GROOF

Greenhouses to reduce CO2 on roofs

OPERATING COST COMPARISON STUDY

2022

Ancion Nicolas, Scattareggia Florent, , Libault Arthur, Guillaud Romain, Galli Amandine, Bron Théo, Prof N. Crutzen, Prof M. Jijakli

AGENDA

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Interreg North-West Europe
GROOF
European Regional Development Fund

INTRODUCTION

The GROOF project is an innovative cross-sectorial approach to reduce CO2 emissions in the building and agricultural sectors by combining energy use for heating and cooling with local food production. This CO2 emissions reduction is possible thanks to (1) the re-circulation of the heat generated by the building to a rooftop greenhouse (RTG) actively (through the ventilation system) and passively to promote plant production, (2) the collection of CO2 produced by human activity and building activities to stimulate plants growth and improve yields, and (3) the reduction of transport-generated CO2 emissions by producing fresh food locally.

For each of these aspects, GROOF teams has :

- Identified barriers to market access,
- Created a state of the art based on literature and experience of existing rooftop greenhouse.
- Experimented, validated and demonstrated the effectiveness of rooftop greenhouses thanks to the study of 4 pilots.
- Coached early adopters of rooftop greenhouses (project holders) all over Northwest Europe.
- Gathered all the knowledge in dedicated guidelines to fosters every company or individuals that want to develop a rooftop and/or integrated greenhouse project

This report focuses on key data regarding the operational costs of rooftop greenhouses in North West Europe area, gathered with two rooftop greenhouses developed within the GROOF project, one focusing on CBD production, the other one on vegetable production .

MONITORING TOOL

Essential tool

In 1950, there were nearly 380 million inhabitants in Europe compared to 514 million in 2019. In 70 years, the European population has increased by more than 35%. According to data collected on Eurostat, in 2012, 525 cities in the European Union had more than 100,000 inhabitants. We also note that 30 of these cities in the European Union have a population of more than 1 million inhabitants. Also in 2012, just over 70% of the population of the European Union lives in urban areas. We are facing increasing urbanization. The number of cities is increasing to the detriment of rural areas, as Defrise, Burnod, Tonneau and Andriamanga (2019)* tell us. The population that lives there continues to grow and wherever it is, this population must feed itself. Bringing food into cities appears as a key action in order to recreate a relationship between cities and its food belt. Therefore, business that will be build based on urban agriculture need to understand their cost price and adapt their pricing strategy , to survive in the long term.

To understand the cost price, the first important differentiation to understand are direct and indirect costs.

***all references can be found in the attached document : Arthur Libault's master thesis**

MONITORING TOOL

Variable vs fixed

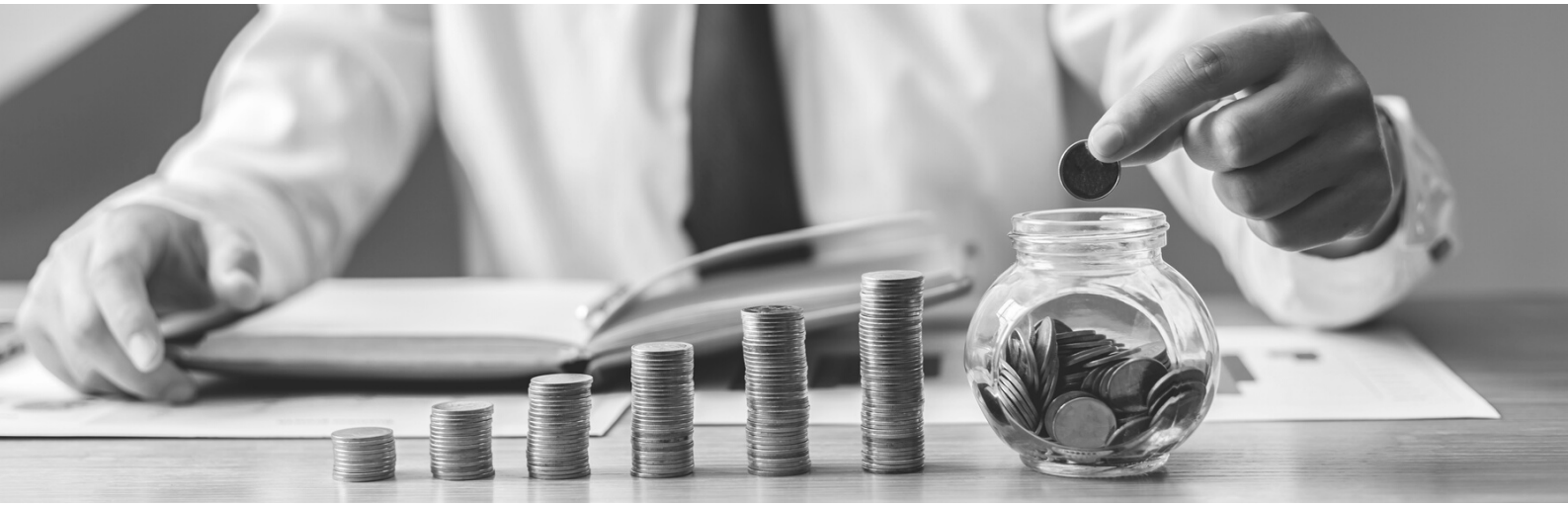
Variable costs change based on the amount of output produced. Fixed costs remain the same regardless of production output. We developed it for you;

Variable costs are related to production. This means that if production stops, payment of these costs will no longer be made. The main variable costs include the following (Soleki and Clément, s.d.):

- The purchase of raw materials (seeds, fertiliser, etc.);
- Tools, note that expensive tools can be taken over as an investment;
- The packages ;
- Temporary employees, i.e. people with a fixed-term contract, a seasonal contract, students…;
- Transportation ;
- Storage costs;
- Small equipment (gloves, bags, papers, etc.).

Fixed costs will not stop, even if the production is stopped. Here are some examples ;

- Maintenance of transparent expanses to ensure the passage of light
- Cleaning of exterior gutters to prevent water infiltration;
- Energy-related charges (water, electricity and gas);
- The contracts of permanent employees, that is to say people with a fixed contract ;
- Insurance such as fire insurance, machine breakdown insurance, liability insurance or staff insurance;
- Taxes such as property tax or garbage tax;
- The costs of participation in the management of the building such as the maintenance of the elevator



MONITORING TOOL

Indicator to measure success

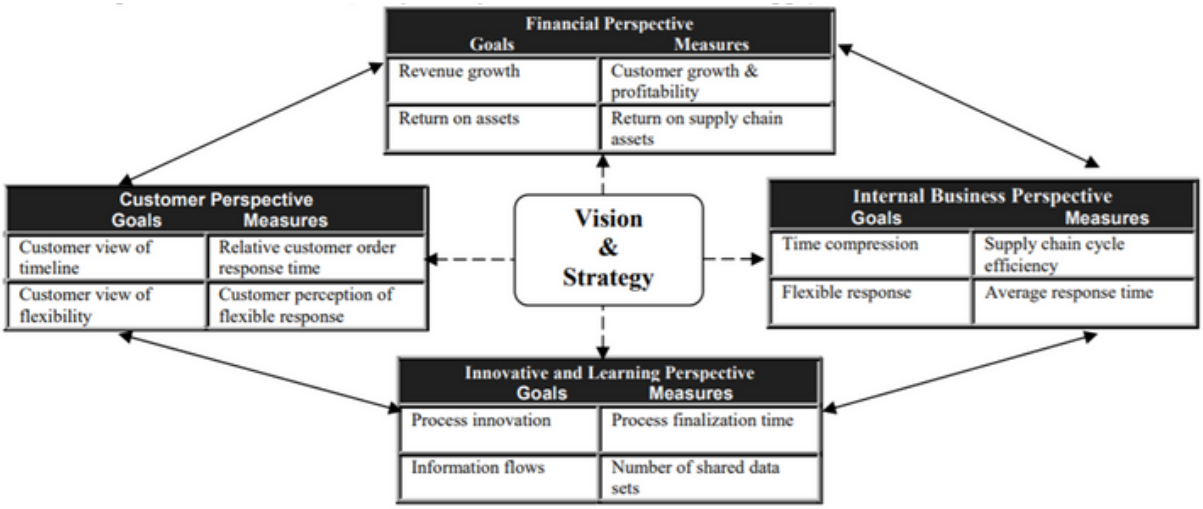
"If you can't measure it, you can't manage it".

Monitoring indicators is a must have while conducting your farm in your business journey.

The choice of indicators is key to highlight your performance and emphasize areas that needs attention. Therefore, the real challenge is to determine the few essential metrics, instead of measure everything.
Usual Key business perspectives/axes:

- Financial
- Customer
- Marketing and sales
- Operational process and supply chain
- Employee
- Corporate social responsibility
- Environmental / non-market

The concept of the Balanced Scorecard (BSC) was developed in the early 1990s as a new approach to performance measurement due to problems of short-termism and past orientation in management accounting (Kaplan and Norton, 1992). The concept of the BSC is based on the assumption that the efficient use of investment capital is no longer the sole determinant for competitive advantages, but increasingly soft factors such as intellectual capital, knowledge creation or excellent customer orientation become more important.
The Balanced Scorecard is a framework, which helps translating a company's strategy into performance measures.



We will focus in this report on the financial data.

MONITORING TOOL

The GROOF open-source tool

Focusing on the financial part and in order to understand how much the production cost, an open source tool has been created on Excel, in the frame of INTERREG NWE GROOF project.

You can easly download the tool, understand the formulas and their sources, in order to modify and it adapt to your reality. And therfore have an analysis and decision-making tool.

It has been done in two steps:

For the first one, we forecast all the actions needed to be done and structure it through key actions. The objectif to do that will be an easier and quicker macro analyses. This is really key afterward. When you can analyse and understand, you can take decisions to adapt your work the following season.

For instance in the Uliège test:

Semis
Semis
Entretien des semis
Arrosage des semis
Plantation
Repiquage/plantation des semis
Elimination mâles
Identification plantes
Entretien végétaux
Entretien et nettoyage des plantes
Tuteurage / SCROG
Contôle sanitaire
Gestion éclairage serre
Entretien serre
Entretien et nettoyage de la serre
Irrigation
Ajustement EC & pH
Gestion de l'irrigation
Apport H2O
Prise de données IKS

Traitement
Ethephon
Traitement phytosanitaire
Encodage données
Travail de bureau
Encodage time sheet
Encodage des résultas
Encodage data logger
Récolte
Récolte et mesures des plantes
pesée fraiche
Divers
Autres actions
Post-Récolte
broyage
Sechage
pesée sèche
Pisciculture
Prise de données IKS/eau
contrôle du nourrissage
nettoyage système
entretien installation
Analyse labo
extraction CELABOR

MONITORING TOOL

The GROOF open-source tool

The second step, will be to list all the cost related to your production activity, in the CBD case;

	Month 2						
Date	Day	Systems	Actions	Time (min)	l/h	Nb of	Total
20-05-21	10	All	Irrigation	6		1	-
20-05-21	10	All	Plantation	14		1	-
20-05-21	10	All	Entretien végétaux	4		1	-
20-05-21	10	All	Plantation	31		1	-
20-05-21	10	All	Plantation	40		2	-
21-05-21	11	All	Plantation	5		1	-
21-05-21	11	All	Entretien végétaux	5		1	-
21-05-21	11	All	Irrigation	3		1	-
24-05-21	14	All	Irrigation	6		1	-
25-05-21	15	All	Irrigation	15		1	-
25-05-21	15	1	Irrigation	2		1	-
25-05-21	15	2	Plantation	1		1	-
25-05-21	15	3	Plantation	1		1	-
25-05-21	15	1	Irrigation	4		1	-
25-05-21	15	2	Irrigation	4		1	-
25-05-21	15	3	Irrigation	4		1	-
26-05-21	16	All	Irrigation	5		1	-
26-05-21	16	All	Irrigation	10		1	-
26-05-21	16	2	Plantation	3		1	-
26-05-21	16	2	Plantation	2		1	-
27-05-21	17	All	Irrigation	15		1	-
27-05-21	17	All	Encodage donnée:	15		1	-

	Month 1			
Date		Unit	Quantity	System
20-04-21	Seeds	pc	800	All
	LR seedling	pc	800	All
	Hydroponic baskets	pc	180	All
10-05-21	Plagron Hydro A	litres	0,5	
	Plagron Hydro B	litres	0,5	
	Plagron Hydro A	litres	0,25	
	Plagron Hydro B	litres	0,25	
11-05-21	H2SO4 10%	litres	1	
	Plagron Hydro A	litres	0,25	
	Plagron Hydro B	litres	0,25	
	H2SO4 10%	litres	0,5	
12-05-21	H2SO4 10%	litres	0,25	
13-05-21	KOH 0,3 M	litres	0,2	

It is just a glims of it, in order to give you a global overview.

You can find the complete tool following this link ; https://hdl.handle.net/2268/300760

CBD PRODUCTION

Once having the monitoring tool, it was needed to decided what type of crops and which agronomic technical itinerary. Hemp has been one of them.

For this study, GROOF has made an association with another project; Tropical Plant Factory, whichi is a portfolio of projects whose vocation is to develop an integrated plant factory concept producing plants with high added value for several fields of application (health, cosmetics, nutrition, etc.), while promoting active ingredients under used assets (industrial wastelands, waste energies). This is to sustain a local supply chain, activating the development of jobs in a professional sector with high added value. Within Tropical Plant Factory, the Optibiomasse project focuses on optimizing the continuous production of plant biomass oriented towards molecules of pharmaceutical interest by acting on the biotic and abiotic factors of the crop.
These two innovative projects have come together to conduct the following research.
In order to study different economic models, our team is interested in the pharmaceutical sector, and the profitability of dedicated cultures for the latter. For this purpose, a study on the productivity of metabolite of interest is conducted on industrial hemp.

Why Hemp ?

The hemp flower market is still quite unstable and offers imported, poorly controlled products at prices between €7 and €12 per gram depending on the variety of hemp sold for its variable CBD rate of 8 to 14%. In the illegal market in Belgium, the price per gram varied between €3 and €4.25 in 2012. During this period, prices tended to increase (Vanhove & al, 2012), but since 2019 prices on the market of CBD tend to decrease. The shift to legal cannabis in Canada can serve as an example, and today it is observed that the prices of legal flowers are higher than the price of these flowers on the illegal market. (Wadsworth et al, 2022)

Why industrial hemp?

Hemp is the only plant subspecies of the "*cannabis sativa*" species that can be legally cultivated in Belgium and Europe.
Hemp (Cannabis sativa sativa) is a plant with many uses. It has been used for more than 2000 years (Chevalier, 1944) and its outlets are many and varied.
Mainly cultivated for its stem, a source of vegetable fibre, the latter is used in the manufacture of boat ropes for example, and more recently in the building industry and the automotive industry.

CBD PRODUCTION

Multiple complementary valuations

This plant also produces seeds, the oil of which (rich in omega 3 / omega 6) is used in different food products for humans and animals (Bertucelli, 2015). Its use also extends to cosmetics.
Currently, the flowers of this plant are the subject of much debate. However, it is increasingly proven that some of these compounds (metabolites of interest: cannabinoids, terpenes, etc.) are useful in managing the pain of certain diseases or in reducing symptoms (Gugliandolo et al, 2018; Borrelli, 2014; T. Iah, 2021).
Industrial hemp is a potential candidate producer of these metabolites of interest, and is the subject of our technical and economic study.

The Culture

Over a cycle of 16 weeks after the system is set up, we studied the development of hemp plants in NFT hydroponic systems connected to a 400 liters tank. The additions of mineral, base and acid fertilizers are carried out by a computer. We have recorded twice a week the size of the plants, the number of nodes of the plant, as well as the parameters of the systems, the electroconductivity (EC), the pH and the temperature of the water of each system.

CBD PRODUCTION

The harvest

The harvest stage of the plants takes place when the pistils are fully browned and the trichomes change from translucent to milky. Once this stage of development has been reached, we proceed to harvest the plants.
We first weigh the total plants in order to compare their total biomass. Each plant being numbered beforehand, we report the values directly in tables constructed previously.
We then weigh the inflorescences of the plant, then we place them in ravines (small containers suitable for drying in an oven).

Once all the ravines are prepared, we can place them in an oven maintained at 65°C for 72 hours in order to dry all the inflorescences.
After three days of drying, we weigh the ravines a second time in order to obtain the dry masses of the inflorescences.

With dried flowers, we use a grinder set at 0.75mm. We obtain a powder that we will pass through a 0.25mm sieve just after. A Falcon tube will be used per plant to deposit 300mg (± 5mg) of the powder at 0.25mm. For this, we use a precision balance. All sample masses deposited in the falcons are also recorded.

CBD PRODUCTION

The analysis

Within 3 days following the previous steps, the samples were prepared to laboratory analysis. On site, we are preparing to set up a UPLC (Ultra Performing Liquid Chromatography) analysis.

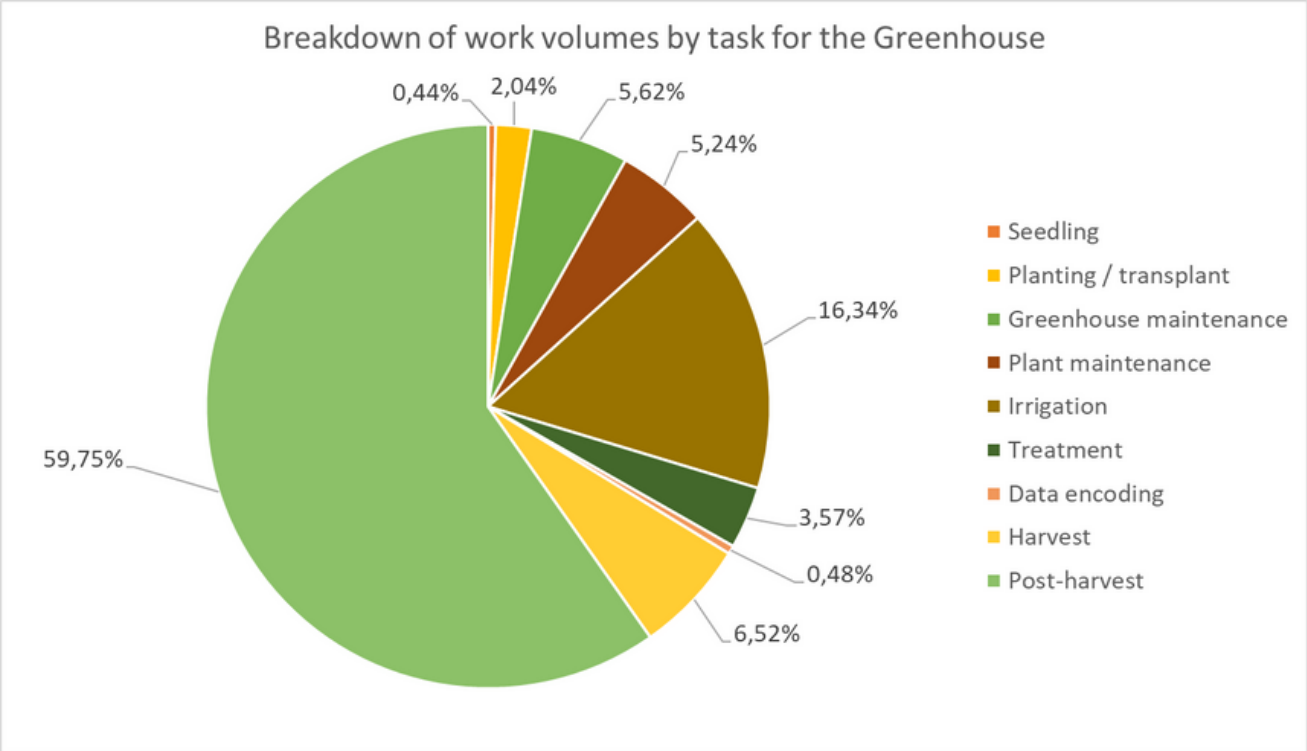
CBD PRODUCTION

The results

The cannabinoid levels obtained are related with the volume of dry flowers produced per square meter.

We manage to produce more than **3g of CBD/m2** in the greenhouse.

The cost



Hemp cultivation monitoring allows us to quantify production costs for greenhouse cultivation, several categories of tasks allow us to visualize which aspects of production should be improved. The different categories are as follows: sowing / planting / greenhouse maintenance / plant maintenance / irrigation / treatment / harvest / post-harvest / data encoding.

The time spent on the post-harvest stage represents nearly 60% of the total time dedicated to cultivation. The activity underlying this stage is the preparation of the flowers for drying (manicure), which consists of removing the leaves to keep only the floral tops. The filling time of the basins also represents a large part of the work carried out.

CBD PRODUCTION

Now, lat's have a look at the volumes of inputs consumed during cultivation. The most important consumption concerns the acid. Though the pH regulator of hydroponic solutions, the acid is added to the solution by the solution monitoring system after each filling of the tanks. Indeed, the city water used to fill the tanks being quite basic, it is necessary to add acid to regulate the pH between 5.5 and 6.6. Approximately 4 liters of acid, 1.5 liters of base, 1 liter of each fertilizer and just over 1 cubic meter of water consumed for 4 months of cultivation.

Thanks to this monitoring tool, we analyze all the stages of the production of hemp for the use of its flower and makes it possible to quantify the economic opportunities. The scale of the greenhouse on the roof of Gembloux AgroBio-Tech University of Liège (Serr'ure).

We have devided the main cost in three item, hereafter is their importance in the operational cost ;

75% : human cost
10% : consumables (fertilizers, acid, base, water, etc)
15% : post-haverst cost (drying, systems cleanig and HPLC analysis)

One gram of dry matter : production cost VS selling price

The calculation of the cost price does not take into account the amortization of CAPEX (costs investments), because being in the case of a research greenhouse, the profitability on the industrial production was not the goal in this cross international projects. The Goal was to firstly manage the culture within our climate reality and monitor it's operationalcost. An extrapolation will be done in a scientific article that will follow.

CBD PRODUCTION

Therefore, **The cost price in the greenhouse is €1.98/ gram of dry matter (€/gDM) and comes from the variety of Félina 32.**

A deepens economic extrapolation will be done in an scientific article later this year, with commercial approach and a potential selling price.

In addition, you can already find another scientific report that Uliège conducted on Euphorbia : https://hdl.handle.net/2268/289785

The research took place in the Uliège Rooftop greenhouse, presented through key figures in the next page.

HEMP PRODUCTION SPACE

Uliège Rooftop Greenhouse
CBD
120m² production area

The greenhouse name: SERR'URE : "SERRe URbaine basse Energie" -> Low Energy URBAN GREENHOUSE

It's a research greenhouse where several types of crops can be cultivated. For this study, we focused on the CBD production that took place in 2022.

Type of building

The Belgian pilot is built on a brand new researchs building center of the university of Liège :TERRA, in Gembloux (Walloon region). In addition, the RTG is part of a bigger research platform called WASABI, which stands for the "Walloon platform for innovative systems in agriculture and urban biodiversity".WASABI is also a teaching and research platform in urban peri-urban agriculture & biodiversity.

The Greenhouse

198 square meters divided in 3 areas. (1) technical, (2) production test and (3) the demonstration one. The north wall is isolated and the SERR'URE design is optimised to consume less energy than a classic chapel greenhouse.

Objectives

This has been designed for research purposes. It features 10 hydroponic tables, a climate control and is connected to the heating system of the support building. A monitoring system is also installed, which makes studies and calculations feasible.

Production system

To be flexible to the diversity of cultures and research thematics, Goponic system was implemented. Such system can be adapted to be used as NFT, DWC or Drip irrigation system. It offers multiple uses as required in small space and in urban environment.

VEGETABLES PRODUCTION GALLY

A vegetable production was chosen alongside hemp. It took place in Saint-Denis, where the RTG is included in a larger urban farm. There, everything is sold on the market located 20 meters from the greenhouse and run by the company Les Jardins de Gally, a GROOF partner. During the analyzed period (summer 2022), the greenhouse production was made of **tomatoes, cuncumbers and eggplants.**

Planting started very late, in May, just after the structure was ready to welcome the production system. The first vegetables could be produced in July and August. September is included in the study even though almost no production was done. This is explained by some days of heatwave at that time which caused a big production loss. Learning from this experience, a ventilation system paired with a fogger will be implemented as an adiabatic cooling system for the greenhouse.

We identified several types of costs, from which the main one is the cost of labour. In this case, there is no heating cost since Gally made the choice of avoiding heating the greenhouse, the price of energy being particularly high at that time. Consequently, the production period is narrower than it could be and the heating system was maintained for frost-free purpose only. Additionnaly, the farm doesn't present any water cost as the water is pumped directly from a private water drilling.

VEGETABLES

The culture

They chose to use an hydroponic growing system for its lightness and flexibility in space organisation. The system is composed of substrate bags on gutters with a dripping irrigation system. The bags offer a great rooting capacity for plants, which is very interesting for tomatoes. It is also a technology well known in Gally, since all of their on-ground greenhouses with tomatoes or strawberries use culture breads. Using it on other sites allows Gally to buy in bulk and keep a small quantity of substrates for their rooftop greenhouse, diminishing the operational costs.
The choice for tomatoes comes from an understanding of the local demand. In fact, tomatoes are selling well on the farm but Gally can not produce enough of it on site to meet the demand. Before Groof, the production was operated mainly on their fields and a bit on the farm's on-ground greenhouse. This rooftop greenhouse adds some productive space as well as favourable climatic conditions for tomato and other "ratatouille" vegetables, such as eggplant and zucchini.
In order to grow tomatoes, they transplant the young tomato plants into the substrate in April, with a ratio of 2 stems per bag of roughly one meter length, and instal the dripping system on top of it. The irrigation brings most of the fertilizer, the rest comes from the starter in the substrate bag. This fertilizer is a mixed solution that Gally produces in large quantities before allocating a small part of it to the Groof greenhouse.
The residual waters are collected in the gutter and stored in a tank to be used on the other greenhouse. This part wasn't well implemented the first year but will be for the second.

VEGETABLES

The Harvest

Tomatoes and eggplants have roughly the same growing cycle allowing for a merge of the harvesting periods, about 2 month after transplantation. For the first year of production, they fell behind schedule due to the delay in the greenhouse construction. Transplant were made in May with young plants a bit more developped than intended. The harvesting period started in the very end of June and finished in the beginning of September, even though it should have lasted until the end of September at least. We will address this point in the following pages.

The harvest is collected in baskets and goes directly to the farm's market on opening days, or in the fridge while waiting for the next opening. Both are located roughly 20 meters from the greenhouse and since the production is relatively small, this logistic is made by foot.

VEGETABLES

Staff Cost

Preparation, maintenance and monitoring was the most time consuming activity for Gally's case, representing nearly 85% of the total working time. This first category includes planting, tutoring, lightening the plants, cleaning the area, removing dead parts or plants, irrigating by hand during dog days, collecting data for the monitoring. Although, monitoring was the least time consuming due to the simplicity of Gally's monitoring system. Harvesting (15%) is less important overall but can reach half of the working time in the greenhouse during the fructification period. We can see that the most important month in terms of working hours was June. And it is precisely in June that the most time intensive activity occured, which is the tutoring, a mandatory step for hydroponic tomatoes.
Staff cost is a very expensive item that can't be overlooked. Yet, The staff cost per hour depends on the country and the type of workers you work with. This needs to be adapted according to your own case.

Product: Tomatoes + eggplants + cucumber					
Month	Préparation, maintenance, monitoring [h]	Harvest [h]	Total hours [h]	Averarge staff cost [€/h]	Total cost [€]
May	10,00		10,00	18	180,00
Jun	75,25		75,25	18	1.354,50
Jul	57,25	2,00	59,25	18	1.066,50
Aug	22,75	20,00	42,75	18	769,50
Sep	30,00	10,00	40,00	18	720,00
Total préparation, maintenance, monitoring [h]			**195,25**		
Total Harvest [h]			**32,00**		
Total Hours [h]			**227,25**		
Total staff cost		**€**	**3.514,50**		

VEGETABLES

Yield and sales

Most of the production is made out of tomatoes. As expected, the peak of production took place in August, though the production should have continued until mid or end of September. Unfortunately, a significant part of the harvest never happened since part of the plants burned during the heatwave. This has been taken into consideration and will be solved this year, so we can expect it won't happen in the next harvesting periods, allowing for higher yields. This is one of many issues that can be expected at the beginning of the GH exploitation, and being able to tackle them and adapt the system to its conditions is crucial to perpetuate the production. The selling price is relatively low for the region, but in the case of Gally, the price can't be raised much as there is a market relatively close to the farm. Also, customers in the area are low-income people overall, and therefore are not keen to pay a higher price even though it is locally produced.

Product: Tomatoes + eggplants + cucumber				
Month	Marketable products [kg]	Non-marketable products [kg]	Total yield [kg]	Averarge net price [€/kg]
Jun	23,00	-	23,00	3,75
Jul	253,25	-	253,25	3,75
Aug	527,46	3,00	530,46	3,75
Sep	24,90	-	24,90	3,75
Total amount of marketable products [kg/a]			**828,61**	
Total amoun of non-marketable products [kg/a]			**3,00**	
Total yield [kg/a]			**831,61**	
Total sales		**€**	**3.107,29**	

VEGETABLES

Water

Even though water in this case is free as the farm benefits from a private water drill, this might not be your case so these numbers could be useful for your project. As you might know, tomatoes require a big amount of water, but the need for water can skyrocket for a GH tomato production, mostly due to the heat stored inside the greenhouse and also by the building's materials. Here, the concrete slab stores a high quantity of energy and the ventilation was suboptimal, resulting in a need of transpiration for the plant to regulate its temperature. This value wasn't monitored but the humidity inside the greenhouse reached 80% on average mid of August with a peak at 97%!
This explains the relatively high quantity of water used. As we said earlier, the plants burned and so no water was used in September, when we harvested the last tomatoes and disposed of the plants.

	Groundwater [l]	Tap water [l]	Total water consumption [l]	Average net price (tapwater) [€/l]
May	22733	0	22733	
Jun	26253	0	26253	
Jul	36373	0	36373	
Aug	54560	0	54560	
Total tap water		**-**		
Total water used (l/a)		**139.919,00**		
Total cost		**- €**		
Total savings from groundwater		**- €**		

VEGETABLES

Total costs

As we can see on the table below, most of the costs are related to the staff (77%). The young plants also play a big role but are directly related to the yield. There is no heating and almost no electricity as the plants only grew with natural light and the ventilation system was simple.
Insurance are isn't included in this calculation as this information has not been communicated. As rooftop greenhouses are an innovative concept, finding an insurer and setting a price for it might be an issue.

Consumption Costs				
Designation	Quantity	Unit/a	Price/Unit	Amount [€/a]
Heat energy		kWh		0
Electricity	363,5	kWh	0,14	51
Soil / growing media + tipp-ex	134,0	units	1,6	217
Packaging		kg		0
Polinators (e.g. Bumblebees)	2,0	piece	38,6	77
Young plants	318,0	piece	2,33	742
Water (ground water)	139 919	m^3	0,00	0
Fertilizer	104	kg	1,12	117
			Consumption Costs	**1 203**
Staff cost				4 090,50
			Total consumtion+ staff costs	**5 294**

VEGETABLES PRODUCTION SPACE

GALLY Rooftop Greenhouse
Vegetables
360 m²

Gally's rooftop greenhouse was designed to supplement the offer for fresh products of the urban farm of Saint-Denis, while not having more ground space, and still being able to preserve the farm's landscape.

Type of building

The French pilot takes advantage of the construction of a new building on an urban farm. The building has been designed to support a productive greenhouse on top of it.

The Greenhouse

The 360m² greenhouse is made of steel for its structure and plastic (polycarbonate and ETFE film) for the covering. The very simple design is based on an agricultural model, in order to be as cheap and efficient as possible: energetically and economically.

Objectives

The aim is purely commercial. The greenhouse allows the production of crops that can't be grown in the farm's open fields so easily (mostly because of the farm's climatic conditions), therefore completing the offer for fresh products sold on site, e.g. tomatoes, cucumbers, eggplants or peppers.

Production system

The greenhouse uses an hydroponic dripping system paired with substrate bags placed on gutters on one hand, and with garden plots on the other hand. The system is designed to be very simple, light, and easy to use/maintain by the team. This system may evolve following the key lessons from the first production year.

CONCLUSION

This report lay the first stone for future researches of a key question; what can we grow in a rooftop greenhouse, with which objective(s), what about the ROI, etc. We have focused here on the operational cost of several types of production. Of course, as we have seen all along the GROOF project, the financial objectives are very often combine with social and environmental

Concerning the CBD, it would be necessary to extrapolate on real costs with a larger greenhouse dedicated to productive use such as tomatoes with potentially the addition of horticultural lamps to maximize the number of cycles possible over the year. In addition, some very time-consuming missions in our study such as the post-harvest and irrigation stage could be mechanized and automated in order to limit the cost of production. Subsequently a calculation of the time required for the amortization of the investments will have to be made and included in a future scientific paper.

Regarding the vegetables production, further research is also needed. However, we can already see that operational break-even is feasible. To reach it, production losses must be avoided while the technical aspects of the greenhouse must be mastered. In the case of Gally, we can also see that an easy access to free water is a key advantage. Similarily to what we noticed with the CBD, the main cost is (by far) the labour cost.

Find all GROOF reasearch in the online guidlines website, through the link bellow.

Guidelines

Regularly updated , you will find them on https://urbanfarming-greenhouse.eu/ or by scanning this QR code ---------->

References

SEE THE REFERENCE LIST IN THE ATTACHED DOCUMENT

THANKS

To all the GROOF partners, early adopters, business partners and supporters.

Contact

GROOF

info@groof.eu

https://www.urbanfarming-greenhouse.eu/

http://groof.eu/

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