EARL Lucille

- Experimentation at the agricultural school

This graphic does not show any outliers but presents strong variations of medians (Figure 11). Cora and Primel get the highest medians of yields at 1600 grams/m². Primel seems to be the most interesting variety, because of its high median, its medium dispersion and its positive asymmetry. There are some chances to get very high yields (above 1800 grams/m²). Cora presents a significant dispersion and a negative asymmetry (and the minimum value). Even if its median is high, there are chances to get very low yields. Contender has the third median at 1500 grams/m² and presents an almost symmetrical dispersion. Rocdor has a higher median than Delinel (respectively at 1350 grams/m² and 1250 grams/m²) but also a more important dispersion. The dispersion of Delinel is small. However, both varieties have a positive asymmetry.
The most interesting varieties, according to the box plots are Primel and Contender. There are too many risks of getting a low yield with Cora. Rocdor and particularly Delinel do seem productive.

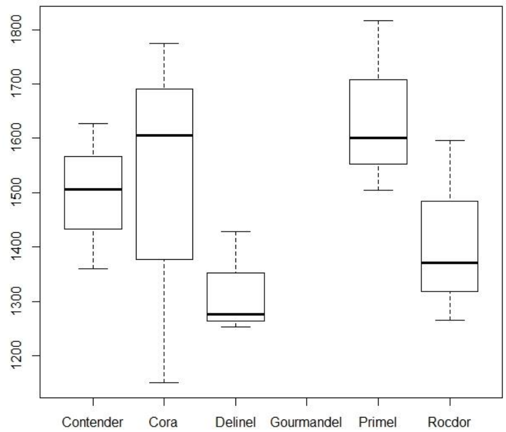


Figure 11: Box plots from the agricultural school

- Comparison of both experimentations

In both experimentations, Cora presents high degrees of dispersions and negative asymmetries. This variety does not seem very reliable even if it gets the highest medians in both experimentations. Contender presents intermediate degrees of dispersions and seems reliable considering the symmetry of its values. Moreover, it presents similar medians in both experimentations. Delinel is interesting according to the experimentation at the EARL Lucille. But it presents a lower median in the experimentation at the agricultural school. Primel shows opposite dynamics but seems an interesting variety. Finally, Rocdor seems to be less productive than other varieties.

1.1.2.3. Test of equality of variances

A Bartlett test is used to show if the variances in each of the samples are the same (homoscedasticity). It was established a null hypothesis (H_0) mentioning that all variances are equal. However, the results of the test are that all p-values are superior of 0.01 (Table 5). It means that H_0 is rejected and that variances of the samples are not equal.

Table 5: Bartlett tests

		Bartlett's K-squared	df	p-value
EARL Lucille's farm	Yield/bloc	1.8379	3	0.6067
	Yield/variety	1.5859	4	0.8113
School of agriculture's farm	Yield/bloc	0.3081	2	0.8572
	Yield/variety	2.897	4	0.5752

Thanks to this result it was possible to create a model to analyze the variances. But before that, it was necessary to test the hypothesis that the residues follow a normal distribution.

1.1.2.4. Analysis of the normality of the residues

In statistics, lots of tests can be used if the data set follows a normal distribution. But it is crucial to test the normality before using those tests. The Shapiro-Wilk test determines if the data set follows a normal distribution. It was established a null hypothesis (H_0) mentioning that the residues follow a normal distribution. In both experimentations p-value > 0.01 that means H_0 is accepted (Table 6). The residues do follow a normal distribution.

Table 6: Shapiro-Wilk tests

	W	p-value
EARL Lucile's farm	0.9254	0.1261
School of agriculture's farm	0.9362	0.3374

However, the sizes of the samples were probably not large enough for a correct application of the Shapiro-Wilk test. Hence, a graphical analysis completed the Shapiro-Wilk test and the Bartlett test.

1.1.2.5. Graphical analyses of the residues

- Experimentation at the EARL Lucille

The histogram of residues confirms that the residues follow a normal distribution (Figure 12). The rectangles are high around the value 0 and the red curve is confirms the observation. The blue curve is a smoothed representation of the red curve.

The Quantile-Quantile graph presents the theoretical quantiles in abscissa and the sample quantiles observed in the experimentations. The theoretical quantiles are represented by the line crossing the graph. This line is symbolizing a normal distribution. The points of the sample quantiles are close to the line and form a line between -1 and 1. It means that the residues follow a normal distribution. However, there are some points far from the line symbolizing a normal distribution. Those points, because there are not too many of them do not false the normal distribution of the residues.

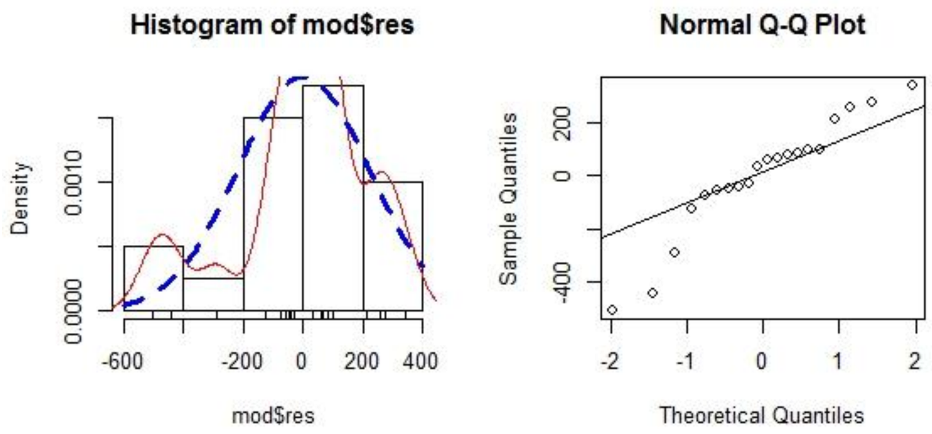


Figure 12: Normality of the residues at the EARL Lucille

- Experimentation at the agricultural school

The histogram of residues confirms that the residues follow a normal distribution (Figure 13). The blue curve represents a correct Gauss curve. Compared to the histogram of residues resulting from the experimentation at the EARL Lucille, the curve is less marked and more spread out. There is a higher dispersion of the residues.

The Quantile-Quantile graph also confirms that the residues follow a normal distribution. There is just one value that is a little bit far from the line symbolizing a normal distribution.

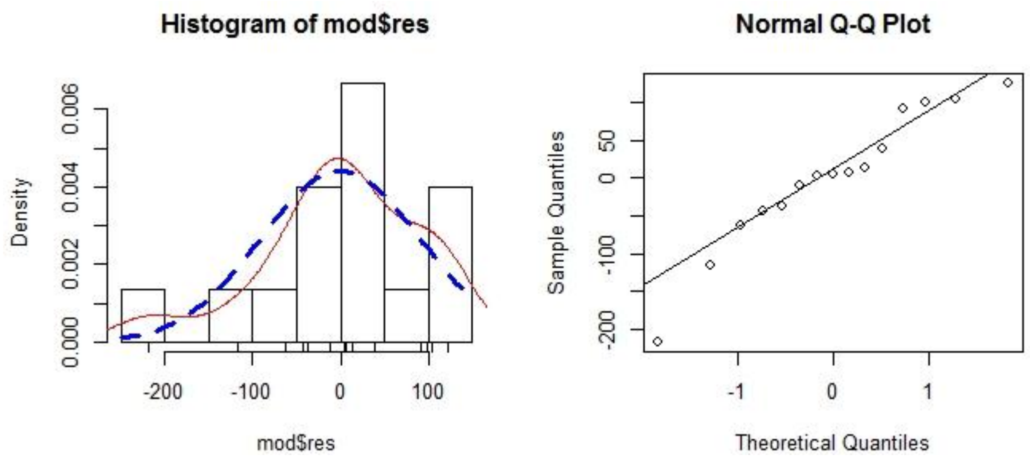


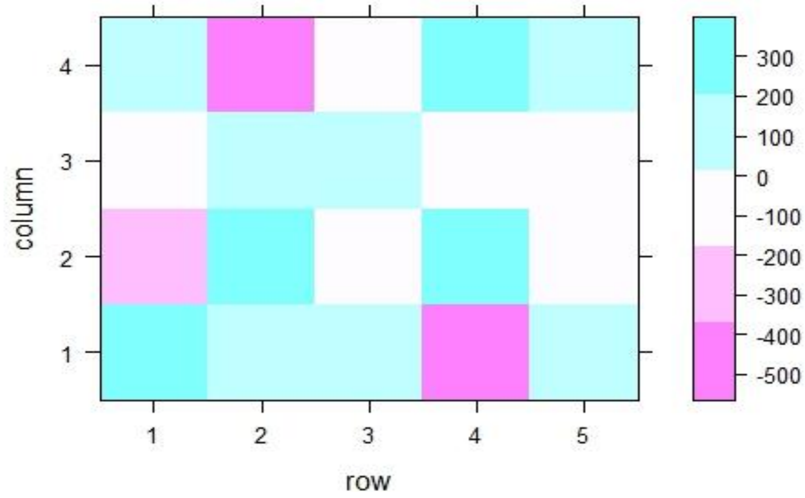
Figure 13: Normality of the residues at the agricultural school

1.1.2.6. Independence of residues

- Experimentation at the EARL Lucille

The following graph presents the varieties in abscissa and the blocks in ordinate (Figure 14). The colors represent the difference of elementary plot's yield with the mean yields. The white is the mean yield, the blue the yield with a positive difference and the pink the yield with a negative difference. Every square symbolizes one variety in one block.

In B1 yields are higher except for the variety 4 (Primel). The variety 1 (Contender) even presents a very high yield. It is exactly the same as what was observed through the graphs of interactions of means of yields and blocks. Hence, it is possible to say that there are no significant groups of squares with the same colors so the residues are independent.



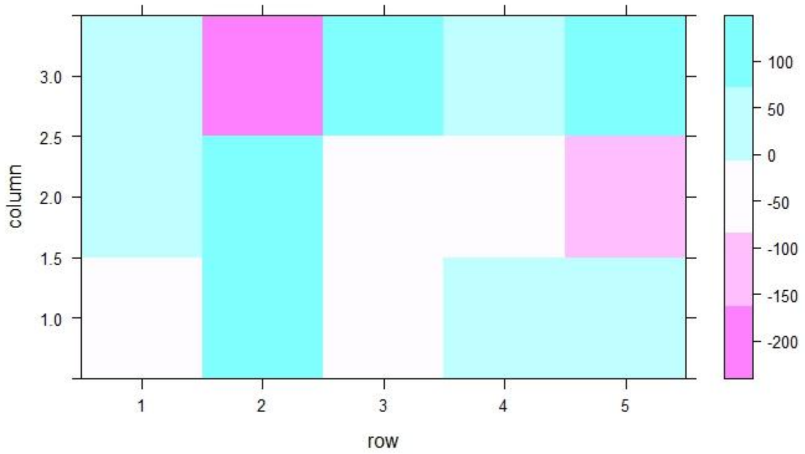
Key:

1: Contender
2: Cora
3: Primel
4: Delinel
5: Rocdor

Figure 14: Independence of residues at the EARL Lucille

- Experimentation at the agricultural school

There is the same observation as in the graph on the independence of residues at the EARL Lucille. There are no significant groups of colors. It means that the residues are independent of the blocks (Figure 15).



Key:

1: Contender
2: Cora
3: Primel
4: Delinel
5: Rocdor

Figure 15: Independence of residues at the agricultural school

1.1.2.7. Analyses of variances

While, all parameters were verified it was possible to do an analysis of variances (ANOVA). Results are that there are no significant differences between sample means. However, a Student Newman Keuls (SNK) test was established in order to verify the ANOVA.

Results of the SNK confirm the ANOVA: there are no distinctions between means of yields of the five varieties. Even if it was possible to observe different dynamics of yields, notably in the graphs on interactions between means of yields and blocks (Figure 8 and Figure 9) and the box plots graphs (Figure 10 and Figure 11), there are statistically no differences between the five varieties.

Although there are no statistical differences between varieties, two final graphs were draw in order to appreciate the differences of yields.

1.1.2.8. Final graph with the yields

- Experimentation at the EARL Lucille

The graph presents the mean of yield of each variety with their standard error (Figure 16). Contender presents the highest yield with an average production of 1466.2 grams/m² of dwarf beans. But its standard error is high. The variety Delinel gets an average yield of 1380 grams/m² and a medium standard error. Cora presents the third mean of yield at 1377.3 grams/m² and a high standard error. Primel comes fourth with an average production of 1324.2 grams/m² and a medium standard error. Finally, Rocdor produce 1136 grams/m² of dwarf bean and has a medium standard error. Those standard errors mean that it is possible to get same yields for all varieties (approximately 1250 grams/m²). It is interesting to remark that the high standard error of Contender and Cora are correlating the observations of the box plots; those varieties presented high degrees of dispersions.

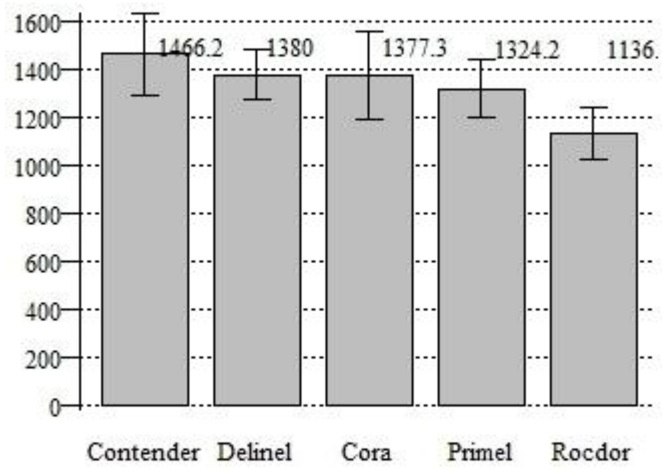


Figure 16: Average yields and standards errors at the EARL Lucille

- Experimentation at the agricultural school

The most productive variety is Primel with an average production of 1640.3 grams/m² of dwarf beans and a medium standard error (Figure 17). Cora produces on average 1510.3 grams/m² of beans but presents a high standard error. Contender comes third with a mean of yield at 1498.1 grams/m² and a medium standard error. In fourth is Rocdor that produces 1411.1 grams/m² of dwarf beans and presents a medium standard error. In the final position is Delinel with an average production of 1319.2 grams/m² and a small standard error. Considering standard errors it is possible to get same yields for Primel, Cora, Contender and Rocdor. However, it seems that Delinel produces less dwarf beans than the other varieties and could be placed behind them. The standard error of Cora is high, considering its significant dispersion observed in the box plot. Even if Cora had the same median as Primel, its average production is 130 grams/m² behind because of the drop in production observed in B3 in the interaction graph. According to this graph, it seems that it is more interesting for farmers to grow Primel. Farmers willing to grow Cora take the risk of underproduction. Contender produces a suitable average of dwarf beans.

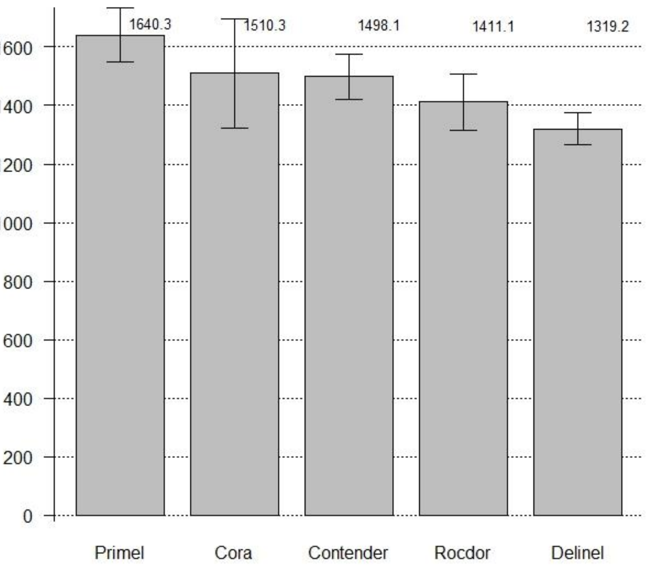


Figure 17: Average yields and standards errors at the agricultural school

- Comparison of both experimentations

A quick overview shows that the average productions of dwarf beans were more important in the experimentation taking place at the agricultural school of Coconi than in the experimentation taking place at the EARL Lucille. Moreover, the varieties are not placed in the same order because of the difference of yields. In the first graph there are Contender, Delinel, Cora, Primel and Rocdor whereas in the second graph the order is Primel, Cora, Contender, Rocdor and Delinel. Delinel, the second most productive variety at the EARL Lucille was the least productive at the agricultural school. However, its averages productions are almost the same in the two experimentations (plus 60.8 grams/m² at the EARL Lucille). Primel could produce approximately between 1200 grams/m² and 1750 grams/m² of dwarf beans which are synonym of good productions. It is the same phenomena for Contender which comes first at the EARL Lucille and third at the agricultural school. But its average productions are almost the same (plus 31.9 grams/m² at the agricultural school). This variety produces yields from 1250 grams/m² to 1625 grams/m². Cora is the variety that presents the highest standard errors in both experimentations but its average productions are not too far from each other (plus 133 grams/m² at the agricultural school). This variety could produce correct yield (1190 grams/m²) or high yield (almost 1700 grams/m²). Primel and Rocdor are both presenting very different means of yields in both experimentations, with respectively 316.1 grams/m² and 275.1 grams/m² of difference. Primel is the most productive variety at the agricultural school but only the fourth variety at the EARL Lucille. This variety could produce very high yields (1750 grams/m²) and quite bad yields (1200 grams/m²). Rocdor stays an underproductive variety in both experimentations. It does not seem interesting to cultivate it, except for its color (it is a butter bean variety).
It would be recommended to farmers to grow Contender because of its regularity. Then if they are willing to take some risks, they could cultivate the Cora and Primel varieties which can obtain very important yields.

1.1.2.9. Conclusion

The statistical treatments of data revealed that the experimentations were not perfect. The size of samples was not big enough to get correct results with statistical tests. It might be because there were not enough harvests or because there would need to be more repetitions (blocks) in the experimental frameworks. Also there were external factors interacting with the yields and the blocks which could have falsified the results. It is notably remarkable for the Cora variety for which there were significant decreases of yields in both experimentations. This variety should definitely be tested again in a future varietal trial as should be the Primel variety which gets excellent results in the experimentation taking place at the agricultural school. The regularity of production of the Contender variety confirms its predominant place in the dwarf bean production sector.

1.1.3. Statistical analysis on the number of pods

The experimentation at the agricultural school of Coconi was subject to another observation that consisted in measuring the number of pods picked at each harvest. As for the statistical analyses of yields, tests were made to establish if there are differences between varieties statistically identifiable. Results are that it is possible to show differences of average numbers of pods (Figure 18). There are three groups: “a”, “ab” and “b”. Cora represents the group “a” and has an average production of 409.7 pods/m². As for the tests on yields, Cora presents a high standard error which could be explained by the fact that there are great variations in its mean yield. Rocdor, Delinel and Primel represent the group “ab”. They produce respectively 364.7 pods/m², 354.2 pods/m² and 318.1 pods/m². The standard error of Rocdor is medium whereas they are small for Delinel and Primel. It means that there could be more variations in the number of pods obtained when cultivating Rocdor than there would be when cultivating Delinel and Primel. Contender represents the group “b” and has the smallest average number of pods per square meter with 275.3 pods/m².

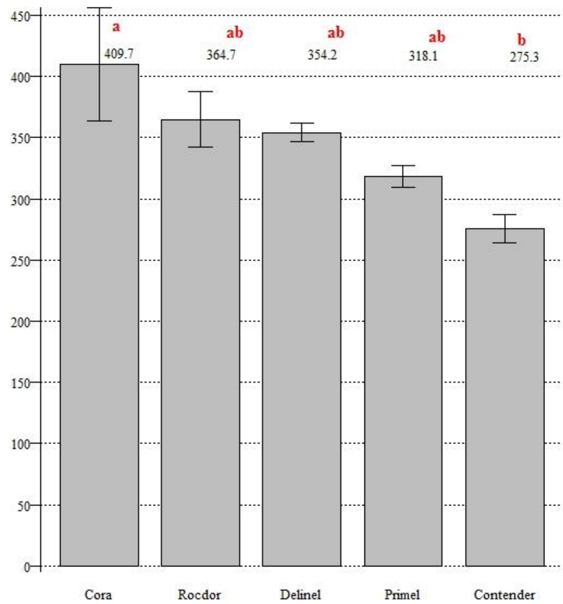


Figure 18: Average number of pods, standards errors and groups at the agricultural school

Considering the average yields obtained previously, it seems that Contender produces big pods and Cora small ones. Those results are correlating the characteristics of varieties provided by the breeders (

Table 4).

The consumers are known to prefer small pods because they are supposed to be tastier, with small seeds and no strings (Vanhuffel, 2013). However those consumers' habits may not be significant in Mayotte, considering that the population does not have the same habits as those living in mainland France. Moreover, the varieties experimented in the varietal trial were all stringless (types mangetout and stringless). So, it seems that it would not be a problem for farmers to grow dwarf beans producing big pods. Considering this statement, the variety Contender is still very appreciable.

1.2. Economic analysis of the dwarf bean cultivation

The economic analysis of the crop was based on the technical itinerary used during both experimentations at the school's farm and at the EARL Lucille's farm. But it was also based on the selling prices observed in various markets.

1.2.1. Costs of production

It was possible to estimate costs of production of dwarf bean through the crop operations, the time needed and the costs of inputs (Table 7). The crop cultivation was done under greenhouse, with automatic watering of plants (drop-by-drop system) and without any phytosanitary treatments. The amortization costs were not integrated to the estimation because no information was found. The surface dedicated to dwarf bean cultivation was not very important in Mayotte, also the costs of production were calculated for a production area of 100 m². The total costs of production (without amortization) were estimated at 287.25 € per 100 m² of dwarf beans or 2.9 €/m². The main expenditure items are the seeds (70€) and the labor with notably the time for harvesting (20h). The use of drop by drop systems and power tiller reduce considerably the need of labor.

Table 7: Costs of production of dwarf bean cultivation

	Quantity	**Price**	**Total**
Seeds (Cora)	1000 g	0.07 €/g	70 €
Manure	20 kg	0.0625 €/kg	1.25 €
Fuel	1 L	1.5 €/L	1.5 €
Total inputs			**72.75 €**
Tillage (power tiller)	0.5 h	6.96 €/h	3.48 €
Fertilization	1 h	6.96 €/h	7 €
Sowing	3 h	6.96 €/h	21 €
Thinning - Re-sowing	1.5 h	6.96 €/h	10 €
Weeding	3 h	6.96 €/h	21 €
Mounding	1.5 h	6.96 €/h	10 €
Harvest - Sorting - Weighing (7 harvests)	20 h	6.96 €/h	139 €
Cleaning of the field	2 h	6.96 €/h	14 €
Total labor	**32.5 h**	**6.96 €/h**	**225.50 €**
Total costs (amortization free)			**287.25 €**

The distribution of labor was not equal. Labor was mostly needed during the harvest period (Figure 19). It took 62% of the total labor. Then at a smaller scale were the sowing and the weeding at 9%. The time dedicated to soil tillage was very low because of the use of a power tiller. Also there was no need to spend time watering the plants. This ideal case was not shared by all farmers. Some of them, without any equipment will spend more time in soil tillage and plant watering.

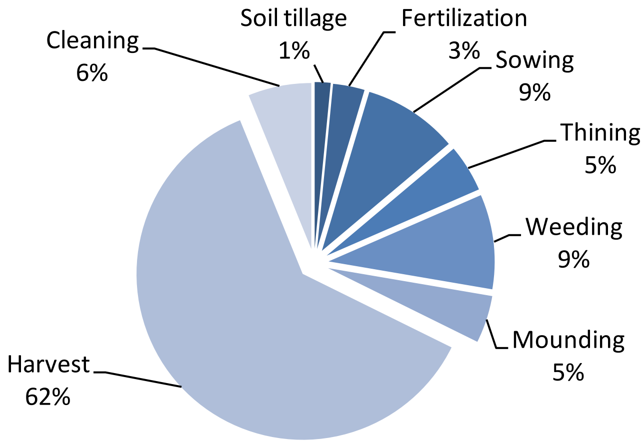


Figure 19: Distribution of labor of a crop cycle of dwarf bean

The total time requested for 100 m² of dwarf bean cultivation represented 4.6 days (32.5h) (Table 8). The crop cycle was about two months (+1 to +6 days). It represented only 0.11 full-time equivalent (FTE) per month for 100 m² of crop.

Table 8: Time requested for 100 m² of dwarf beans

Total time needed	4.6 days / 100 m²	464 days / ha
Full-time equivalent / month for a two months crop cycle	0.11 FTE/ 100 m²	11 FTE/ ha

1.2.2. Simulation of revenues

The net margin of this crop was linked to the average yields obtain during the experimentations. The selling price varied according to the season and the place of sell. It was a high price at the shop of the COOPAC (5 €/kg) and a low price when direct selling in informal markets (3 €/kg). The differences of price were explained by the costs of labor between legal and illegal farms. The net margin simulation for 100 m² of dwarf beans showed that with an average production of 0.75 kg/m² and a selling price at 4 €/kg it was possible to own 13 € for 100 m² of crop (Table 9). With high yields obtained during the experimentations (1.5 kg/m²) it was possible to win 463 € for 100 m² of crop sold at 5 €/kg of dwarf bean. Also this simulation of net margin was not taking into account the amortization costs.

Table 9: Simulation of net margin for 100 m² of dwarf beans

		Average yield of dwarf beans (Kg/m²)					
		0.5	**0.75**	**1**	**1.25**	**1.5**	**1.75**
Price of sell per Kg (in €)	**2.5**	-162 €	-100 €	-37 €	25 €	88 €	150 €
	3	-137 €	-62 €	13 €	88 €	163 €	238 €
	3.5	-112 €	-25 €	63 €	150 €	238 €	325 €

	4	-87 €	13 €	113 €	213 €	313 €	413 €
	4.5	-62 €	50 €	163 €	275 €	388 €	500 €
	5	-37 €	88 €	213 €	338 €	463 €	588 €

1.3. Results of interviews

1.3.1. Technical itineraries

9 farmers were able to present the technical itinerary they used. The most cultivated variety is Contender from Technisem (4 farmers grow it). Three other varieties were directly imported from mainland France. The average surface area dedicated to dwarf bean cultivation is about 120 m² per producer (mini. 20 m² and max. 300 m²) and it is mainly cultivated in open field (only one farm produced dwarf bean under greenhouse). Farmers always practice tillage (manual or mechanical) and direct sowing of two to three seeds per planting hole. The average spacing is 30 cm in rows and 35 cm between rows. The cultivation of beans is mainly done on beds of 1 m large. The management of the crop consists of one weeding (for 78% of the farmers) and one mounding (for 44% of farmers). The mounding is not a usual practice and has not been vulgarized because farmers do it at various stages of the crop (when plants measures 15-20 cm high or when blooming). Dwarf beans do not need fertilizer for their cultivation. One farmer does not apply any fertilizers, however five farmers apply organic amendments, one applies mineral fertilizer and two mixed fertilization. The organic amendments are added to the soil before the planting and the mineral fertilizer are added when plants are blooming. 44% of farmers apply treatments on their crop and 56% do not do anything.
Farmers are harvesting dwarf beans every two to three days and keep the crop in place for two to three and a half months. Unfortunately, no farmers were able to mention yields. The crop residues are left out of the field or given to animals. Feeding animals with crop residues is a common practice, especially during the dry season when forage becomes rare.

From the observation of what farmers do, the content of the bibliography, what researchers from the CIRAD did and what was observed during the experimentations, a technical itinerary was proposed in the ITR document (Appendix 13). In the ITR a table was made to present the main pests of dwarf bean based on the inventory of pests and diseases of the vegetable crops in Mayotte produced by Blancard (2012). In the table are presented two diseases and three pests, with their symptoms, the prophylactic measures and their biological and chemical treatments. Also general recommendations about pest control and observation are mentioned above the table. It was also apparent that most of the farmers did not know how much time was needed for each task of the crop cultivation so a sharing of the work was presented in the ITR (according to what was observed during the experimentation).

1.3.2. Farmers' interest in dwarf bean cultivation

50% of the farmers interviewed have produced dwarf bean at least once (but only 2 farmers were producing dwarf bean when the interview was done). The cultivation of dwarf bean is not popular with farmers; 55% of them do not want to grow it in the future. According to 12 farmers the disadvantages of dwarf bean are a high cost of production and high pest pressure for 33% of them (Table 10). Then there are the disadvantages of commercialization of the product, frequency of harvest and time needed for harvest for 25% of them. It is also difficult to harvest for 17% of them (considering the height of the plant). It appears that the disadvantages of the crop are mainly linked to the harvest tasks.

Table 10: Disadvantages of the dwarf bean cultivation *

	Nb. cit.	Freq.
High cost of production	4	33%
High pest pressure	4	33%
Hard to sell	3	25%
Frequency of harvest	3	25%
Length of time for harvesting	3	25%
Difficulty of harvest	2	17%
Other	3	25%

* Multi-answering possible
12 farmers were able to answer

The costs of production of 100 m² of dwarf bean cultivation were calculated in the ITR, with and without labor. Considering an average yield of 1.2 kg / m², the production costs without labor are 0.7€/m² and with labor they are about 2.6€/m². Moreover, a simulation of net margin was established for 100 m² of culture. The table presents various yield ratios and sell price. It is a tool for farmers in order to choose which selling price would be the more adapted to their case.

However, farmers found also some advantages of the cultivation of dwarf bean (Table 11). It is easy to sell and it is highly productive for 42% of farmers. Moreover it maintains the soil fertility for 33% of producers. At a smaller scale, for one farmer, it is a good specie for plant rotation and there is little pest pressure (in opposition with the main disadvantages). One farmer mentioned the fact that dwarf bean is good in association with maize.
The rotation and association aspects were developed in the ITR considering that the utilization of this botanical family should be developed in Mayotte and that it can be associated with maize easily. A rotation cycle with the main species cultivated in Mayotte was introduced.

Table 11: Advantages of the dwarf bean cultivation *

	Nb. cit.	Freq.
Easy to sell	5	42%
High production	5	42%
Maintain soil fertility	4	33%
Good crop rotation	1	8%
Good added value	1	8%
few pest pressure	1	8%
Other	6	50%

* Multi-answering possible
12 farmers were able to answer

Farmers did not collect any data about the cultivation of dwarf beans. It was necessary to create a data collection sheet by recycling and improving the sheet created by the CAPAM. Such a sheet would be useful for farmers to calculate the production costs, the time needed and the yields. This sheet was made in a way that it could be used for all kinds of vegetable production. First there are the characteristics of the farmer and the characteristics of the crop. Then there are tables for fertilization, treatments and observations of the crop. A final table is about yield, the quantities harvested and the selling price.

2. ITR on organic amendments

2.1. Experimentation on organic amendments

Experimentation on organic amendments was initiated at the agricultural school of Coconi. The experimentation was established for a period of five years. However the first cultivation of cucumbers did not give satisfying results, considering external factors that have falsified the results: there were some problems with the irrigation systems and significant pest attacks which destroyed the crop.

In order to promote the production of compost by the technicians, two methods of composting were experimented: the fast composting method of Berkeley and the windrow composting method. The fast composting method did not get satisfactory results, new experimentation needed. The windrow composting method was developed in the ITR. Temperatures of the heap of the fast composting method were measured every day or every two days (Figure 20). However it did not help to figured out why the method did not work. The temperatures raised up the first days than decreased. They were supposed to decrease until the ambient temperature (synonymous of end of processus) but they rose up again. This phenomenon was due to the watering of the heap on the 7th of June. After 21 days, the experimentation stopped.

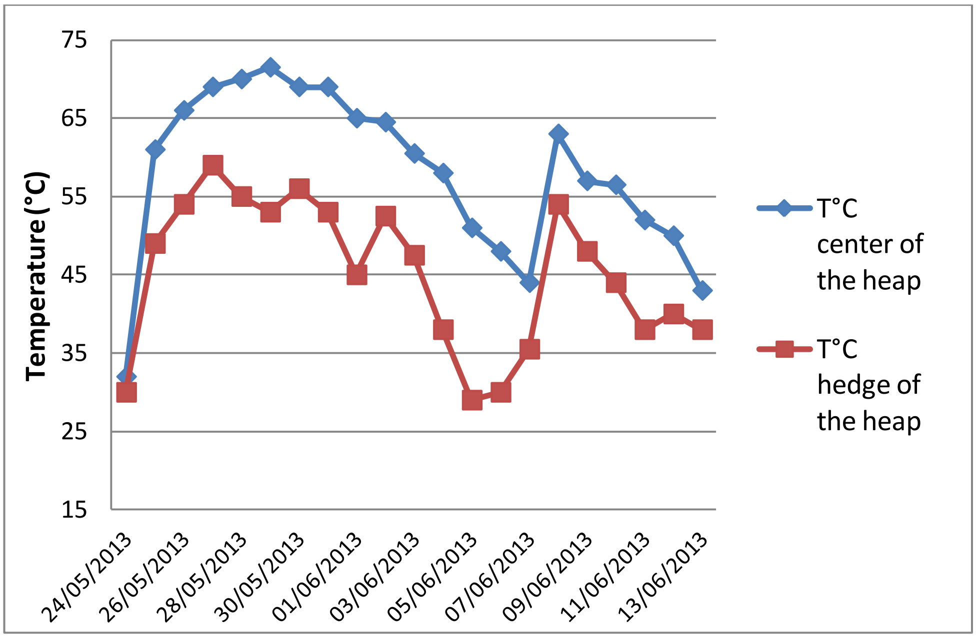


Figure 20: Measured temperature of the fast composting method

2.2. Results of interviews

Farmers were questioned about their management of the fertilization of their fields. It appears that 95% of the farmers interviewed used organic amendments and 85% mineral fertilizers. In the following results, only farmers using organic amendments will be considered (one farmer excluded).

2.2.1. Time of fertilization

Organic amendments are added to the soil before plantation of vegetable crops for 80% of the farmers (Table 12). Whereas mineral fertilizers are added to the soil during the cultivation (when crops measured 15 to 20 cm high or when blooming) for 65% of the farmers interviewed. It has to be noticed that 40% of the producers reason their decision when applying fertilizers: they are not adding fertilizers systematically on every crop. The fertilization is added to the soil according to the visual aspect of the crop.

Table 12: Fertilization application *

	Nb. cit.	Freq.
Before plantation	16	80%
During crop cultivation	13	65%
Reasoned decision	8	40%

* Multi-answering possible

20 farmers were able to answer

2.2.2. Type of fertilization

All interviewed farmers are using dried chicken manure (Table 13). This could be explained by the fact that battery farming of chicken was developed all over Mayotte. There are reliable suppliers with constant production of chicken manure. The cooperative of chicken producers (SCAM) is the first supplier of manure on the island.

In most cases the manure is sold dry. The fertilizer can be purchased in various formats:

- In a bag: a 40 liters grains bag (for animal feeding) is sold at 2.5 to 3 €.
- In bulk: a truck full of manure cost 50 €.

However, manure can be free when vegetable producers come and pick it up directly from the chicken house (in exchange of cleaning the stables, chicken farmers offer the manure).

Cow manure is also used but on a smaller scale. It is free in every case: as for the chicken manure, vegetable producers can come and pick it up from the stables or in the field. In most cases, producers using cow manure have family links with cow breeders.

The horse manure is very appreciated by producers but there is only one stud farm in Mayotte and not much manure is available there. The experimental station of Dembeni is often getting the manure from this stud farm.

Table 13: Type of organic amendments use by interviewed vegetable producers *

	Nb. cit.	Freq.
Dried chicken manure	19	100%
Cow manure	6	32%
Horse manure	2	11%
RCW	1	5%
Compost	1	5%
Other	6	32%

* Multi-answering possible

19 farmers were able to answer

Several other types of manure are used (rabbit manure, sheep manure, duck manure, etc.) but only on a very small scale and these are free. It has to be noticed that one vegetable producer makes compost and another uses Ramial Chipped Wood (RCW). These two farmers are not dependent on suppliers: they produce their own organic amendment.
In order to promote the independency of producers and to close the cycle of nutrients, those two techniques appear to be very interesting and hence were developed in the ITR on organic amendments (Appendix 14).

2.2.3. Application of fertilization

It is hard to estimate the quantities of organic amendments that are added to the soil and on what area because the farmers do not collect data about their practices. That is why in the ITR a data collection sheet specific to organic amendments was introduced. Nevertheless, according to the interviewed producers, the estimated quantities of dried chicken manure used are from 40 to 80 m^3 per hectare or one handful per planting hole or one shovel per two planting holes. The application of organic amendment is always manual.

2.3. Bibliography specific to Mayotte

Because there was not much information and many results of experimentations specific to Mayotte; the ITR on organic amendments was mainly based on bibliography. The reference documents used to produce the ITR were edited by the CIRAD of La Réunion (Chabalier & al., 2006), Agrisud (AGRISUD, 2010) and Agromisa (Inckel & al., 2005).

3. ITR on plant protection

3.1. Results of interviews

Farmers were asked about the main pest pressure in their farm (Appendix 15). They were able to give examples of pests that were predominant during the period of interviews (the dry season). One farmer did not mention any pest pressure in his farm.

3.1.1. Main pest pressure

The main pests cited by interviewed farmers are vegetable flies (*Dacus ciliatus* and *Neoceratitis cyanescens*), aphids (*Myzus persicae*, *Aulacophora foveicolis*, *Aphis gossypi* and *Aphis craccivora*) and brown rot (*Ralstonia solanaacearum*) with respectively 58%, 53% and 53% of citations. According to the interviews, mites (*Polyphagotarsonemus latus*), leafminer flies and snails are also sources of troubles for farmers (mentioned in 21% of cases).

The problem of the vegetable flies is one of the main constraints for the development of the vegetable sector in Mayotte. It can destroy 90% of the production and the phytosanitary products are not efficient in controlling the pest. The files spend most of their time out of the crop and come only to reproduce on fruits and vegetables (Chesneau, 2013).
The solutions for fighting the brown rot are using tolerant varieties of vegetable plants or doing grafting (Huat J. , 2006). Empirical observations showed that using insect proof nets is efficient to fight against the vegetable fly. However the same observations established that this technique is not efficient in blocking aphids attack.

The problems of diseases are not predominant from farmers' point of views because virus and C*ercosporia* were mentioned in only 21% and 16% of the interviews. However, this phenomenon could be explained by the fact that during the dry season, diseases are not predominant problems.

The problem of nematodes (*Meloydogyne spp*) has not been predominant whereas it is commonly established by agricultural institutions and technicians that most of the agricultural soils in Mayotte are infested by this specie. It could be explained by the lack of knowledge of the farmers and the fact that the disease is present in the soil and is not easy to identify without pulling out plants and looking at their roots.

One thing that has to be mentioned, is the problem of crabs that come to eat crops during the night in fields close to the mangrove. Apparently, pouring boiling water over them does not work but is used.

3.1.2. Conventional method of pest control

3.1.2.1. Equipments

95% of the farmers interviewed are using phytosanitary products to control pests. Only one producer does not use anything because he believes in natural regulation. The utilization of insecticides and fungicides is the only solution for lots of farmers.

However farmers are under-equipped to use phytosanitary products (Table 14). 79% of them have a sprayer or an atomizer and 16% an artisanal mini sprayer (re-use of window cleaner spray). One farmer did not have any equipment and just added the product ("the white powder") into the water of his watering can. Even if almost half of the interviewed farmers (47%) wear a mask, just a few of them have protection suits, boots or gloves. Generally, they have one of these three basic equipments mentioned but not all. 16% of the producers do not have any equipment except a sprayer. However, producers that have all the equipments needed do not use it all the time.

Table 14: Equipments for phytosanitary treatments *

	Nb. cit.	Freq.
Sprayer (10 to 20 L)	13	68%
Mask	9	47%
Protection suit	7	37%
Boots	7	37%
Gloves	7	37%
Sprayer (mini)	3	16%
Nothing	3	16%
Atomizer	2	11%

* Multi-answering possible
19 farmers were able to answer

It appears that there is a general lack of protection against phytosanitary products and a lack of knowledge about how, where and when to use the products. Moreover, in lots of cases farmers use only one product whatever the kind of pest and crop has to be control. There is a huge awareness campaign to be done in order to change habits of farmers about pest control and prevention of health risks incurred by phytosanitary products. Especially warning the farmers that produce seeds, it is dangerous to dip seeds in phytosanitary products.

3.1.2.2. Phytosanitary products

Farmers were asked about what kind of phytosanitary products they use. It was interesting to see that some have lots of products stored and some have one or two products that they use to fight all kinds of pests. 84% of the producers interviewed have products of the pyrethroid family (Table 15). 47% farmers have products of the carbamate family and 47% have products with both chemical families in it (carbamate + pyrethroid). Those chemical families are the most present in farmers' storage.

The principal phytosanitary products that can be purchased in agricultural shops in Mayotte are presented in the ITR on plant protection (Appendix 16). Even if the ITR is based around sustainable protection of plants, it is necessary to remind to vegetable producers which of their products can be sprayed on which crop and from which pest it protects it against.

Three kinds of products censed during the interviews are usable in organic agriculture: copper, spinosoïd and sulfur. They are used respectively by 47%, 11% and 11% of interviewed farmers. However they do not represent the majority of the pesticides. Herbicide was cited only once (triazine family). It seems that farmers still do manual weeding. In total there were five chemical families usable as insecticide and five chemical families usable as fungicide.

Table 15: List of phytosanitary products censed during interviews *

Chemical family	F/H/I**	Nb. cit.	Freq.
Pyrethroid	I	16	84%
Copper***	F	9	47%
Carbamate	F	9	47%
Carbamate + Pyrethroid	F/I	5	26%
Strobilurin	F	5	26%
Chloronicotinyl	I	3	16%
Avermectin	I	2	11%
Spinosoïd***	I	2	11%
Sulfur ***	F	2	11%
Dicarboximide	F	1	5%
Organophosphate	I	1	5%
Triazine	H	1	5%

* Multi-answering possible

** F = Fungicide / H = Herbicide / I = Insecticide

*** Usable in organic agriculture

19 farmers were able to answer

3.1.2.3. Registration of treatments

There are only 16% of farmers interviewed that collect data on their phytosanitary treatments. Once more, it appears that it is useful to introduce in the ITR a data collection sheet. On remark of a farmer makes the creation of a data collection sheet even more appreciable; "no I do not register data of treatments, because I know how to manage it, I do a treatment every three days". The creation of the sheet was inspired by the one created by the CAPAM. In the short term data collection has for objective to help farmers with the management of the phytosanitary products and especially with the alternation of chemical families. In the long term it is useful for technicians to know what chemical families are used most in Mayotte and then adapt their advice.

3.1.3. Alternative methods for pest control

Even if farmers do spray lots of phytosanitary products to control pests, they also resort to alternative management of pests:

- Crop association: It is possible to observe crops association, inside a field or in its periphery. 44% of farmers are doing it (Table 16).The most observed associations are lettuces and brèdes (green eatable leaves); maize and eggplant; maize and chili.
- Maceration: 33% of interviewed producers use diverse maceration of plants. Each farmer prepares its own mixture of various species of wild or cultivated plants. Some plant macerations were described in the ITR according to the document edited by Agrisud (AGRISUD, 2010).
- There are not enough farmers that practice prophylaxis. Only 22% of interviewed farmers pull out seek plants, 17% pick up 'sting' vegetables (by the vegetable flies) and 11% clean their fields from plant residues.

Nevertheless they should all use prophylaxes methods because they are free and effective to avoid pest infestations. That is why a complete sheet dedicated to the prophylaxes methods was introduced in the ITR. The methods presented are the results of the study of the bibliography and especially the one edited by the Program for countries of Africa, the Caribbean and the Pacific (UG; PIP, 2009). They also result from interviews with technicians (Chesneau, 2013) (Vanhuffel, 2013).

Table 16: Alternative methods for pest control *

	Nb. cit.	Freq.
Association of crops	8	44%
Maceration	6	33%
Pull out seek plants	4	22%
Weeding	4	22%
Pick up 'sting' vegetables	3	17%
Mulching	3	17%
Cleaning of plant residues	2	11%
Tolerant varieties	2	11%
Other	7	39%

* Multi-answering possible

18 farmers were able to answer

Crop rotations are useful to stop the proliferation of pests and diseases and to vary nutrients uptake. Most of the farmers could only mention the specie that was in place before the actual one. Farmers of the COOPAC have cultural calendars but not the other farmers. At the next culture, they will grow what they think would make some money in return. It regularly happens that farmers grow the same crop once or twice in the same field. It is particularly true for the cultivation of lettuce. The reason is that it is a short cycle crop. Moreover, producers do not pay attention to the rotation of the botanical family. It is possible to find in the same field a rotation of bell pepper, tomato and eggplant (all of the

Solanaceae family). 75% of the farmers do two crops rotation and 25% do three crops rotation (Table 17).

Table 17: Number of species in a crop rotation *

	Nb. cit.	Freq.
1	6	30%
2	15	75%
3	5	25%

* Multi-answering possible
20 farmers were able to answer

The Common Agricultural Policy (CAP) of the European Union (EU) establishes Agri-Environmental Measures (AEM) that are financial compensations for farmers that put in practice some measures in favor of the environment (and indirectly in favor of agriculture). Mayotte is an ultra-peripheral region of Europe and because of it the island is not subject to the CAP. However, special AEM for Mayotte exists and it was interesting to find out if farmers knew about them. It appears that only 40% of interviewed producers knew what AEM are. The 60% of farmers who did not know about it were very enthusiastic about putting in practice such measures (but also about getting financial compensations). In fact, 100% of farmers are willing to establish AEM but most of them do not know how to apply.

It would be very interesting to vulgarize the techniques promoted by the AEM. However, it is possible to do so only if technicians can raise awareness of the farmers. That is why AEM were mentioned in the ITR on plant protection and on organic amendments but under the title of "Apply research to Mayotte" and "Agroecological techniques".

3.2. Apply research to Mayotte

3.2.1. The vegetable flies

The vegetable flies are a major problem of the vegetable production sector in Mayotte. The CIRAD is working on it by testing the method GAMOUR (Agroecological management of vegetable flies in la Réunion) in Mayotte. This method is a combination of prophylaxis measures, management of habitats and biological control. Even if the method is not yet applicable in Mayotte, there were results of the study of the fly: there are 13 vegetal hosts' species and one parasitoid of the fly (*Psytallia spp*, with a level of parasitism very low < 1) (Chesneau, 2013). Additionally, there are four species of *Cucurbitaceae* flies (the most presents is *Dacus ciliatus*) and two species of *Solanaceae* flies (mostly *Neoceratitis cyanescens*).

3.2.2. The improved fallow

Lots of farmers stop cultivating vegetable crops during the raining season and the abandoned lands are not protected against erosion. The introduction of an improving fallow constituted of *Fabaceae* (*Vigna ombelata*) or *Poaceae* (*Panicum*) between two cycles of vegetable production helps to stop erosion and to enrich the soil in nutrients (especially in nitrogen). furthermore, the residues could constitute an inter-row of vegetable crops which would limit the development of weeds and the evapotranspiration (leading to water saving) and would be a refuge of auxiliary fauna (Chabierski, 2003).

3.2.3. The brown rot

The brown rot (*Ralstonia solanacearum*) is present everywhere in Mayotte with a more important frequency during the rainy season. There is no conventional control of the disease. The CIRAD is working on identifying the main species existing in Mayotte but it is also establishing experimentations to select species tolerant to the disease. Results of experimentations are that some species of tomatoes, eggplants and bell peppers were selected and mentioned in the ITR. Moreover another technique was experimented and is actually reviewed: the grafting of productive species on tolerant species (Chesneau, 2013) (Huat J. , 2006).

E. Discussion

1. Discussion on the experimentations

1.1. Experimentation on dwarf bean

1.1.1. Limits of the experimentations

There were some constraints of cultivating dwarf bean under tropical climate: high temperature, high humidity and high pest pressure.

Even if the temperature was not measured it was possible to observe different phenomena linked to this problematic. The first leaves of Contender were burned by the sun in both experimentations. However the development of the plant was not too affected, considering the fast growth of the plant which produced new leaves rapidly. The varieties Primel, Delinel and Rocdor of the breeder Vilmorin are not specifically dedicated to tropical climate. They are commercialized in mainland France. It seems that growing them under hot climate impacted their physiologies by improving the phenomenon of etiolation: they produced poles. Because of this, it has not been possible to select a sample of the population in each experimental plot. The poles were going up and down and the plants became entangled.

The pests' pressures were considerable in the experimentation taking place at the agricultural school. The establishment of the varietal trial next to cabbage crops infested by aphids was an issue. There is no utilization of pesticides at the agricultural school so the transfer of the pest from cabbage to dwarf bean could not be stopped. Moreover mites' infestations affected the crop at the end of the experimentation. Without this it would were possible to do some more harvests. However, it was interesting to notice that even with strong pest pressure it is possible to produce dwarf beans and to obtain good yields.

There are several hypotheses explaining why the average yields were less important at the experimentation taking place at the EARL Lucille. The plastic tunnel used for the varietal trial was covered with fungi that retained luminosity. Furthermore, blocks 2 and 4 were in the shade until ten o'clock in the morning because of giant bamboos growing next to the greenhouse. The soil was very compacted and it was necessary to do several runs with the power tiller to break large soil clods. The first harvests were done too late and the plants spent lots of energy in producing the first pods. The last hypothesis is based on the type of fertilization that was added to the soil. Mineral fertilizers could have made the vegetative stage last longer because of its high content in nitrogen (Messiaen, 2012).

It is a shame that the experimentation taking place at the EARL Lucille did not measure the number of pods per square meter. It would were interesting and more pertinent to compare the results obtained at the agricultural school with another experimentation.

1.1.2. Comparison of the results with other experimentations done in Mayotte

In both experimentations the means of yields are higher than the ones obtained by the CIRAD in its experimentations of 1993 and 2006 (Table 18). All varieties except Rocdor were subjected to varietal trials. The yields of Contender are two times higher than the yields obtained by the CIRAD in 2006 and 400 to 450 grams higher from the experimentation of 1993. It is the same phenomena for Primel which produced 320 to 640 grams/m² more than the experimentation of 1993; for Cora with 500 to 650 grams/m² more than the experimentation of 2006 and for Delinel with more than twice the yield obtained in 2006.

Table 18: Comparison of means of yields of five varieties of dwarf beans

	Contender	Primel	Cora	Delinel	Rocdor
Experimentation of 1993	1030	1000	-	-	-
Experimentation of 2006	770	-	870	570	-
Experimentation at the EARL Lucille, 2013	1466.2	1324.2	1377.3	1380	1136
Experimentation at the agricultural school, 2013	1498.1	1640.3	1510.3	1319.2	1411.1

Sources: (DAF, 1993) (Gimenez & Huat, 2006)

These very important differences of yields could be explained by the seasonal effect. The experimentations of 1993 and 2006 took place during the rainy season whereas experimentations of 2013 took place during the dry season. Temperature and humidity are significantly higher during the rainy season. The dwarf bean plant is very sensitive to high temperatures and its development stops when temperatures are above 30°C (CIRAD; GRET, 2002).

The difference of yields could also be due to the planting density. In both experimentations established during this mission, the planting densities were 23.3 plants/m² whereas it was 8 plants/m² in 1993 and 13.3 plants/m² in 2006. A higher density of plantation seems better to get high yields.

The importation in Mayotte of varieties other than Contender and Cora such as Primel has to be encouraged.

1.1.3. Limits of the statistical analyses

The statistical analyses have not been very satisfying because of their low precision. This could be explained by the size of the samples. It would were better to get bigger elementary plots and more repetitions of the modalities (more blocks). The block effects in both experimentations could also be responsible for the low precision of the analyses. The luminosity and shadow factors had an impact on the block effect at the varietal trial taking place at the EARL Lucille. At the agricultural school, this is probably the fertilization factor that was responsible for the block effect. The experimentation took place on one bed of 25 meters. It appears that there is a difference of fertility from one end of the bed to the other. When the greenhouse was built in 2012, lots of manure was spread on the front of the beds. The observation of various beds confirmed this hypothesis. There are bigger plants in the front than in the back. However, this observation was done too late; the varietal trial was already finished.

1.1.4. Discussion on the economic study

There are lots of interests in producing dwarf beans. One of them is that the return on investment is correct. If average yields of production are correct (above 0.75 kg/m²) it is possible to win money (if product sell at 4 €/kg). This economic study will help farmers to choose to cultivate this crop.

1.2. Experimentation on organic amendments

The experimentation did not produce any results because of the strong aphid's attack and the problem of irrigation. The size of the attack could were explained by the fact that the technical itinerary of the cucumber had not been correctly followed. Indeed, the density of plantation was too high (3.75 plants/m² instead of 2.5 plants/m² (Lycée agricole de Coconi, 2010)).

Also, this experimentation takes place on two beds. Each bed was divided in five elementary plots in order to offer three repetitions of three elementary plots. It means that one block was divided in two: it begins on one bed and finishes on the other one. However a repetition should be in one block (Gouet, 1991). Moreover, the observation of the difference of fertility from the front and the back of a bed is also significant in the greenhouse where the experimentation takes place. It is possible to establish the hypothesis that there will be block effects in every statistical analyses and so, falsify the results. It was more satisfactory to dedicate the entire greenhouse for the experimentation. The block effects were limited. However this was not possible because of other experimentations such as the one that has for objective to evaluate the effect of confinement of the greenhouses.
Also, the experimentation depends on the production of compost. There was not enough compost to establish a bigger experimentation anyway. The production of compost could be a limiting factor for the perenniality of the experimentation on organic amendments.
The two beds are located in the extremity of the greenhouse; there are other beds in between. Considering the visual aspect of the experimentation it was better to establish it on beds that are close to each other.
The experimentation should be done during five years to compare the long term impacts of the different types of organic amendments. There is a considerable turnover at the agricultural school. The person in charge of the experimentations could be gone before the end of the five years. If the transfer of information is not done well, the experimentation could be stopped prematurely as it was the case for the experimentation on Ramial Chipped Wood.
The vulgarization of the utilization of RCW as organic amendment might be difficult because there are only 45 branch and plant grinders in Mayotte (DAAF-SISE, 2011a). It is not known if the service provider of the DARTM has one.

2. Discussion on the interviews

There were many tasks to accomplish during this mission; it was difficult to meet many of the farmers. At the beginning of the mission it was established that the ITR (especially the ITR on dwarf bean) should reflect the practices of the producers. But most of them do not collect any data on their productions (yields, time needed for each tasks, phytosanitary treatments, etc.). That is why the economical study on dwarf bean has not been created from the results of the interviews as expected at the beginning of the mission. The creation of data collection sheets should be of great help for the professionalization of the sector. The farmers would then have feedback on their activities and the technicians will have better tools for providing supports.

Also it appears that asking more specific questions would have produce better results and more data for the technicians. Questions such as “are you ready to use RCW to fertilize your soil?”; “would you make it yourself?” and “how much would you buy it?” would have been more pertinent.

3. Discussion of the project on ITR

3.1. General discussion on the project

The objective of the project was to gather together all information available and research done in Mayotte. Lots of data and information are missing because of the change of agricultural institutions and the high turnover of the workers. It was a very difficult task to gather information from the different stakeholders. Lots of information was not found because nobody knew about it or because it was lost. For example, the dissolution of the ADVA for the creation of the DARTM resulted in the

creation of a room full of unclassified documents. Nobody was able to get information from this particular library. It is the same remark for the library of the CIRAD which has not been digitized; lots of reports were lost. However it was very interesting that the mission tried to gather all information possible. It will definitely be an advantage for the future of the vegetable sector and the agriculture of Mayotte in general.
It is positive that the project groups all stakeholders of the vegetable sector. It has for consequences to improve the dynamic of the sector. With this project, the competition between institutions was transformed into collaboration; they work together with the common objective of improving the sector.

3.2. The transfer of the results to vegetable producers

In order to transfer the results of the project, it would be correct to organize professional open days to all kinds of farmers. Such events would be helpful to raise awareness of farmers about the utilization of organic amendments, sustainable plant protection and cultivation of dwarf beans. Also there is still a lot to do about the training of farmers in plant protection. They might be better informed that the systematical utilization of phytosanitary products is no longer advised. However the set-up of the training should be different to the ones usually provided by the DAAF because only a few farmers can benefit from these training days. Informal training, on fields, in French and shimaoré has to be encouraged. It would be interesting to develop other experimentations on alternative pest control as is currently doing the CIRAD with the project GAMOUR. Experimentations on plant macerations could allow farmers reduce their utilization of phytosanitary products.

The ITR documents provide new tools for the vegetable technicians. However, without more technicians it will be very difficult to improve the whole vegetable sector. The limit of the project could be that it would only have an impact on the vegetable producers that already get support from the technicians. In the future, it is possible that the gap between professional farmers and traditional farmers becomes more and more sizable. But hopefully, this project will raise the general quality of the vegetable sector by impacting all the vegetable producers of Mayotte.

CONCLUSION

The dwarf bean experimentations have established that the Contender, Primel and Cora varieties are producing correct yields during the dry season on Mayotte. The regularity of Contender makes it the most reliable variety of dwarf bean for vegetable producers. Primel is not available in Mayotte but could be imported. The Cora variety needs to be tested again because of its high degree of dispersion. The dwarf bean cultivation can be done without using mineral fertilizers as it was observed that higher yields were obtained with duck manure. Shade nets are useful to protect the plants from too much luminosity. It can also affect the temperature on the plant. Considering that the dwarf bean is sensitive to high temperature, the utilization of shade nets is recommended. However, not too much shade or the average production will decrease. The cultivation of dwarf beans seems to be better adapted to the temperature of the dry season.

Vegetable flies, aphids and brown rot were the main pests observed during the dry season in 2013. Too many vegetable producers use systematically phytosanitary products to control pests. There are not too many chemical families available on the island and there are real risks that phenomena of resistances appear. Moreover, farmers do not have the equipments required for treatments. They are exposed to important health risks. However the CIRAD is testing various agroecological methods that should soon or later be vulgarized for general application by farmers. The development of sustainable plant protection is on its way, encouraged by agricultural institutions notably through agri-environmental measures in favor of sustainable management of pests.

Most of the vegetable producers interviewed during this mission do not practice rational use of fertilizers. The utilization of organic amendments such as dried chicken manure is well vulgarized but only a few farmers produce their own fertilizers. Experimentations on compost have not given satisfactory results yet. Continuing experimentations at the agricultural school will certainly lead to composting methods transferable to all farmers of Mayotte. Moreover the experimentation on organic amendments can help to change the farmers' habits. The farm of the agricultural school of Coconi is on its way to becoming a model farm. Efforts have to be maintained and continued.

The support of vegetable producers is improved with the creation of the three recommended technical itineraries. Technicians get new tools dedicated to more sustainable vegetable production, now they have to use them. However, with only two vegetable crops technicians for 1250 producers, the task seems difficult. Farmers have to rely on themselves and to help each other as they are doing at the COOPAC if they want to improve their activities.

The project on ITR encourages the various agricultural institutions to work together. It is only in this way that the vegetable sector can be improved. ITR documents are useful tools but they might not be of first importance for farmers and moreover they might not be usable by lot of farmers. These documents are addressed to educated farmers able to read French. It would be useful to translate them in to Shimaoré.

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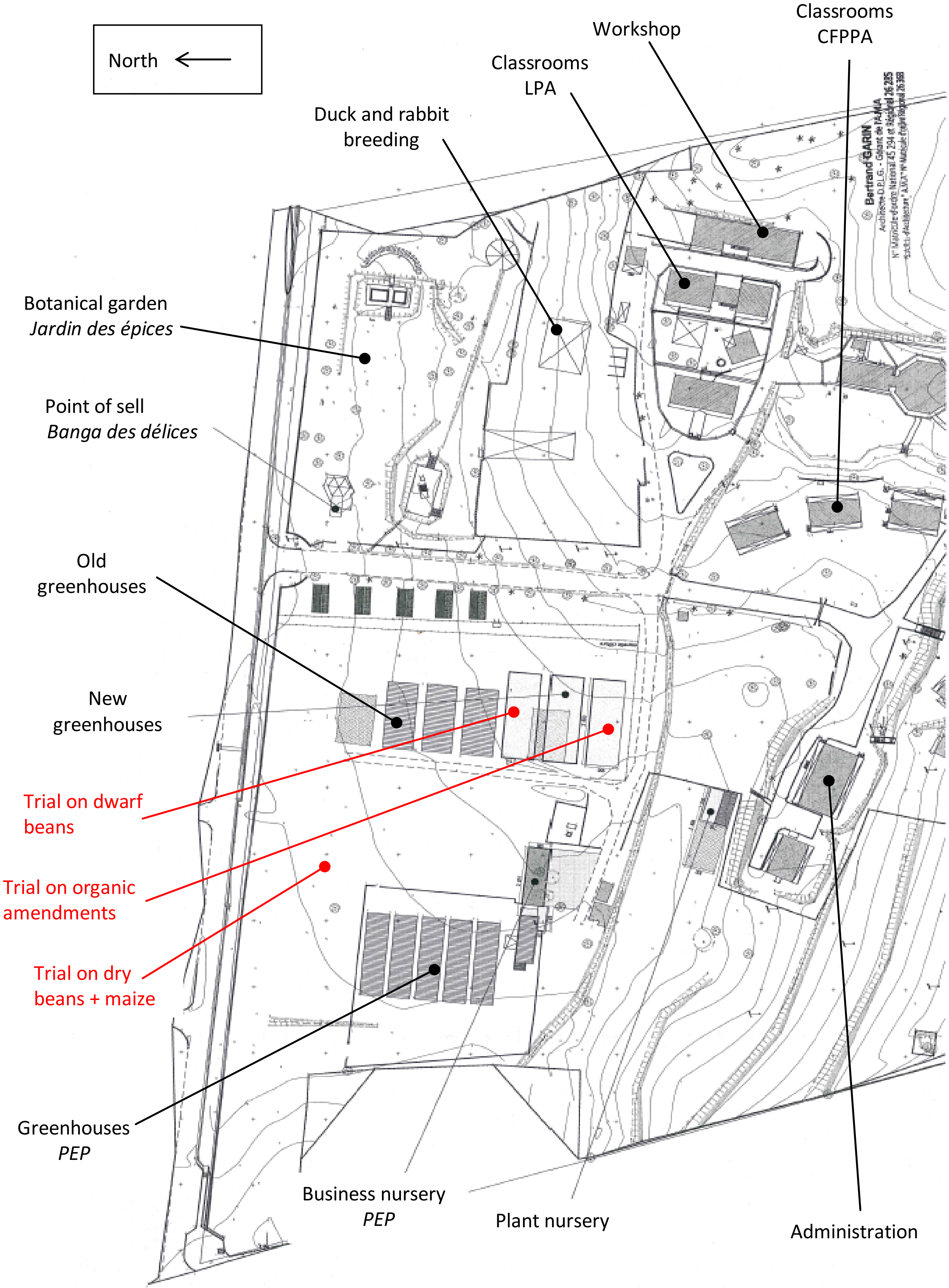
LIST OF APPENDIXES

Appendix 1: Plan of the agricultural school of Coconi



Appendix 2: Campaign for the valorization of local products

Source: (ODEADOM, 2010)

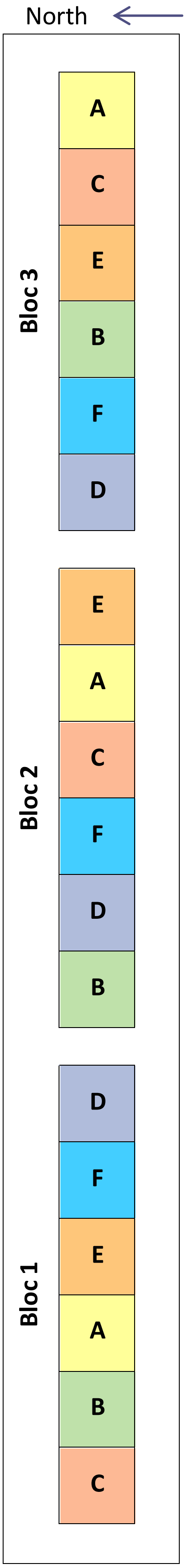
Appendix 3: List of stakeholders interviewed during the mission

Interviews of the stakeholders:

- The vegetable crops technician from the CAPAM (Luc Vanhuffel),
- The deputy director of the DARTM (Moustoifa Abdou),
- The coordinator of experimentations at the experimental station of Dembeni (Anli Abdou),
- The supervisor of the program Ecophyto from the DAAF (Anli Liachouroutu),
- The supervisor of the program economy of agricultural products from the DAAF (Patrice Crocis)
- The vegetable researcher of the CIRAD (Thomas Chesneau),
- The supervisor of the Agri-environmental Measures from the DAAF (Carol Develter),
- The coordinator of the vegetable cooperative (COOPAC, Aurélie Aufman),
- The supervisor of experimentations at the agricultural school of Coconi (Emilie Perreard)
- The farm workers at the agricultural school of Coconi (Jelan and Gérard)

Appendix 4: Varietal trial on dwarf bean at the farm of the agricultural school of Coconi

Trial plan

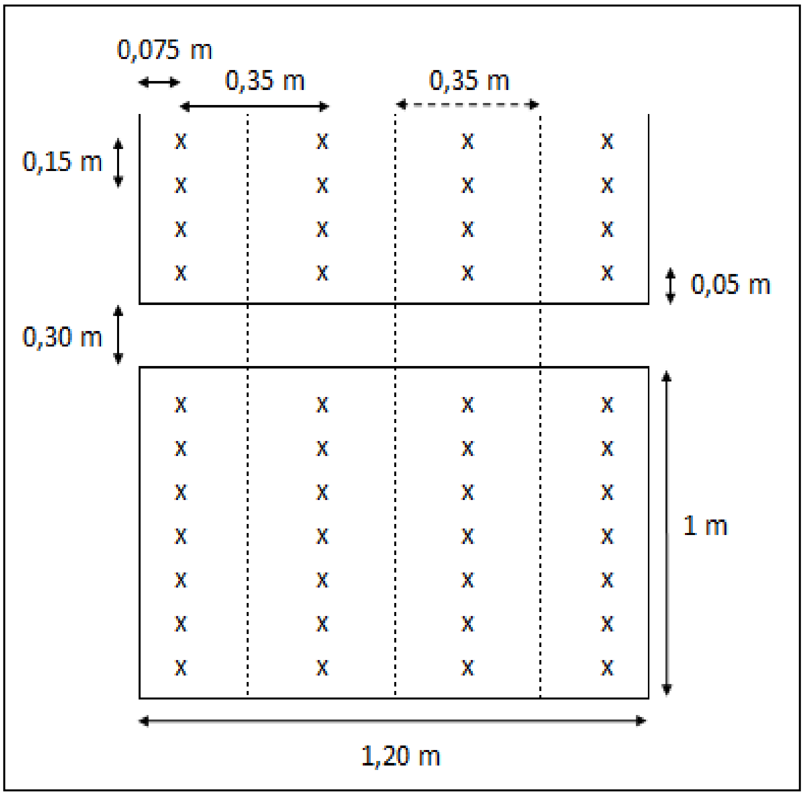


Modalities

Varieties:

A	**Contender**
B	**Cora**
C	**Gourmandel**
D	**Rocdor**
E	**Primel**
F	**Delinel**

Plan of an elementary plot



Legend:

x Planting hole

Irrigation system drop by drop

Characteristics of the experimental plan

Horticultural tunnel: Length = 26 m, Width = 9 m, Surface = 234 m²
Vegetable bed: L_p = 25 m, W_p = 1,2 m, S_p = 30 m²
Irrigation: 3 rows of drip water * 1 bed, 249 drippers (flow rate 2 l/h)

Elementary plot: L_{ep} = 1,2 m, W_{pe} = 1 m, S_{pe} = 1,2 m²
7 plants * 4 rows = 28 dwarf bean plants

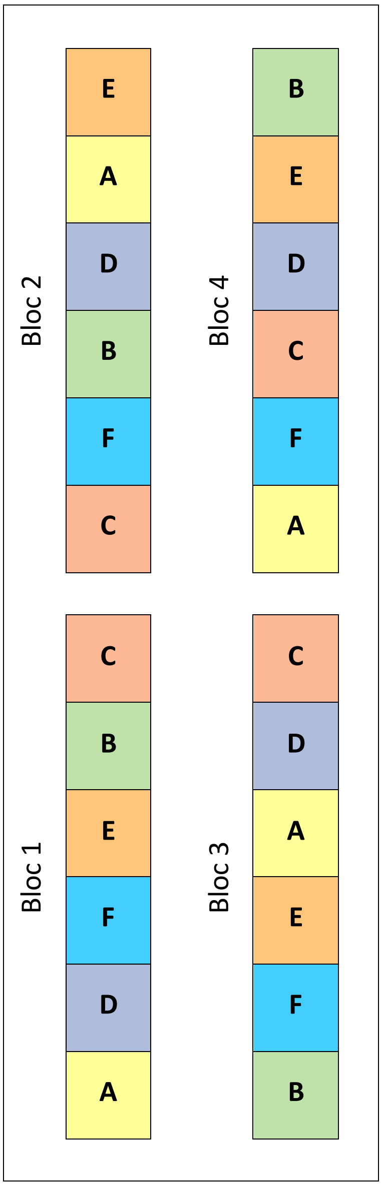
Number of plants in trial: 28 plants * 6 repetitions * 3 blocs = 504 plants
Number of plants on the edge: 16 plants * 2 repetitions = 32 plants
Total number of plants: 504 + 32 = 536 plants

Planting density: 23,3 dwarf bean plants/m²

Appendix 5: Varietal trial on dwarf bean at the EARL Lucille's farm

Trial plan

North ←

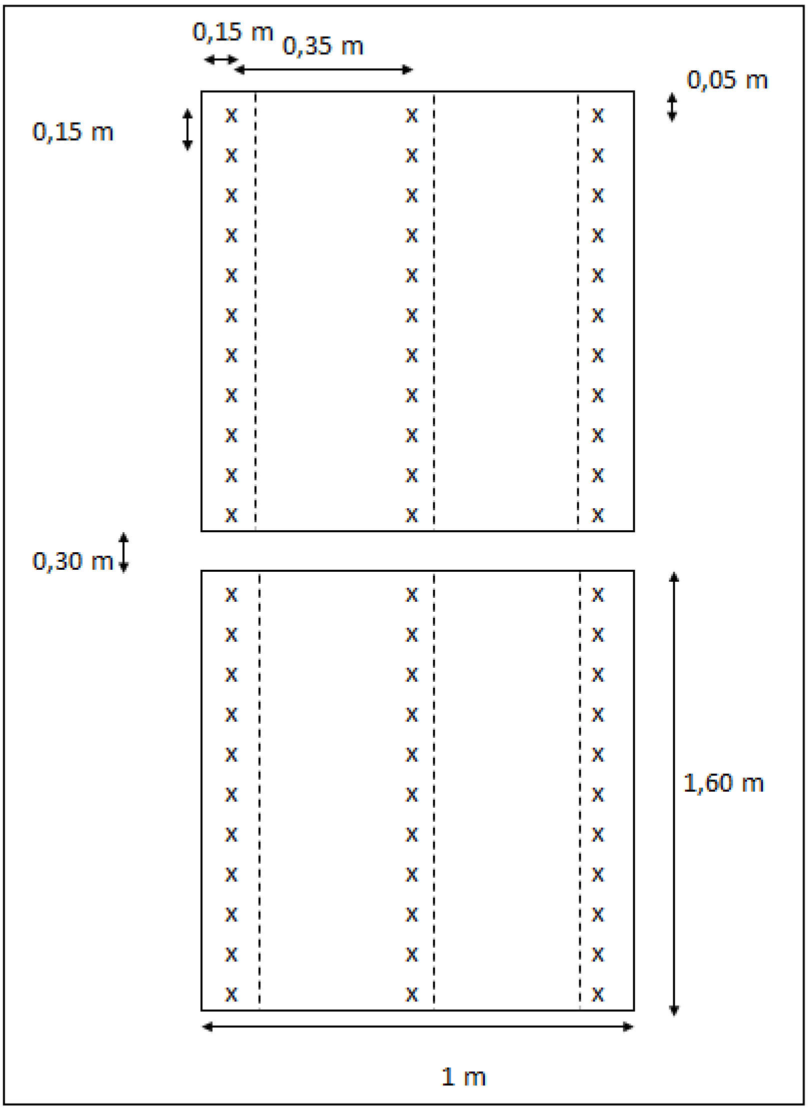


Modalities

Varieties:

A	**Contender**
B	**Cora**
C	**Gourmandel**
D	**Rocdor**
E	**Primel**
F	**Delinel**

Plan of an elementary plot



Legend:

x Planting hole

Irrigation system drop by drop

Characteristics of the experimental plan

Horticultural tunnel: L = 25 m, W = 5 m, S = 125 m²
Vegetable bed: L_p = 24 m, W_p = 1 m, S_p = 24 m²
Irrigation: 3 rows of drip water * 2 beds, 480 drippers (flow rate 2 l/h)

Elementary plot: L_{ep} = 1,6 m, W_{ep} = 1 m, S_{ep} = 1,6 m²
11 plants * 3 rows = 33 bean plants

Number of plants in trial: 33 plants * 6 repetitions * 4 blocs = 792 plants
Number of plants on the edge: 16 plants * 4 repetitions = 64 plants
Total number of plants: 792 + 64 = 856 bean plants

Plantation density: 23,3 bean plants/m²

Appendix 6: Technical itineraries of both trials on dwarf bean

Technical itinerary of the trial at the agricultural school

Date	Interventions	Observations
3 May	Tillage	20 cm tillage with a power tiller / 1 round trip
3 May	Fertilization	1,25 kg/m² of duck manure
3 May	Bed formation	Surface leveled and refined with a rake
3 May	Irrigation system	Placement of the irrigation system 5 min / 3 times / day
6 May	Irrigation	Manuel irrigation
07 May	Irrigation	Manuel irrigation
07 May	Sowing	direct sowing of 2 seeds per planting hole All varieties were sowed
08 May	Irrigation	Manuel irrigation
15 May	Thinning	Conservation of one plant / planting hole
21 May	Weeding	With a hoe
21 May	Mounding	
17 June	Harvest	0,593 kg
19 June	Harvest	1,382 kg
20 June	Harvest	1,304 kg
24 June	Harvest	7,758 kg
27 June	Harvest	4,971 kg
1 July	Harvest	5,634 kg
5 July	Harvest	3,727 kg
8 July	Harvest	1,582 kg

Technical itinerary of the trial at the EARL Lucille's farm

Date	Interventions	Observations
22 May	Tillage	20 cm tillage with a power tiller Very compact soil, big aggregates
24 May	Tillage	Second 20 cm tillage / Big aggregates
27 May	Tillage	Third 20 cm tillage
28 May	Fertilization	10 grams/m² of 13 8 24
28 May	Bed formation	Surface leveled and refined with a rake
28 May	Irrigation system	Placement of the irrigation system 5 min / 3 times / day
29 May	Sowing	direct sowing of 1 or 2 seeds per planting hole All varieties were sowed
30 May	Irrigation	Manual irrigation
2 June	Irrigation	Manual irrigation
8 June	Thinning	Conservation of one plant / planting hole
12 June	Weeding	With a hoe
12 June	Mounding	
18 July	Harvest	14,463 kg
22 July	Harvest	7,397 kg
30 June	Harvest	6,862 kg
5 August	Harvest	3,363 kg

Appendix 7: Varietal trial on climbing bean and pea associated to maize in open field

Trial plan

North

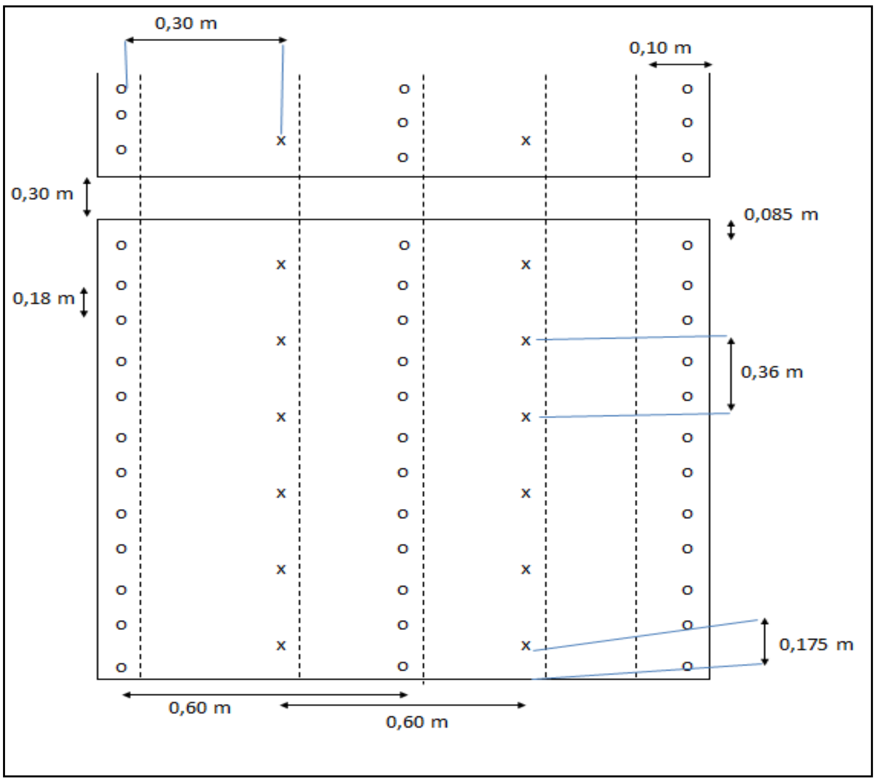
bloc 1	bloc 2	bloc 3
D	C	B
F	B	G
B	A	D
E	E	F
G	F	C
C	D	A
A	G	E

Modalities

Varieties:

A	**Cameroon pea**
B	**Mahorais pea**
C	**Mallow hyacinth bean**
D	**Red hyacinth bean**
E	**40 days cowpea**
F	**Yard long bean**
G	**Payet bean**

Plan of an elementary plot



Legend:

x Bean planting hole

o Maize planting hole

Irrigation system drop by drop

x

Characteristics of the experimental plan

Field:	L = 18 m, W = 6 m, S = 108 m²
Vegetable bed:	L_p = 17 m, W_p = 1,5 m, S_p = 25,5 m²
Irrigation:	rows of drip water * vegetable plate, drippers (flow rate 2 l/h)
Elementary plot:	L_{ep} = 2,15 m, W_{ep} = 1,5 m, S_{ep} = 3,225 m² 6 plants * 2 rows = 12 bean plants 12 plants * 3 rows = 36 maize plants
Number of plants:	12 plants * 7 repetitions * 3 beds = 252 bean plants 36 plants * 7 repetitions * 3 beds = 756 maize plants
Plantation density:	3,7 bean plants/m² 11,2 maize plants/m²

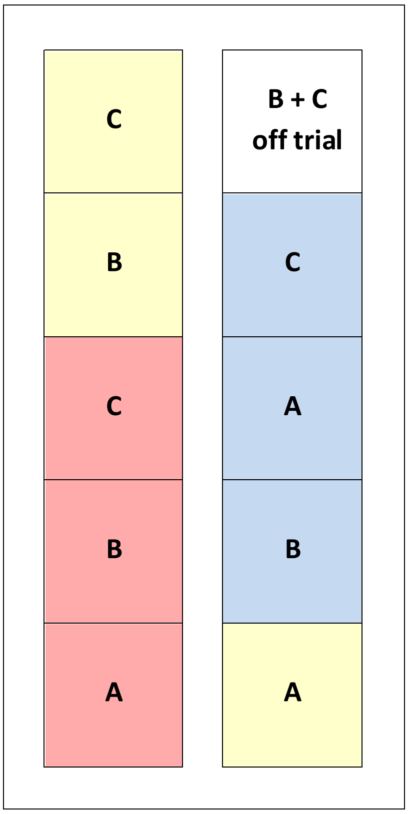
Technical itinerary

Date	Interventions	Observations
20 May	Tillage	Tillage with a rotavator
27 May	Tillage	Second 20 cm tillage with a power tiller
27 May	Fertilization	1,75 kg/m² of duck manure
28 May	Bed formation	Surface leveled and refined with a rake
29 May	Irrigation system	Placement of the irrigation system Manual irrigation : 15 to 30 min / 2 to 3 days
4 June	Sowing	direct sowing 2 seeds of maize / planting hole
18 June	Sowing Re-sowing	Direct sowing of 2 *Fabaceae* seeds / planting hole 3-4 seeds of maize / planting hole
1 July	Re-sowing	5-6 seeds of maize / planting hole 2 *Fabaceae* seeds on empty planting hole Replacement of the variety C
3 July	Weeding	With a hoe
4 July	Weeding	With a hoe
5 July	Weeding	With a hoe
26 July	Maintenance	Keeping plants on their elementary plot
5 August	Maintenance	Keeping plants on their elementary plot
15 August	Maintenance	Keeping plants on their elementary plot
26 August	Maintenance	Keeping plants on their elementary plot
5 Sept	Maintenance	Keeping plants on their elementary plot
5 Sept	Harvest	Variety G

Appendix 8: Comparison of three types of organic amendments for fertilization of vegetble crops cultivated under greenhouse

Trial plan

North ←



Modalities

Caption:

A **Compost**

B **BRF**

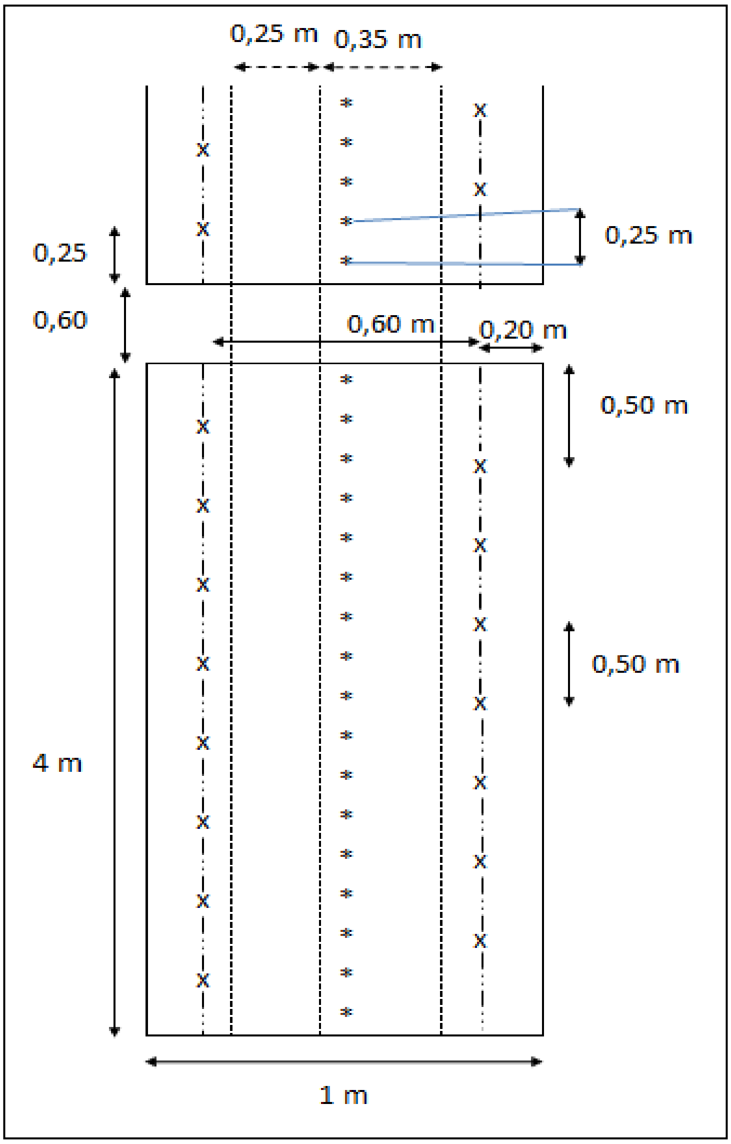
C **Manure**

Bloc 1

Bloc 2

Bloc 3

Plan of an elementary plot



Caption:

x Cucumber planting hole

! Carrot planting hole

* Lettuce planting hole

⋮ Irrigation system drop by drop

Characteristics of the experimental plan

Vegetable plate:	L_p = 25 m, W_p = 1 m, S_p = 25 m²
Irrigation:	3 rows of drip water * 2 beds, 498 drippers (flow rate: 2 l/h)
Elementary plot:	L_{pe} = 4 m, W_{pe} = 1 m, S_{pe} = 4 m² (8 plants * 1 row) + (7 plants * 1 row) = 15 cucumber plants 32 plants * 2 rows = 64 carot plants 17 plants * 1 row = 17 lettuce plants
Number of plants:	15 plants * 3 repetitions * 3 blocs = 135 cucumber plants 32 plants * 3 repetitions * 3 blocs = 288 carrot plants 17 plants * 3 repetitions * 3 blocs = 153 lettuce plants
Planting density:	3,75 cucumber plants/m² 8 carrot plants/m² 4,25 lettuce plants/m²

Technical itinerary

Date	Interventions	Observations
7 June	Sowing	Sowing cucumbers in plant nursery
19 June	Production of RCW	Collect of branches and grinding
20 June	Tillage	20 cm tillage with a power tiller
21 June	Fertilization	According to modalities
21 June	Bed formation	Surface leveled and refined with a rake
21 June	Irrigation system	Placement of the irrigation system
24 June	Plantation	Plantation of cucumbers
24 June	Horticultural wire	Placement of wire to conduct cucumbers
26 June	Plantation	Transplanting carrots
1 July	Maintenance	Conduct cucumbers around horticultural wires
3 July	Weeding	With a hoe
8 July	Maintenance	Conduct cucumbers around horticultural wires
12 July	Maintenance	Conduct cucumbers around horticultural wires
14 July	Treatment	Maceration of garlic and chilly plus black soap
29 July	Harvest	2,417 kg
30 July	Sowing	Sowing lettuce in plant nursery
5 August	Harvest	18,475 kg
9 August	Harvest	6,775 kg
12 August	Harvest	13, 401 kg
12 August	Cleaning	Cucumbers uprooting
14 August	Treatment	Maceration of garlic and chilly plus black soap
16 August	Plantation	Plantation of lettuce
19 August	Treatment	Maceration of garlic and chilly plus black soap

Appendix 9: Fabrication of compost at the agricultural school of Coconi

A transect walk with notification of the observations through the school's farm presented a quick overview of the situation. Were visited the animal husbandry and the place to store the manure; then there were the vegetable crops production area and the actual management of the crop residues. Meeting the farm workers was the final part to understand the situation.

The second step was to define which composting methods would be experiment according to the potential and the need of the school's farm, the will of the stakeholders and the bibliography. There was a quick need for compost that is why the fast composting method from Berkeley was chosen. This method was supposed to produce compost in one to two weeks. It was a manual and small scale production system of compost. The second method chose was mechanized and adapted to large scale production system. The windrow composting method was chosen.

In collaboration with the chief operating officer, the supervisor of experimentations and the farm workers two composting areas were designated. The manual composting area was placed under carambole trees, next to the usual compost area. The mechanical composting area was located next to the meteorological station, with enough space for a tractor to move on. This area was not protected from the sun.

A list of equipments and materials needed for the realization of the project was made and established the needs. It was necessary to obtain wood boards, screws, geotextile trap and thermometers. The next step was to create documents on how to create and manage those two composting methods. Tables were made, a drawing of the compost bins and a data collection sheet for the temperature. Unfortunately this work was stolen by thieves.

It was necessary to meet teachers and find those that wanted to be involved in the project. Then comparing their schedules and availability to facilitate the organization and the repartition of the tasks to do between classes.

Two compost bins for the fast composting method from Berkeley were built and place on the defined area with the collaboration of teachers, students and the workers of the workshop. The equipments used for the creation of the compost bins are wood boards, saw, screws, screwdriver and meter. Once the compost bin in place, they were filed up with several layers of green and dry material, and watered the fresh compost heap. Then to control the temperature of the heap two special compost thermometers of 40 cm each were placed, one in the centre of the heap and one in its periphery. Temperature was measured everyday and registered in a data collection sheet on Excel and a final temperature curve of the compost was made. The curve temperature was a tool used for controlling the evolution of the compost heap and used by teachers of soil biology in their courses. The heap was return in the next bin every day or every two days after that the temperature gets over fifty degrees Celsius during two to three days.

The windrow composting method was made by using manure from the animal husbandry. Manure was storage on three compartments of difficult access by tractor. 6 m^3 of manure from one compartment were used to make a windrow of 1 m high, 1,5 m large and 6 m long. A geotextile trap was covering the windrow composting method from the sun and some bamboo sticks fixed the trap. The windrow was returned once a week or twice a month according to the availability of the teachers.

Appendix 10: Interview guide

Itinéraires Techniques Recommanés à Mayotte

2013

Présentation Générale de l'Exploitant et de son Exploitation

1. Prénom/Nom

2. Téléphone

3. Localisation

4. Agriculture seule activité professionnelle ?
○ 1. oui ○ 2. non

5. Agriculture seule source de revenu ?
○ 1. oui ○ 2. non

6. Possédez vous un numéro SIRET ?
○ 1. oui ○ 2. non

7. Quelles sont les qualités de vos terres ?
☐ 1. accès à l'eau ☐ 2. accès à l'exploitation
☐ 3. accès réseau routier ☐ 4. terrain plat
☐ 5. sol riche ☐ 6. surface de l'exploitation
☐ 7. autres
Vous pouvez cocher plusieurs cases (5 au maximum).

8. Si 'autres', précisez :

9. Contraintes de vos terres ?
☐ 1. accès à l'eau ☐ 2. accès à l'exploitation
☐ 3. sol pauvre ☐ 4. surface de l'exploitation
☐ 5. terrain en pente ☐ 6. terrain pierreux
☐ 7. autres
Vous pouvez cocher plusieurs cases.

10. Si 'autres', précisez :

11. Quelles sont les productions de l'exploitation ?
☐ 1. Maraîchage ☐ 2. vivrier ☐ 3. élevage
☐ 4. fruitier ☐ 5. autre
Vous pouvez cocher plusieurs cases.

12. Si 'autre', précisez :

13. Surface totale de production?

14. Adhérent à un groupement de producteur ?
○ 1. oui ○ 2. non

15. Lequel ?
La question n'est pertinente que si groupement de producteur ? = "oui"

Les Cultures Maraîchères

16. Principales productions maraîchères ?

17. Surface de production (ha)

18. Possédez-vous des serres?
○ 1. oui ○ 2. non

19. Souhaitez-vous en avoir (plus) ?
○ 1. oui ○ 2. non

20. Si 'oui', précisez :

21. Quelles sont les rotations de cultures sous serre?

22. Quelles sont les rotations de cultures de plein champ ?

23. Discussion choix des cultures

24. Approvisionnement en eau?

25. Quantité d'eau suffisante en saison sèche ?
○ 1. oui ○ 2. non

26. Adaptation au manque d'eau

La question n'est pertinente que si appro eau saison sèche = "non"

27. Quelles productions rapportent le plus d'argent ?

28. A qui vendez vous vos production ?

29. Où vendez vous vos productions ?

30. Collectez vous des données sur vos productions ?
○ 1. oui ○ 2. non

31. Qu'en faites vous ?

La question n'est pertinente que si Données de productions = "oui"

Le Haricot

32. Cultivez vous ou avez vous cultivé des haricots ?
○ 1. oui ○ 2. non

33. ITK_haricot_cultivar

34. ITK_haricot marque

35. ITK_haricot surface SS ou PC

36. ITK_haricot le sol

37. ITK_haricot semis/densité

38. ITK_haricot entretien

39. ITK_haricot irrigation

40. ITK_haricot fertilisation

41. ITK_haricot traitements phyto

42. ITK_haricot récolte

43. ITK_haricot les résidus de culture

44. ITK_haricot durée du cycle (mois)

45. Souhaitez vous cultiver des haricots à l'avenir ?
○ 1. oui ○ 2. non

La question n'est pertinente que si Culture de haricot = "non"

46. Avantages de la cuture du haricot ?

- ☐ 1. Entretien du sol
- ☐ 2. rotation
- ☐ 3. bonne valeur ajoutée
- ☐ 4. forte production
- ☐ 5. peu de pression des bioagresseurs
- ☐ 6. se vend bien
- ☐ 7. autres

Vous pouvez cocher plusieurs cases.

47. Si 'autres', précisez :

48. Inconvénients de la culture de haricot ?

- ☐ 1. difficile à vendre
- ☐ 2. faible durée de conservation
- ☐ 3. forte pression des bioagresseurs
- ☐ 4. coûts de productions élevés
- ☐ 5. difficulté de récolte
- ☐ 6. fréquence de récolte
- ☐ 7. durée de récolte
- ☐ 8. autres

Vous pouvez cocher plusieurs cases (7 au maximum).

49. Si 'autres', précisez :

La Fertilisation

50. Type de fertilisation ?

☐ 1. organique ☐ 2. minérale

Vous pouvez cocher plusieurs cases.

51. Nature fertilisation organique

☐ 1. bovin ☐ 2. canard ☐ 3. poule ☐ 4. lapin

☐ 5. cheval ☐ 6. BRF ☐ 7. compost ☐ 8. autre

Vous pouvez cocher plusieurs cases.

52. Si 'autre', précisez :

53. Cultures fertilisation organique

○ 1. Toutes ○ 2. autres

54. Si 'autres', précisez :

55. Quantités apportées (kg/ha)

56. Provenance (prix) ou fabrication

57. Méthodes de fertilisation

☐ 1. manuelle ☐ 2. mécanisée

Vous pouvez cocher plusieurs cases.

58. Si 'mécanisée', précisez :

59. Applications fertilisants ?

☐ 1. à la plantation ☐ 2. en cours de cycle

☐ 3. raisonnée

Vous pouvez cocher plusieurs cases.

La Protection des Cultures

60. Principaux bioagresseurs des cultures ?

61. Traitez vous vos cultures ?
○ 1. oui ○ 2. non

62. Principaux produits phytosanitaires utilisés

63. Equipements pour les traitements ?
☐ 1. gants ☐ 2. bottes
☐ 3. masques ☐ 4. combinaison
☐ 5. pulvérisateur ☐ 6. atomiseur
☐ 7. pschitt pschitt ☐ 8. rien
Vous pouvez cocher plusieurs cases (7 au maximum).

64. Remplissez vous un registre de traitement?
○ 1. oui ○ 2. non

65. Pourquoi :

66. Méthodes de luttes alternatives ? (prophylaxie, associations, produits naturels, etc)

67. Connaissance de MAE ?
○ 1. oui ○ 2. non

68. Souhaitez vous mettre en place des dispositifs MAE ?
○ 1. oui ○ 2. non

Projets de colaboration

69. Accueillir des stagiaires du LPA ?
○ 1. oui ○ 2. oui, j'en accueille déjà ○ 3. non

70. Mettre en place des expérimentations avec le LPA ?
○ 1. oui ○ 2. non

71. Echange entre agriculteurs ?
○ 1. oui ○ 2. non

72. Si 'oui', précisez :

73. VARIABLE_73
☐ 1. Thème n° 1 ☐ 2. Thème n° 2 ☐ 3. Thème n° 3
Vous pouvez cocher plusieurs cases.

Appendix 11: Script and results of the variance analysis of the experimentation on dwarf bean at the EARL Lucille

```
####################################################################################
ANALYSIS OF THE VARIABLE  "YIELD"
####################################################################################

setwd ("I:/TOZZZZZZZZZZ/Thomas_2013/R Thomas")
dir()
jeu=read.table("Essai_Haricot_Vert_EARL_Lucille.txt",h=T,sep="\t")
jeu$date=as.Date(jeu$date,"%d/%m/%Y")
jeu$rdt=as.numeric(jeu$rdt)
jeu$rdt=round(jeu$rdt/1.2,3)

summary(jeu)
        var          date             bloc
 Contender:16   Min.   :2013-07-18   B1:20
 Cora     :16   1st Qu.:2013-07-21   B2:20
 Delinel  :16   Median :2013-07-26   B3:20
 Primel   :16   Mean   :2013-07-26   B4:20
 Rocdor   :16   3rd Qu.:2013-07-31
                Max.   :2013-08-05
      rdt
 Min.   :  41.67
 1st Qu.: 175.21
 Median : 298.33
 Mean   : 334.22
 3rd Qu.: 395.00
 Max.   :1010.83

rend=aggregate(jeu["rdt"],c(jeu["var"],jeu["bloc"]),sum,na.rm=T)

summary(rend)
        var     bloc        rdt
 Contender:4   B1:5   Min.   : 836.7
 Cora     :4   B2:5   1st Qu.:1114.2
 Delinel  :4   B3:5   Median :1425.8
 Primel   :4   B4:5   Mean   :1336.9
 Rocdor   :4          3rd Qu.:1505.0
                      Max.   :1915.0

windows()
library(lattice)
interaction.plot(rend$bloc,rend$var,rend$rdt,las=2,col=1:6,lwd=2)
```

```
boxplot(rend$rdt~rend$var)

bartlett.test(rend$rdt,rend$bloc) ; bartlett.test(rend$rdt,rend$var)

        Bartlett test of homogeneity of variances

data:  rend$rdt and rend$bloc
Bartlett's K-squared = 1.8379, df = 3,
p-value = 0.6067


        Bartlett test of homogeneity of variances

data:  rend$rdt and rend$var
Bartlett's K-squared = 1.5859, df = 4,
p-value = 0.8113


mod=lm(rend$rdt~rend$var+rend$bloc,y=T)

shapiro.test(mod$res)

        Shapiro-Wilk normality test

data:  mod$res
W = 0.9254, p-value = 0.1261


windows()
par(mfrow=c(2,2))
hist(mod$res,freq=F)
lines(density(mod$res),col="red")
rug(jitter(mod$res,5))
f=function(t){dnorm(t,mean=mean(mod$res),sd=sd(mod$res))}
curve(f,add=T,col="blue",lwd=3,lty=2)
qqnorm(mod$res)
qqline(mod$res)
plot(mod$fit, mod$res)
abline(h=qnorm(c(0.025,0.975))*sd(mod$res))
plot(mod$fit,mod$y)
abline(0,1)

library(lattice)
windows()
resi=matrix(mod$res,nrow=5)
```

```
levelplot(resi,cuts=4)

anova(mod)
Analysis of Variance Table

Response: rend$rdt
          Df Sum Sq Mean Sq F value Pr(>F)
rend$var   4 241905   60476  0.7973 0.5495
rend$bloc  3 286346   95449  1.2584 0.3324
Residuals 12 910199   75850

library(agricolae)
modele=aov(rdt~var,data=rend,y=T)
S=SNK.test(modele,"var","Effet variétal")

Study:

Student Newman Keuls Test
for rdt

Mean Square Error:  79769.68

var,  means

               rdt  std.err r      Min.
Contender 1466.250 173.5320 4 1068.334
Cora      1377.292 182.6021 4  836.667
Delinel   1380.000 103.0107 4 1200.834
Primel    1324.167 118.9921 4 1008.334
Rocdor    1136.667 107.1675 4  905.833
              Max.
Contender 1914.999
Cora      1634.167
Delinel   1650.000
Primel    1564.167
Rocdor    1424.167

alpha: 0.05 ; Df Error: 15

Critical Range
       2        3        4        5
425.6758 518.7457 575.5994 616.6952

Means with the same letter are not significantly different.
```

Groups, Treatments and means

a	Contender	1466
a	Delinel	1380
a	Cora	1377
a	Primel	1324
a	Rocdor	1137

```
S=S$groups

par(mar=c(7,4,1,6),bty="l",cex.lab=1,cex.axis=0.8,mgp=c(2.5,0.5,0),family="serif")
mc=sapply(split(rend$rdt,rend$var),mean)
mc=mc[-4]
t=order(mc,decreasing=T)
mc=mc[order(mc,decreasing=T)]
library(sciplot)
sc=sapply(split(rend$rdt,rend$var),se)
sc=sc[-4]
sc=sc[t]
library(gplots)
aux=barplot2(mc,las=1,space=0.3,plot.ci=TRUE,ci.l=(mc-
sc),ci.u=(mc+sc),xpd=FALSE,xlab=paste("Moyenne +/- erreur standard du rendement par
m²"),ci.lwd=1,ci.width=0.3,grid.lty=3,grid.inc=10,plot.grid=TRUE)
text(aux,max(mc)+1/40*mc,labels=round(S$means,1),col="black",adj=-0.2,cex=0.8)
```

Appendix 12: Script and results of the variance analysis of the experimentation on dwarf bean at the farm of the agricultural school of Coconi

```
##################################################################################
ANALYSIS OF THE VARIABLE "NUMBER OF PODS"
##################################################################################

 setwd("C:/Users/Administrateur/Desktop/R Thomas")
 dir()
 jeu=read.table("Essai_Haricot_Vert_LPA.txt",h=T,sep="\t")
 jeu$date=as.Date(jeu$date,"%d/%m/%Y")
 jeu$gousses=round(as.numeric(jeu$gousses)/1.2,3)
 jeu$rdt=as.numeric(jeu$rdt)
 jeu$rdt=round(jeu$rdt/1.2,3)
 jeu$PM=round(jeu$rdt/jeu$gousses,3)
 jeu=jeu[!jeu$var=="Gourmandel",]
 summary(jeu)
           var         date            bloc       rdt            gousses
 Contender :21   Min.   :2013-06-17   B1:32   Min.   : 33.33   Min.   :  8.33
 Cora      :18   1st Qu.:2013-06-24   B2:32   1st Qu.:137.50   1st Qu.: 36.67
 Delinel   :18   Median :2013-06-27   B3:32   Median :233.75   Median : 56.25
 Gourmandel: 0   Mean   :2013-06-28           Mean   :235.50   Mean   : 57.40
 Primel    :21   3rd Qu.:2013-07-05           3rd Qu.:304.79   3rd Qu.: 73.33
 Rocdor    :18   Max.   :2013-07-08           Max.   :606.67   Max.   :164.17
                                              NA's   :2        NA's   :6


gousses=aggregate(jeu["gousses"],c(jeu["var"],jeu["bloc"]),sum,na.rm=T)
summary(gousses)
var    bloc     gousses
 Contender :3   B1:5   Min.   :252.5
 Cora      :3   B2:5   1st Qu.:311.2
 Delinel   :3   B3:5   Median :340.0
 Gourmandel:0          Mean   :344.4
 Primel    :3          3rd Qu.:361.2
 Rocdor    :3          Max.   :480.0

 windows()
 library(lattice)
 interaction.plot(gousses$bloc,gousses$var,gousses$gousses,las=2,col=1:6,lwd=2)

 bartlett.test(gousses$gousses,gousses$bloc) ; bartlett.test(gousses$gousses,gousses$var)

    Bartlett test of homogeneity of variances
```

```
data:  gousses$gousses and gousses$bloc
Bartlett's K-squared = 1.7638, df = 2, p-value = 0.414


        Bartlett test of homogeneity of variances

data:  gousses$gousses and gousses$var
Bartlett's K-squared = 7.8643, df = 4, p-value = 0.09668

 mod=lm(gousses$gousses~gousses$var+gousses$bloc,y=T)

 shapiro.test(mod$res)

     Shapiro-Wilk normality test

Shapiro-Wilk normality test

data:  mod$res
W = 0.9308, p-value = 0.2808

 windows()
 par(mfrow=c(2,2))
 hist(mod$res,freq=F,breaks=10)
 lines(density(mod$res),col="red")
 rug(jitter(mod$res,5))
 f=function(t){dnorm(t,mean=mean(mod$res),sd=sd(mod$res))}
 curve(f,add=T,col="blue",lwd=3,lty=2)
 qqnorm(mod$res)
 qqline(mod$res)
 plot(mod$fit, mod$res)
 abline(h=qnorm(c(0.025,0.975))*sd(mod$res))
 plot(mod$fit,mod$y)
 abline(0,1)

 library(lattice)
 windows()
 resi=matrix(mod$res,nrow=5)
 levelplot(resi,cuts=4)

anova(mod)

Analysis of Variance Table

Response: gousses$gousses
             Df  Sum Sq Mean Sq F value   Pr(>F)
```

```
gousses$var   4 30744.2  7686.1  7.5508 0.008004 **
gousses$bloc  2  9531.3  4765.7  4.6818 0.045060 *
Residuals     8  8143.3  1017.9
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

 library(agricolae)
 modele=aov(gousses~var,data=gousses,y=T)
 S=SNK.test(modele,"var","Effet variétal")

Study:

Student Newman Keuls Test
for gousses

Mean Square Error:  1767.461

var,  means

          gousses   std.err r   Min.   Max.
Contender 275.2767 11.398533 3 252.50 287.50
Cora      409.7267 46.562798 3 321.67 480.00
Delinel   354.1633  7.406079 3 340.00 365.00
Primel    318.0567  8.941926 3 300.83 330.83
Rocdor    364.7267 22.648168 3 340.84 410.00

alpha: 0.05 ; Df Error: 10

Critical Range
       2        3         4         5
 76.48417  94.09902 105.01691 112.97127

Means with the same letter are not significantly different.

Groups, Treatments and means
a       Cora          409.7
ab      Rocdor        364.7
ab      Delinel       354.2
ab      Primel        318.1
b       Contender     275.3

S=S$groups

par(mar=c(7,4,1,6),bty="l",cex.lab=1,cex.axis=0.8,mgp=c(2.5,0.5,0),family="serif")
mc=sapply(split(gousses$gousses,gousses$var),mean)
```

```
mc=mc[-4]
t=order(mc,decreasing=T)
mc=mc[order(mc,decreasing=T)]
library(sciplot)
sc=sapply(split(gousses$gousses,gousses$var),se)
sc=sc[-4]
sc=sc[t]
library(gplots)
aux=barplot2(mc,las=1,space=0.3,plot.ci=TRUE,ci.l=(mc-
sc),ci.u=(mc+sc),xpd=FALSE,xlab=paste("Moyenne +/- erreur standard du nombre de gousses par
m²"),ci.lwd=1,ci.width=0.3,grid.lty=3,grid.inc=10,plot.grid=TRUE)
text(aux,max(mc)+1/13*mc,labels=M,col="red",adj=-1.5,font=2,cex=1)
text(aux,max(mc)+1/40*mc,labels=round(S$means,1),col="black",adj=-0.2,cex=0.8)

##################################################################################
ANALYSIS OF THE VARIABLE  "YIELD"
##################################################################################

 rend=aggregate(jeu["rdt"],c(jeu["var"],jeu["bloc"]),sum,na.rm=T)

 summary(rend)

  var    bloc       rdt
 Contender :3   B1:5   Min.   :1150
 Cora      :3   B2:5   1st Qu.:1318
 Delinel   :3   B3:5   Median :1504
 Gourmandel:0          Mean   :1476
 Primel    :3          3rd Qu.:1603
 Rocdor    :3          Max.   :1816

  windows()
  library(lattice)
  interaction.plot(rend$bloc,rend$var,rend$rdt,las=2,col=1:6,lwd=2)

  boxplot(rend$rdt~rend$var)

 bartlett.test(rend$rdt,rend$bloc) ; bartlett.test(rend$rdt,rend$var)

      Bartlett test of homogeneity of variances

data:  rend$rdt and rend$bloc
Bartlett's K-squared = 0.3081, df = 2, p-value = 0.8572

       Bartlett test of homogeneity of variances
data:  rend$rdt and rend$var
```

```
Bartlett's K-squared = 2.897, df = 4, p-value = 0.5752

 mod=lm(rend$rdt~rend$var+rend$bloc,y=T)

 shapiro.test(mod$res)

  Shapiro-Wilk normality test
data:  mod$res
W = 0.9362, p-value = 0.3374

 windows()
 par(mfrow=c(2,2))
 hist(mod$res,freq=F)
 lines(density(mod$res),col="red")
 rug(jitter(mod$res,5))
 f=function(t){dnorm(t,mean=mean(mod$res),sd=sd(mod$res))}
 curve(f,add=T,col="blue",lwd=3,lty=2)
 qqnorm(mod$res)
 qqline(mod$res)
 plot(mod$fit, mod$res)
 abline(h=qnorm(c(0.025,0.975))*sd(mod$res))
 plot(mod$fit,mod$y)
 abline(0,1)

 library(lattice)
 windows()
 resi=matrix(mod$res,nrow=5)
 levelplot(resi,cuts=4)

anova(mod)

Analysis of Variance Table

Response: rend$rdt
          Df Sum Sq Mean Sq F value   Pr(>F)
rend$var   4 172367   43092  3.0083 0.086534 .
rend$bloc  2 256670  128335  8.9591 0.009077 **
Residuals  8 114596   14324
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

 library(agricolae)
 modele=aov(rdt~var,data=rend,y=T)
 S=SNK.test(modele,"var","Effet variétal")
```

```
 Study: 
Student Newman Keuls Test
for rdt 

Mean Square Error:  37126.55 

var,  means

             rdt   std.err r     Min.     Max.
Contender 1498.056  77.34080 3 1360.000 1627.501
Cora      1510.277 186.64089 3 1149.999 1774.999
Delinel   1319.167  54.96829 3 1253.333 1428.333
Primel    1640.278  92.10709 3 1504.166 1815.834
Rocdor    1411.111  97.75443 3 1264.999 1596.667

alpha: 0.05 ; Df Error: 10 

Critical Range
       2        3        4        5 
350.5411 431.2732 481.3119 517.7682 

Means with the same letter are not significantly different.

Groups, Treatments and means
a 	 Primel 	 1640 
a 	 Cora 	 1510 
a 	 Contender 	 1498 
a 	 Rocdor 	 1411 
a 	 Delinel 	 1319 

S=S$groups

par(mar=c(7,4,1,6),bty="l",cex.lab=1,cex.axis=0.8,mgp=c(2.5,0.5,0),family="serif")
mc=sapply(split(rend$rdt,rend$var),mean)
mc=mc[-4]
t=order(mc,decreasing=T)
mc=mc[order(mc,decreasing=T)]
library(sciplot)
sc=sapply(split(rend$rdt,rend$var),se)
sc=sc[-4]
sc=sc[t]
library(gplots)
aux=barplot2(mc,las=1,space=0.3,plot.ci=TRUE,ci.l=(mc-
sc),ci.u=(mc+sc),xpd=FALSE,xlab=paste("Moyenne +/- erreur standard du rendement par
m²"),ci.lwd=1,ci.width=0.3,grid.lty=3,grid.inc=10,plot.grid=TRUE)
text(aux,max(mc)+1/40*mc,labels=round(S$means,1),col="black",adj=-0.2,cex=0.8)
```

Appendix 13: Recommended Technical Itineraries on dwarf bean production in Mayotte

Date de parution : Septembre 2013

Itinéraire technique recommandé

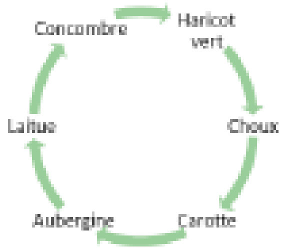
LE HARICOT VERT NAIN À MAYOTTE

Le haricot vert (*Phaseolus vulgaris*) appartient à la famille des Fabacées. Il préfère les sols drainants, avec un pH proche de 5,5 à 6,5. La température optimale de croissance est de 17 à 25 °C. Le haricot se plante toute l'année mais craint les excès de température d'où des problèmes de croissance en saison des pluies en basse altitude et sous abri mal aéré. Il est peu consommateur d'éléments minéraux. Le haricot vert nain atteint 30 - 40 cm de hauteur maximum.

AVANT PLANTATION

Dans l'exemple de **la rotation** présentée ci-contre, l'alternance des familles botaniques et des types de légumes cultivés (fruit, feuille, racine) permet de limiter la concentration des parasites et pathogènes dans la parcelle, de prospecter le sol à différentes profondeurs et d'alterner des cultures ayant des besoins minéraux différents.
Les précédents culturaux du haricot vert peuvent être : tomate, poivron, carotte, concombre, menthe.

L'association culturale du maïs et du haricot permet d'augmenter le rendement du haricot (s'il est semé 7 jours avant le maïs). Les cultures associées au haricot sont aussi : aubergine, betterave, carotte, chou, concombre, épinard, laitue et radis.

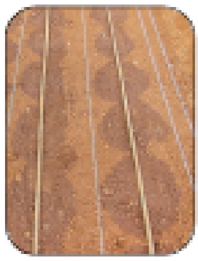


CALENDRIER ET PRINCIPALES TÂCHES À EFFECTUER

J - 4 à J - 1 PRÉPARATION DU SOL	Pratiquer un labour	au motoculteur ou bêcher le sol sur 20 cm de profondeur.
	Apporter une fumure de fond	de 2 kg/m² de fumier bien décomposé. Affiner le sol au râteau.
	Confectionner des planches	de 1 m de large surélevées de 20 cm (30 cm en saison des pluies) et séparées par des passe-pieds de 50 cm.
	Mettre en place un système d'irrigation par goutte à goutte et faire le plein de la réserve du sol.	Fractionner en 3 les apports d'eau journalier. Les besoins en eau du haricot sont : - 1,5 à 2 litres/m²/jour de la plantation à 20 jours, - 2,5 à 3 litres/m²/jour de 20 jours à la fin de la récolte.
J 0 PLANTATION	Semis direct à raison de 1 - 2 graines/trou	en quinconce à 2-3 cm de profondeur, écartement de 15 cm sur ligne x 35 cm entre ligne soit 20 poquets/m².
J + 7 ECLAIRCIR	Eclaircir à 1 plant/trou de plantation.	
J + 10 BUTTAGE	Effectuer un buttage afin de maintenir un port droit des plantes.	
J + 14 DÉSHERBAGE	Effectuer un désherbage et un binage.	
J +20 IRRIGATION	Augmenter la dose d'irrigation.	
J + 21 DÉSHERBAGE	Effectuer un deuxième désherbage + binage.	
J + 42 à J + 62 RÉCOLTE	Récolter les gousses tous les 3 à 4 jours après l'entrée en production	et les conserver en vrac dans un endroit frais et sec. Calibre : très fins 6mm / fins 9 mm. Un arrosage après la cueillette favorise la récolte suivante.
J + 63 NETTOYAGE	Enfouir les résidus de culture ou tout arracher en cas de présence élevée de ravageurs.	

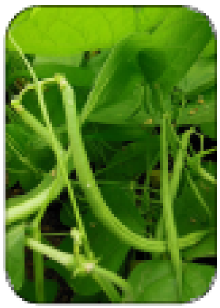
J = Jour

J - 4 : Labour + apport de matière organique



J 0 : Bien arroser avant semis

J + 10 : Buttage des jeunes plants



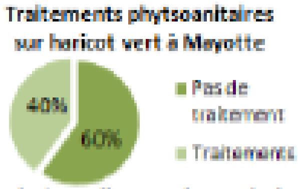
J + 40 : Récolte fréquente 2-3 fois par semaine

Crédit photo : T. Proire (LPA Coconi)

Réalisé par le lycée agricole de Coconi, la Chambre d'agriculture et le CIRAD avec le concours financier du Conseil général de Mayotte et de l'Etat

SUIVI SANITAIRE

L'observation hebdomadaire des cultures permet de contrôler l'état sanitaire des plants et de réagir rapidement face à d'éventuelles attaques de nuisibles. Observer l'ensemble de vos plants en parcourant les allées entre les cultures afin de détecter les foyers d'infection. L'utilisation de traitements chimiques n'est recommandée qu'en cas d'absolue nécessité ; préférer les traitements naturels. Penser à alterner les matières actives en tenant compte de leur rémanence et des délais avant récolte. Ne plus traiter pendant la période de récolte.



Données issues d'une enquête menée chez 20 maraichers en 2013

ENNEMI	SYMPTÔMES	MESURES PROPHYLACTIQUES ET LUTTE BIOLOGIQUE	LUTTE CHIMIQUE *
	MALADIES (CHAMPIGNONS, BACTÉRIES)		
Anthracnose *Colletotrichum lindemuthianum*	Maladie aérienne. Nécrose brune sur nervures et pétioles des feuilles. (Tâches brunes sur feuilles) aussi sur tiges et gousses.	Variétés résistantes. Apport de matière organique bien décomposée. Aérer les cultures.	Cuivre (*Bouillie bordelaise*) Azoxystrobine (*Ortiva Gold*) Mancozèbe (*Dithane M45*) Pyriméthanil (*Scala*)
Rouille *Uromyces appendiculatus*	Maladie aérienne. Pustule jaunâtre devenant des masses de spores brun roux au centre d'une tâche jaune, sur les deux faces des feuilles. Dessèchement et chute des feuilles.	Éliminer les déchets de récolte. Le cuivre à une légère action préventive.	Mancozèbe (*Dithane M45*)
	RAVAGEURS		
Acarien *Phytonemus pallidus*	Tâches décolorées sur feuillage. Déformation des feuilles. Brunissement des gousses.	Irrigation par aspersion. Contrôle des mauvaises herbes. Cendres de fleurs de palmier mâle.	Héxythiazox (*Nissorun*)
Chenilles défoliatrices *Foreuse + pyrale*	Troue les gousses et mange les graines. Attaque parfois les fleurs.	Contrôle des mauvaises herbes. Bacillus thuringiensis (*Dipel*) --> foreuse Spinosad (*Success 4*)--> foreuse	Deltaméthrine (*Decis Protech*) --> pyrale
Pucerons *Aphis fabae* *Aphis craccivora*	Déformation des feuilles et des boutons floraux.	Contrôle des mauvaises herbes. Macération d'ail et de piment.	Deltaméthrine (*Decis Protech*) Pyrimicarbe + Lambda cyhalothrine (*Karaté K*)

** Valable en septembre 2013. Toujours se référer au site internet http://e-phy.agriculture.gouv.fr/ et au recueil de l'ACTA avant l'application de tout traitement phytosanitaire afin de s'assurer de l'homologation des produits.*

CHOIX VARIÉTAL

La variété Cora semble être la variété la plus intéressante à cultiver compte tenu du prix des semences, du comportement agronomique de la plante et des rendements obtenus lors des essais variétaux en 2013.

Nom	Obtenteur	Production (kg/m²) ****	Précocité (jours)	Caractéristiques des gousses	Poids des graines
Contender * (variété la + cultivée à Mayotte en 2013)	Technisem Vilmorin	1,1 - 1,4 ^{SS} 0,8 - 1 ^{SDP}	41 - 50 ^{SS} 45 - 48 ^{SDP}	Grosse gousse verte, ovale, incurvée de 14 - 15 cm	110 - 120 graines / 50 g
Cora *	Technisem	1 - 1,5 ^{SS} 0,8 - 0,9 ^{SDP}	43 - 50 ^{SS} 45 - 50 ^{SDP}	Petite gousse verte, ronde, brillante et droite de 12 - 14 cm	205 - 215 graines / 50 g
Primel	Vilmorin	1 - 1,6 ^{SS} 1 - 1,5 ^{SDP}	41 - 50 ^{SS} 45 - 55 ^{SDP}	Grande gousse verte foncé, ronde et droite de 15 - 16 cm	130 - 140 graines / 50g
Rocdor	Vilmorin	0,9 - 1,3 ^{SS}	43 - 50 ^{SS}	Gousse jaune, ronde et droite de 14 - 15 cm	200 - 210 graines / 50 g
Delinel	Vilmorin	1 - 1,2 ^{SS} 0,5 - 0,7 ^{SDP}	43 - 50 ^{SS} 45 - 50 ^{SDP}	Grande gousse verte, ronde et droite de 15 - 17cm	170 - 180 graines / 50 g

** Disponible à Mayotte en 2013. La variété "Gourmandel" a été testée en saison sèche en 2013. La levée, la précocité et le rendement ont été mauvais.*

^{SS} *Rendements issus d'essais variétaux réalisés sous serre en saison sèche (SS) en 2013 sur les sites de production du Lycée Agricole de Coconi (LPA) et de l'exploitation de M. Gagnlardot. Les rendements élevés correspondent à une forte précocité (Cora : 1,5 kg/m² et précocité de 43 jours).*

^{SDP} *Rendements issus d'essais variétaux réalisés sous serre en saison des pluies (SDP) en 1991 et 2006 par le CIRAD sur le site de la station expérimentale de Dembéni.*

***** Rendement pour un cycle de culture.*

ÉTUDE ÉCONOMIQUE DE LA CULTURE DU HARICOT VERT

COÛTS DE PRODUCTION POUR 100 M² DE CULTURE *

	Quantité	Prix Unitaire	Total
Semences (Cora)	1000 g	0,07 €/g	70 €
Fumier	20 kg	0,0625 €/kg	12,5 €
Carburant	1 L	1,5 €/L	1,5 €
Total intrants			**84 €**
Travail du sol (motoculteur)	0,5 h	6,96 €/h	3,48 €
Fertilisation	1 h	6,96 €/h	7€
Semis	3 h	6,96 €/h	21 €
Eclaircissage - Re-semis	1,5 h	6,96 €/h	10 €
Sarclage - Binage - Désherbage	3 h	6,96 €/h	21 €
Buttage	1,5 h	6,96 €/h	10 €
Récolte - Tri - Pesée (7 récoltes)	20 h	6,96 €/h	139€
Nettoyage post récolte de la parcelle	2 h	6,96 €/h	14 €
Total main d'œuvre **	**32,5 h**		**225,5 €**
Total dépenses (sans amortissement)			**309,5 €**
Total recettes (récolte = 120 kg / 100 m² ; vendus 3 €/kg)			**360 €**
Marge brute (sans main d'œuvre)			**276 €**
Marge nette (avec main d'œuvre)			**50,5 €**

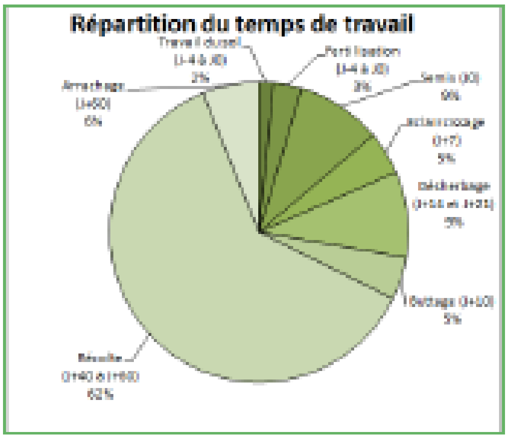
Coûts de production sans main d'œuvre (rendement 1,2 kg/m²) : 0,7 € / kg

Coûts de production avec main d'œuvre (rendement 1,2 kg/m²) : 2,58 € / kg

** Total temps de travaux issus d'une enquête menée chez 20 maraîchers en 2013 et des essais variétaux réalisés au lycée agricole de Coconi et chez M. Gagnardot.

* Culture sous serre avec arrosage automatique et sans traitements phytosanitaires.

TEMPS DE TRAVAUX POUR 100 M² DE CULTURE



Total temps de travaux	4,6 j / 100 m²	464 j / ha
Equivalent Temps Plein / mois pour 1 cycle de culture de 2 mois	0,11 ETP / 100 m²	11 ETP / ha

SIMULATION DE MARGES NETTES POUR 100 M² DE CULTURE

		Rendement : Kg de haricots vendus par m² de culture					
		0,5	0,75	1	1,25	1,5	1,75
Prix de vente au kg (en €)	2,5	-185 €	-122 €	-60 €	3 €	66 €	128 €
	3	-160 €	-85 €	-10 €	66 €	141 €	216 €
	3,5	-135 €	-47 €	41 €	128 €	216 €	303 €
	4	-110 €	-10 €	91 €	191 €	291 €	391 €
	4,5	-85 €	28 €	141 €	253 €	366 €	478 €
	5	-60 €	66 €	191 €	316 €	441 €	566 €

Simulation de marges brutes sans prise en compte de l'amortissement du tunnel, du système d'irrigation et de la consommation d'eau.

FICHE DE COLLECTE

CARACTÉRISTIQUES DE L'AGRICULTEUR		
Nom/Prénom :	Localisation :	n° SIRET :

CARACTÉRISTIQUES DE LA CULTURE

Espèce ______________________ Variété _________________________

Espèce (& var.) précédente ______________________________ Plein champ ☐ Sous abris ☐

Date de semis _______________ Nbre de graines / poquet ____________ % levée ____________

Superficie __________ Ecartements / Densité_____________ Nombre de plants ___________

Irrigation : Goutte à goutte ☐ Aspersion ☐ Manuelle ☐ Débit / fréquence __________________

Date début floraison ____________Date début récolte _____________Date fin de cycle___________

FERTILISATIONS / AMENDEMENTS

Date	Produit	Remarques

TRAITEMENTS

Date	Produit	Remarques

OBSERVATIONS PHYTOSANITAIRES/PHYSIOLOGIQUES

Date	Observations

RÉCOLTE

Date	Quantité (Kg)	Remarques / Observations (calibre, aspect, quantité vendue, prix de vente)
Récolte totale		

Appendix 14: Recommended Technical Itineraries on organic amendments in Mayotte

Date de parution : Septembre 2013

Itinéraire technique recommandé

LES AMENDEMENTS ORGANIQUES À MAYOTTE

Les cultures maraîchères sont exigeantes en engrais minéraux ou organiques. Les fertilisants sont apportés à chaque plantation sans raisonnement sur la fertilité du sol (d'après les enquêtes réalisées en 2013 auprès des maraîchers de Mayotte). Les sols maraîchers se retrouvent déséquilibrés ce qui est préjudiciable au développement des cultures.

Les amendements organiques sont indispensables au maintien de la fertilité des sols afin de créer de l'humus. L'humus est un réservoir à nutriments, une protection contre l'érosion, un structurant du sol et améliore la rétention en eau du sol. La matière organique est donc un pilier de la fertilité du sol.

Cette fiche présente trois types d'amendements organiques disponibles en maraîchage à Mayotte : le bois raméal fragmenté (ou BRF), le fumier et le compost.

EFFETS DES APPORTS DE TROIS TYPES D'AMENDEMENTS ORGANIQUES

Types de matière organique	Effets sur le sol	Apports nutritifs pour la plante	Effets sur les agents pathogènes	Risques sanitaires
Fumier évolué, compost	Augmentation du stock organique du sol, amélioration physique et chimique du sol	Amélioration de la nutrition globale, mais un faible pouvoir nutritif direct	Effet antagoniste sur des agents pathogènes du sol	Peu de risques sanitaires
Fiente d'élevage, lisier déshydraté, guano	Peu d'effet sur le stock organique du sol	Remplace en partie la fertilisation minérale avec un fort pouvoir nutritif direct	-	Possibilité de risques sanitaires Suivre la réglementation Ex : Eviter les animaux morts dans la fosse à fumier !
Bois raméal fragmenté	Augmentation du stock organique du sol, amélioration physique, chimique et biologique du sol	Amélioration de la nutrition globale, mais un faible pouvoir nutritif direct et un risque de faim d'azote (sur 1ère culture)	Effet antagoniste sur des agents pathogènes du sol	Pas de risques sanitaires

Source : Guide de la fertilisation organique à la Réunion, 2006.

BOIS RAMÉAL FRAGMENTÉ (BRF)

Pour plus d'informations sur la technologie BRF à Mayotte, consulter l'ITR : Bois Raméaux Fragmentés : Le retour au sol des branches de l'arbre. (réalisé par le lycée agricole de Coconi en 2010)

Le bois raméal fragmenté (BRF) est une solution pour enrichir le sol en matière organique de façon durable. La biodégradation (par les champignons du sol notamment) de la lignine et des polyphénols est un moyen de former de l'humus stable dans le temps (5 ans), contrairement au compost ou au fumier (1 an). L'utilisation de BRF permet une réduction des besoins en eau, des attaques phytosanitaires, de l'enherbement et une augmentation des rendements.

Épandage de BRF sur 1,5 à 2 cm d'épaisseur

ÉLABORATION DU BRF

Le BRF est élaboré à partir de déchets verts (branches, brindilles et feuilles) et dont le diamètre n'excède pas 7 cm.
Le broyat doit être épandu frais et incorporé sur 5 à 10 cm de profondeur.

LE BRF À MAYOTTE

Il est conseillé de faire un apport de 1,5 - 2 m3 / 100m² la première année puis 7,5 - 1 m3 / 100 m² à partir de la deuxième année.
La fin de la saison des pluies est la meilleure période de l'année pour couper branches et brindilles, nécessaires à la production de BRF.

Les espèces recommandées pour la production de BRF à Mayotte peuvent être : *Azadirachta indica* (neem, ayant aussi de possible propriétés nématicides), *Gliricidia* sepium, *Pterocarpus indicus* (sang dragon) et les arbres fruitiers.

Feuille de neem

Gliricidia sepium

Sang dragon

Attention, les engrais minéraux sont incompatibles avec le BRF car ils tuent les champignons du sol.

L'achat d'un broyeur est un investissement rapidement rentabilisé.

Crédit photo : Wikipédia ; Lycée agricole de Coconi

Réalisé par le lycée agricole de Coconi, la Chambre d'agriculture et le CIRAD avec le concours financier du Conseil général de Mayotte et de l'Etat

FUMIER

L'enfouissement direct du fumier

Le fumier est un mélange de litière (par exemple : copeaux de bois) et de déjections d'animaux d'élevage (bovin, poule, caprin, etc).
La matière organique est rapidement disponible pour les plantes mais la transformation en humus est faible.

Le fumier doit être enfoui profondément (25 à 30 cm) au moins 15 jours avant la plantation pour réduire les risques de brûlures sur les jeunes plants.

A Mayotte * :

100% des maraîchers fertilisent avec du fumier de poule pondeuse

Sac de 40L de fumier séché vendu 2,5€

* Données issues d'une enquête menée chez 20 maraîchers en 2013

Le compostage partiel du fumier

Le compostage des fumiers (de 1 semaine à 6 mois) permet de diminuer les risques de contamination des cultures par les maladies. Le compostage commence par la formation d'un tas de fumier de 1 m de haut par 1 m de large, à l'abri du soleil et de la pluie (arbre ou feuilles de coco tressées). Le tas va chauffer et après 1 semaine minimum à 60-65 °C le fumier est prêt à être enfoui.

La forte demande en amendements organiques chez les maraîchers de Mayotte doit inciter les éleveurs à conserver les fumiers de leurs élevages. Pour une qualité optimale, les fumiers doivent être stockés dans des zones de stockages couvertes et étanches (avec dalle en béton, bassin de rétention des effluents et toit).

COMPOST

Le compost est constitué d'humus. Il possède des propriétés physiques et chimiques qui améliorent la structure, la texture, l'aération, la fertilité, la capacité de rétention en eau et l'écologie des sols.

Le compostage consiste à fermenter des déchets organiques en présence d'oxygène. Il doit se faire à l'abri du soleil et de la pluie. Le compost est prêt lorsqu'il dégage une bonne odeur de terre et est de couleur noir.

Le compost = Simple et peu coûteux

Le compostage en tas

Débris végétaux
Mauvaises herbes, feuilles mortes, déchets de récolte, etc.

Fumier
Fumier de poule pondeuse, de bovin, de cheval, etc.

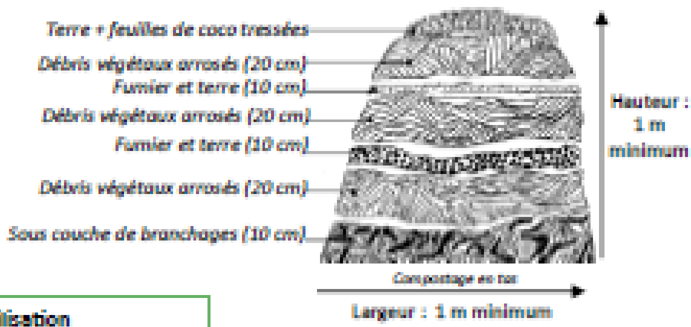
Contrôle de l'humidité (1 x / semaine)
Trop humide --> trous avec un bâton
Trop sec --> idem + arrosage

Composition
50 % matière sèche : feuilles, herbes sèches, etc
50 % matière verte : fumier, déchets de récolte frais, herbe de tonte

Retournement
Toutes les deux semaines

Utilisation
3 à 6 mois après fabrication

Exemple de formation d'un tas de compost en couches



Source : Agrodok 8 : La fabrication et l'utilisation du compost, 2005

Le compostage rapide : le fumier recyclé en andain

Le fumier recyclé commence par la formation d'un andain de 1m de haut, 1 m de large et légèrement tassé. Il doit être à l'abri du soleil et de la pluie. Le contrôle de l'humidité se fait chaque semaine : si l'humidité est trop forte on place des bâtons dans l'andain, s'il est trop sec on l'arrose. Le retournement de l'andain s'effectue après deux semaines. Le fumier recyclé est utilisé après refroidissement complet de l'andain.

Le compostage total du fumier

Pour un compostage total d'un andain de fumier, le retournement doit être répété toutes les deux semaines jusqu'à obtenir un amendement ressemblant à de la terre noire. Il est utilisable de 3 à 6 mois après formation.

Crédit photo : Fondation Agronalas

OUTIL D'AIDE À LA FERTILISATION

Le sol est un support vivant en constante évolution ; il faut le faire analyser régulièrement pour connaître sa composition. A partir d'une analyse de sol, les techniciens maraîchers peuvent établir un plan annuel de fumure qui permet d'entretenir la fertilité du sol.
La première étape avant la plantation d'une culture maraîchère est l'apport d'amendements organiques. Cet amendement agit dans le temps et permet de limiter le recours aux engrais minéraux.

Les apports sont réalisés 2 fois par an (au début de chaque saison) et ne doivent pas dépasser un total de 20 t/ha/an.

Composition en éléments fertilisants de différents amendements organiques

Composition en éléments fertilisants (kg disponible immédiatement / 20 T de produit brut)									
Nature	N total	N (kg)	P_2O_5	K_2O	CaO	MgO	MO	C/N	pH
Fumier de poule pondeuse (avec copeaux de bois)	148	104,4	266	216	400	112	7580	16	6 - 7
Fientes de poule pondeuse (sans copeaux de bois)	622	436	408	512	1272	180	9440	4 - 8	8 - 9
Fumier de cheval	24	-	52	32	114	78	5080	25,3	7
Compost de fumier de poule pondeuse	106	32	324	294	600	122	6780	11,4	8 - 9
Compost de déchets verts	18	Faible	42	116	418	180	5560	16,1	7 - 8

Source : Guide de la fertilisation organique à la Réunion, 2006. Les analyses d'amendements organiques à Mayotte sont encore à réaliser.

Besoins en éléments fertilisants de différentes cultures maraîchères

Fertilisations préconisées (kg/100 m²/cycle)				
Cultures	N	P_2O_5	K_2O	Autres éléments
Tomate	1	0,4	1,6	MgO : 0,15
Laitue	0,8	0,4	2	MgO : 0,12
Choux	1,3	0,8	2	S : 0,3
Cucurbitacées	0,8	0,6	1,4	MgO : 0,4

Sources : Guide de la fertilisation organique à la Réunion, 2006. Fiches technico-économiques du CIRAD Mayotte : La laitue sous abri et la tomate sous abri, 2006.

L'aspect visuel d'une culture permet de savoir si les éléments fertilisants sont présents en quantités suffisantes. En cas de carences, les apports mixtes de matière organique et minérale permettent de répondre aux besoins immédiats des cultures.

TECHNIQUES AGROÉCOLOGIQUES

Apports de matière organique en cultures maraîchères

Il est considéré à l'unanimité que l'intensification des pratiques agricoles, le développement des surfaces maraîchères et une mauvaise gestion des engrais conduisent à une diminution généralisée de la fertilité des sols.

Une solution consiste à remplacer les engrais minéraux par des amendements organiques afin de pallier à la diminution de la fertilité des sols. Les maraichers intéressés par cette technique peuvent contacter la CAPAM.

La jachère améliorante

Pour plus d'informations consulter l'ITR 2013 : Protection durable des cultures maraîchères.

La jachère améliorante consiste à introduire un couvert végétal constituée de Fabacées (exemple : *Vigna ombelata* et Voème) ou de Poacées (*Panicum*) entre des cycles de maraîchage. L'enfouissement permet d'enrichir le sol tout en le préservant de l'érosion.

La lutte contre l'érosion

Lors de fortes pluies, les parcelles en pente sont exposées à des phénomènes d'érosion. Or, un sol érodé est un sol peu fertile. Le paillage des cultures permet de limiter ces phénomènes et ainsi de préserver la fertilité des sols.

LA RECHERCHE APPLIQUÉE À MAYOTTE

2013 : Comparaison de trois types d'amendements organiques (fumier de canard, compost de débris végétaux, BRF de *Pterocarpus indicus*) sous serre au lycée agricole de Coconi. Résultats à venir.
2011 : Incidence de l'incorporation de BRF de *Gliricidia* sur une culture de poivrons en plein champ au lycée agricole de Coconi. Résultats : + 32 % de rendement. Même expérimentation sur une culture de patates douces : + 20 % de rendement.

FICHE COLLECTE : CAHIER D'ÉPANDAGE

CARACTÉRISTIQUES DE L'AGRICULTEUR		
Nom/Prénom :	Localisation :	n° SIRET :

CAHIER D'ÉPANDAGE							
DATE	CULTURE	SURFACE (parcelle)	NATURE	PROVENANCE	PRIX	QUANTITÉ	REMARQUES

Appendix 15: Main pests reported by the interviews of farmers

Main pests	Nb. cit.	Freq.
Fruit and vegetable fly	11	58%
Aphid	10	53%
Brown rot	10	53%
Mite	4	21%
Leafminer fly	4	21%
Snail	4	21%
Virus	4	21%
Cercosporia	3	16%
Nematode	1	5%
Rust	1	5%
Mealy bug	1	5%
Whitefly	1	5%
Fusarium	1	5%
Crab	1	5%

* Multi-answering possible
19 farmers were able to answer

Appendix 16: Recommended Technical Itineraries on sustainable plant protection in Mayotte

Date de parution : Septembre 2013

Itinéraire technique recommandé

PROTECTION DURABLE DES CULTURES MARAÎCHÈRES À MAYOTTE

Les méthodes de luttes agroécologiques représentent une alternative durable à la protection chimique des cultures maraîchères. Elles proposent une protection efficace, rentable, et indispensable pour les écosystèmes et la biodiversité de Mayotte. Ces méthodes reposent sur une série de mesures :

- Retarder l'apparition des maladies et/ou ravageurs par la mise en œuvre de bonnes pratiques agricoles ;
- Observer hebdomadairement l'état sanitaire des cultures ;
- Contacter un technicien pour une identification précise des symptômes observés.

MESURES AGROÉCOLOGIQUES POUR UNE PROTECTION DURABLE

Nuisibles / Mesures	Insectes piqueurs-suceurs	Ravageurs aériens	Ravageurs du sol	Nématodes	Champignons aériens	Champignons du sol	Bactéries aériennes	Bactéries du sol	Viroses	Adventices
CHOIX DES TERRES ET PRÉPARATION DU SOL										
Rotation										
Éviter de planter près de plantes sensibles ou de cultures infestées										
Éviter les terres mal drainées										
Désinfection du sol (solarisation)										
PÉPINIÈRE										
Orientation (en amont des cultures et des vents dominants)										
Isolement des parcelles cultivées										
Désinfection, nettoyage régulier										
MÉTHODES DE CULTURE										
Adapter les méthodes d'irrigation (ex : utiliser l'irrigation goutte à goutte ou par aspersion)		Acariens								
Respecter la densité de la plantation										
PRATIQUES CULTURALES										
Utiliser du paillage végétal										
Utilisation de variétés adaptées ou de porte greffe										
Apport de matières organiques										
Contrôle des mauvaises herbes										
Faire des faux-semis										
Éviter de maintenir le feuillage mouillé durant de longues périodes										
Utiliser des plantes pièges ou des engrais verts	Pucerons	Mouches des légumes								
Utiliser uniquement des jeunes plants sains										
Aérer les abris										
Confusion sexuelle (phéromone)										
SOINS DES PLANTES										
Retirer, détruire les débris de culture										
Ôter manuellement les parties infectées des plantes (fruits piqués)		Mouches des légumes								
Nettoyage du matériel de culture										

Sources : Fiches du programme PIP pour les pays d'Afrique, Caraïbes et Pacifique, 2012. Autres (observations, techniciens)

Réalisé par le lycée agricole de Coconi, la Chambre d'agriculture et le CIRAD avec le concours financier du Conseil général de Mayotte et de l'État

1

RECOMMANDATIONS LIÉES AU CHOIX DES CULTURES

LES ROTATIONS CULTURALES

Les rotations culturales consistent à alterner les familles botaniques et les types de légumes (feuille, fruit, racine) lors de la succession des cultures afin de limiter la prolifération des parasites et pathogènes.

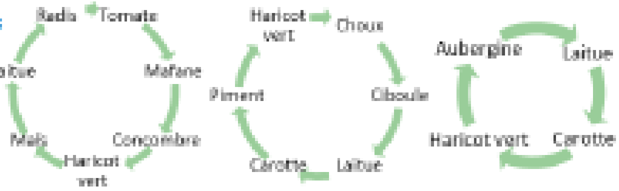
Les exigences en fumure organique varient selon les plantes cultivées. C'est pourquoi lors des rotations il faut penser à alterner les plantes cultivées suivant leur catégorie d'exigence :

Plantes exigeantes Apports en MO de + de 2 kg/m²	Plantes moyennement exigeantes Apports en MO de - de 2 kg/m²	Plantes peu exigeantes Apports en MO d'appoint
Aubergine, choux, concombre, courge et courgette, épinard, maïs, melon, patate douce, poireau, poivron, potiron, piment, tomate	Carotte, betterave, laitue	Ciboule, haricot vert, mâche, mafane, morelle, navet, pois, radis

Voici quelques exemples de rotations tenant compte des cultures maraîchères les plus communément cultivées à Mayotte :

Un minimum de 4 cultures par rotation est recommandé.

Le tableau suivant présente des rotations culturales possibles :



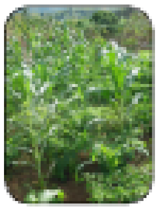
CULTURE PRÉCÉDENTE	CULTURE EN PLACE	CULTURE SUIVANTE
Carotte, coriandre, haricot vert ou persil	AUBERGINE	Carotte, radis, ciboule, choux ou laitue
Ciboule, haricot vert, laitue, piment ou radis	CHOUX	Betterave, carotte, ciboule, concombre ou laitue
Choux, laitue, mafane, morelle, radis ou tomate	CIBOULE	Carotte, choux, concombre ou laitue
Choux, ciboule, laitue ou épinard	CONCOMBRE	Carotte, haricot vert, morelle ou piment
Carotte, concombre, menthe, tomate ou piment	HARICOT VERT	Basilic, choux, laitue ou maïs
Choux, maïs, morelle ou haricot vert	LAITUE	Carotte, concombre, mafane, radis ou tomate
Engrais vert, haricot vert, navet ou radis	MAÏS	Carotte, épinard, laitue ou patate douce
Carotte, ciboule, mafane, navet ou radis	POIVRON PIMENT	Choux, engrais vert, haricot vert ou poireau
Engrais vert, épinard, laitue, persil ou radis	TOMATE	Carotte, ciboule, haricot vert, mafane ou radis

LES ASSOCIATIONS CULTURALES

Une association culturale c'est cultiver en même temps et sur une même parcelle au moins deux cultures. Les associations culturales permettent de produire plus de légumes sur une même surface, d'optimiser l'occupation de l'espace, d'étaler la période de production, de mieux gérer les nuisibles et d'assurer un revenu au maraîcher en garantissant une récolte.

Les associations peuvent se faire en bordure et au sein même d'une parcelle et d'une planche de culture (ex : morelle ou maïs en bordure d'une planche de laitue ou association d'espèces à croissance rapide et lente.

Morelle en bordure de laitue



Association de piment et de maïs

LES ASSOCIATIONS MARAÎCHÈRES : EN GRAS LES ASSOCIATIONS OBSERVÉES À MAYOTTE

AUBERGINE	Carotte, choux, haricot vert, laitue, **maïs**** ou menthe
CAROTTE	Choux, concombre**, épinard, laitue, mafane, morelle, piment, poivron, radis ou tomate
CHOUX	Aubergine, carotte, concombre, épinard, haricot vert**, laitue ou tomate**
CIBOULE	Betterave, **choux****, **laitue****, **mafane***, **morelle***, poivron ou tomate
CONCOMBRE	Basilic, **carotte****, choux, haricot vert, laitue, mafane ou morelle

HARICOT VERT	Aubergine, betterave, carotte, **choux****, concombre, épinard, laitue, **maïs**** ou radis
LAITUE	Betterave, carotte, choux, **ciboule****, concombre, haricot vert, maïs, melon, **morelle*** ou radis
MAÏS	**Aubergine****, concombre, **courge****, **haricot vert****, laitue, **morelle***, **piment**** ou **poivron****
POIVRON PIMENT	Basilic, betterave, carotte, courge, courgette, laitue, **maïs****, **mafane*** ou tomate
TOMATE	Basilic, carotte, **choux****, ciboule, courgette, persil, piment, **poireau****, poivron ou radis

** : association en bordure de la parcelle / ** : en association au sein de la parcelle*

Crédit photo : T. Fraise (LPA Coconi)

LA RECHERCHE APPLIQUÉE À MAYOTTE

LA PROTECTION AGRO-ÉCOLOGIQUE DES CULTURES MARAÎCHÈRES

Méthode GAMOUR

Les **mouches des fruits et légumes** constituent un problème majeur en cultures maraîchères. L'utilisation d'**insecticides** à large spectre est **inefficace**, tue les auxiliaires naturels et pollue les nappes phréatiques.
L'alternative à cette pratique repose sur une gestion agro-écologique des cultures maraîchères. La **méthode GAMOUR** (gestion agro-écologique des mouches des légumes à la Réunion) repose sur la combinaison de **mesures de prophylaxie, de gestion des habitats et de lutte biologique**.

Le CIRAD travaille actuellement sur l'expérimentation de cette méthode afin de tester son efficacité et permettre son transfert à Mayotte. Les cultures sous abris semblent moins exposées aux problèmes de mouches. Les maraichers intéressés par cette technique peuvent contacter la CAPAM.

> Il existe à Mayotte 13 espèces végétales hôtes de mouches des légumes et un insecte parasitoïde : *Psytallia* (taux de parasitisme très faible <1%)
> Il existe 4 espèces de mouches des cucurbitacées dont la plus présente est *Dacus ciliatus* et 2 espèces de mouches des solanacées dont la plus présente est *Neoceratitis cyanescens*

LA JACHÈRE AMÉLIORANTE

De nombreux maraîchers cultivent des légumes en plein champ durant la saison sèche, interrompant les cycles de cultures en saison des pluies. Le sol est alors envahi par une friche herbacée inégalement répartie sur la parcelle, qui ne permet ni la restauration de la fertilité du sol, ni sa protection contre l'érosion en période des pluies.

Couvert végétal sous bananeraie

L'introduction d'une **jachère améliorante constituée de Fabacées** (*Vigna ombelata* ; Voème) ou de **Poacées** (*Panicum*) entre des cycles de maraîchage, pendant **la saison des pluies** permet d'arrêter le développement de ces pratiques destructrices.

Ce couvert végétal permet d'**enrichir le sol en azote tout en le préservant de l'érosion** causée par les fortes pluies. Les résidus de la jachère permettent de constituer un **paillage inter-rang** des cultures maraîchères qui a pour effet de **limiter** le développement des **mauvaises herbes**, de limiter **l'évapotranspiration** (permet de faire des économies d'eau) et d'être un **refuge pour la faune auxiliaire**.

Les maraichers intéressés par la technique de la jachère améliorante peuvent contacter la CAPAM pour connaître la marche à suivre.

LE CAS DU FLÉTRISSEMENT BACTÉRIEN *Pour plus d'informations consulter la fiche du CIRAD : Greffage de l'aubergine et de la tomate 2006*

Les plantes maraîchères de la famille des **Solanacées** (aubergine, morelle, poivron, pomme de terre, tabac, tomate) sont très sensibles au **flétrissement bactérien** (FB), maladie causée par la bactérie *Ralstonia solanacearum*. Elle est présente partout à Mayotte, avec une fréquence d'apparition plus importante en **saison des pluies** qu'en saison sèche, l'eau facilitant la dissémination des bactéries dans le sol. La fréquence d'apparition du FR varient également selon les zones géographiques.
Le prolifération de la bactérie dans les vaisseaux de la plante entraine son flétrissement irréversible. Les dégâts peuvent être importants : totalité de la culture décimée avec impossibilité de cultiver des Solanacées sur la parcelle infestée sans risque de fortes pertes. Il n'existe **pas de lutte chimique** satisfaisante contre cette maladie. **L'alternative** la plus courante, en plus des mesures prophylactiques, est la plantation de **variétés tolérantes**.

LES VARIÉTÉS TOLÉRANTES AU FLÉTRISSEMENT BACTÉRIEN DE MAYOTTE			
TOMATE	AUBERGINE	POMME DE TERRE	POIVRON
Makis Platinium CLN3167B	Zebrina	Désiré	Tibesti Narval

D'autres techniques plus efficaces pour lutter contre le flétrissement bactérien sont :

- La mise en place d'un système de **culture hors sol** et la désinfection de l'eau d'irrigation. Contacter un technicien de la CAPAM.
- L'utilisation de **porte greffe** (PG) pour les cultures d'aubergine et de tomate : **Surya** (EG 203). Des essais sont actuellement en cours afin de déterminer de nouveaux PG.

Les variétés tolérantes au flétrissement bactérien répertoriées dans le tableau sont le résultat d'essais variétaux fait par le CIRAD à partir de 1996 et qui sont actuellement poursuivis dans le cadre du RITA.

Crédit photo : Agropolis ; CIRAD

FICHE COLLECTE : TRAITEMENTS PHYTOSANITAIRES

CARACTÉRISTIQUES DE L'AGRICULTEUR							
Nom/Prénom :			Localisation :			n° SIRET :	
TRAITEMENTS							
DATE	LOCALISATION (n° parcelle, surface)	CULTURE	ENNEMI	PRODUIT	DOSE (ml/L)	SURFACE TRAITÉE (m²)	REMARQUES (mode d'application, temps de traitement)
OBSERVATIONS / MESURES PHYTOSANITAIRES							
DATE	OBSERVATIONS						

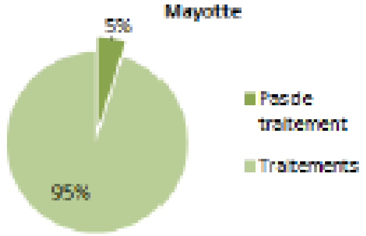
Date de parution : Septembre 2013

TRAITEMENTS PHYTOSANITAIRES CHIMIQUES ET NATURELS

Eviter les traitements chimiques systématiques (ex : une fois par semaine) et les utiliser uniquement après observation des premiers symptômes et identification du ravageur. Attention à n'utiliser que des produits homologués, en respectant les précautions d'usage obligatoires : période d'application, délai avant récolte, dose autorisée, protection (gants, lunettes, masques, bottes, combinaison), alternance des matières actives et des familles chimiques.

Consulter votre technicien maraîcher et le guide phytosanitaire ACTA et vérifier régulièrement les mises à jour sur le site internet : http://e-phy.agriculture.gouv.fr

Utilisation de produits phytosanitaires à Mayotte



Données issues d'une enquête menée chez 20 maraichers en 2013

Traitements phytosanitaires chimiques : Insecticides

Insecticides									
Matière active (famille chimique)	Nom commercial*	Ravageurs							
		Acariens (tarsonème)	Pucerons	Thrips	Aleurode	Mouche mineuse	Teigne des crucifères	Chenille défoliatrice	Noctuelles terricoles et défoliatrices
Abamectin (avermectines)	Vertimec Gold	A / Cc / Co / Cr / Me / P / Pa / PA / T		A / Cc / P / Pr / T		A / Cc / Co / Cr / L / Me / P / Pa / T			
Acétamipride (chloronicotiniles)	Suprême		A / Cc / Ch / Cr / L / Me / P / T		A / P / T				
Acrinathrine (pyréthrinoïdes)	Orytis	A / Cc / Me / P / T		A / Cc / Me / P / T					
Bacillus thuringiensis **	Dipel							T	
Cyromazine (triazines)	Trigard 75 WP					A / Cc / Cr / Me / T			
Deltaméthrine (pyréthrinoïdes)	Decis Protech, Pearl Protech, Split Protech		Ca / Ep / H / L	A / Cc / Cr / Me / O / P / Pr / T	A / Cc / Cr / L / Ma / Me / P / T		Ch / O / Pr	T	A / B / Cc / Ch / Cr / Ep / L / Ma / Me / P / T
Lambda-cyhalothrine (pyréthrinoïdes)	Karaté Zéon		A / L / Ma / P / T				Ch / O / Pr		A / B / Cc / Cr / Ep / L / Ma / Me / P
Pipéronyl butoxyde + Pyrethrines**	KB Insectes Légumes B		Ca / Ch / H / L			T			
Pyrimicarbe (carbamates)	Pirimor G		A / B / Ca / Ch / Cc / Cr / Ep / H / L / Ma / Me / P / T						
Pyrimicarbe + Lambda-cyhalothrine (carbamates + pyréthrinoïdes)	Karaté K		A / B / Ca / Cc / Ch / Cr / Ep / H / L / Ma / Me / T						
Spinosad ** (spinosoïdes)	Success 4 Syneis			A / L / Me / O / P / Pr / T			Ch	A / Ma / P / T	Ch / L / Ma / Me
Thiaméthoxam (néonicotinoïdes)	Actara		A / Cc / L / P / T		A / Cr / P / T				

** Disponible en magasin à Mayotte en 2013 / ** Utilisable en agriculture biologique*

Légende :

A : Aubergine / B : Betterave / Ca : Carotte / Cc : Concombre / Ch : Choux / Cl : Ciboule / Co : Courge / Cr : Courgette / Ep : Epinard / H : Haricot / L : Laitue / Ma : Maïs / Me : Melon / Na : Navet / O : Oignon / P : Poivron / P : Piment / Pa : Pastèque / PA : Plantes Aromatiques / Pr : Poireau / Ra : Radis / T : Tomate

Traitements phytosanitaires chimiques : Fongicides

Fongicides								
Matière active (famille chimique)	Nom commercial*	Maladies						
		Anthrac-nose	Cercospo-riose	Fonte des semis	Mildiou	Oïdium	Rouille	
Azoxystrobine (strobilurines)	Ortiva Gold	Cr / H / Me			A / Ci / Cc / Cr / L / Me / Na / O / P / Pr / Ra / T	A / Ca / Cc / Cr / Me / P / T	Ci / Pr	
Chlorothalonil (chloronitriles)	Visclor 500 L	Cr / Me			Cc / Cr / Me / T			
Cuivre **	Bouillie bordelaise Kocide				Ca / Ch / O / Pr / T			
Fosétyl-Aluminium (phosphonates)	Aliette Flash				Me			
Mancozèbe (carbamates)	Dithane M 45	Ca / Cr / H / Me / Pr / T	B	B / Ch / Pr	A / B / Ca / Cc / Ch / Cr / L / Me / O / P / Pr / T		B / H / Pr	
Propamocarbe HCL(carbamates)	Prévicur N				Cc / Me			
Pyriméthanil (anilino-pyrimidines)	Scala			L				
Soufre **	Kumulus DF					Me		
Thiophanate-méthyl (benzimidazoles)	Topsin 70 WG					Me		

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Traitements phytosanitaires naturels

De nombreux traitements naturels peuvent être élaborés à la ferme. Vous pouvez faire des macérations, décoctions, infusions ou purins de nombreux végétaux qui ont des propriétés répulsives sur les insectes ou létales sur certains champignons. Consulter votre technicien et vos confrères pour trouver la bonne plante, le bon dosage.

Plantes	Partie utilisée	Ravageurs et maladies	Effet	Préparation	Application
Papayer	Feuille	Oïdium Rouille	Fongicide	Piler 1 kg de feuilles fraîches dans 10 L d'eau. Ajouter de l'argile. Mettre dans un récipient ouvert et remuer tous les jours pendant 15 jours. Filtrer.	Préventif : Tous les 15 jours 1 L / 10 m² Curatif : Dès l'apparition des symptômes et toutes les semaines 2 L / 10 m²
Piment	Fruit	Pucerons	Insecticide	Piler des fruits secs puis macérer 2 cuillères de poudre dans 10 L d'eau pendant 12 h. Prendre 2 L de mélange et ajouter 4 L d'eau savonneuse	Préventif : Appliquer 1 mois avant la prolifération des insectes. Répéter tous les 10 jours 0,6 L / 10 m² Curatif : 1,2 L / 10 m² Répéter régulièrement
Basilic	Feuille et tige	Insectes et champignons	Insecticide Fongicide	Tremper 200 g de feuilles dans 1 L d'eau pendant 12 h, broyer et filtrer. Ajouter 1 ml de savon liquide et bien mélanger.	Préventif : Pulvériser le mélange macéré + eau savonneuse à raison de 3 L / 10 m²
Moringa oleifera	Feuille	Fonte des semis	Fongicide	Enfouir les feuilles fraîches dans les poquets ou les pépinières	Préventif : Enfouir 1 kg/m² de pépinière
Ail	Bulbe	Pucerons	Insectifuge	Piler des gousses sèches et macérer 2 cuillères de poudre dans 10 L d'eau --> 12h. Mélanger 2 L de préparation avec 4 L d'eau savonneuse	Préventif : Appliquer 1 mois avant la prolifération des insectes. Répéter tous les 10 jours. 0,6 L / 10 m² Curatif : 1,2 L / 10 m² Répéter régulièrement
Citron-nelle	Plante entière	Bactéries	Bactéricide en préventif	Broyer 50 g et laisser macérer quelques minutes dans 2 L d'eau chaude. Filtrer	Préventif : Pulvériser le mélange macéré + eau savonneuse à raison de 3 L / 10 m²
Neem	Feuille	Chenilles, cicadelles, mouches mineuses	Insecticide	Piler 3 kg de feuilles et macérer dans 10 L d'eau pendant 12 h. Filtrer et presser. Ajouter de l'eau savonneuse pour compléter le mélange à 30 L	Préventif : utiliser comme engrais vert en incorporant les feuilles dans le sol des pépinières ; utiliser comme matière verte en incorporant les feuilles dans le compost Curatif : Pulvériser le mélange à raison de 3 L / 10 m² ; la durée de rémanence est de 6 à 10 jours.
Palmier	Fleur mâle	Acariens tetranyques	Acaricide	Incinérer les inflorescences mâles	Curatif : poudrer en cas d'infestation tetranyque

Source : AGRISUD - L'agroécologie en pratiques - GUIDE édition 2010

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LIST OF INITIALS

ADRUMA: Association for Rural Development in Mayotte
A.E.M.: Agri-Environmental Measures
AFICAM: Association for Initial and Day Release Education of Farmers of Mayotte
A.P.F.P.: Association for the Promotion of Pre-vocational Education

CAP: Common Agricultural Policy
CAPA: Certificate of Professional Competences in Agriculture
CAPAM: Chamber of Agriculture, Fishery and Aquaculture of Mayotte
C.E.C.: Cation exchange capacity
C.F.P.A.: Pre-vocational Education Centre for Agriculture
C.F.P.P.A.: Centre of Professional Formation and Agricultural Promotion
CIRAD: International Centre of Agricultural Research for Development
COOPAC: Cooperative of the farmers of the centre
COPIL: Pilot Committed

DAAF: Direction of Alimentation, Agriculture and Forest
DARTM: Direction of Agriculture, Terrestrial and Maritime Resources
DOM: Ultramarines Domains

EGOM: General States of the UltraMarine
E.P.N.: National Public Institution
E.U.: European Union

ITR: Recommended Technical Itineraries

MAAP: Ministry of Alimentation, Agriculture and Fishery
M.O.: Organic Matter

ODEADOM: Service of Development of the Overseas Agricultural Economics

PEP: Business Nursery

RITA: Network for Innovation and Transfer in Agriculture