Fair & Sustainable Consulting

NFP

Climate Control for BSF greenhouses

Research on affordable, low-tech temperature and humidity mitigation tools for smaller-scale BSF businesses in Kenya

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1. Introduction

Global population growth, increasing demand for animal products and scarcity of conventional feed ingredients drive the search for sustainable alternative protein sources for animal feed. On the African continent, where most of the population growth is expected to occur (1.2 billion people between 2020 and 2050 according to the United Nations[1]), economic growth and changing dietary patterns will lead to a 70% increase in the demand for livestock products by 2050[2]. In East Africa, the expected growth of demand for animal protein is expected to be 4% per annum in the upcoming years[3].

Currently, mainstream protein sources in animal feed are soybean meal and fishmeal. However, the use of soybean meal in animal feed competes with its use as food and the availability of fishmeal is decreasing because of overexploitation of our seas[4]. As the costs of these feed ingredients are expected to increase, prices for animal feed products will be driven up. With feed cost already representing 60-70% of the total costs of livestock production, the search for more sustainable and less costly alternatives has led to a growing interest in insects as protein source in animal feed[5]. Amongst these insects is the Black Soldier Fly. Black Soldier Flies contain high levels of protein and fat, and are rich in micronutrients, vitamins and essential amino acids; hence, they are considered an excellent replacement in pig, poultry and fish feed[6][7]. Their production has a small ecological footprint and contributes to a circular economy by recycling of organic waste.

Climate control is a crucial factor in Black Soldier Fly farming as the insects are sensitive to external factors such as temperature and humidity. It is challenging to pinpoint the exact optimal conditions for BSF rearing as studies have shown that what is considered optimal is context dependent as, for example, sources of waste can predicate the range of ideal temperatures[8]. Even though determining exact generic optimal conditions is therefore challenging, it is commonly believed that larvae are most active with temperatures ranging between 25-35 degrees Celsius[9]. Consensus on the optimal humidity levels for BSF is also lacking. Personally, it has been observed that for flies to emerge properly, become active and mate and produce quality eggs, temperatures between 27-37 degrees Celsius with humidity levels of >35% are required. Additionally, flies need a sufficient amount of daylight and undisturbed environment as mating naturally occurs in direct sunlight. In the hatchery, the ideal temperature range is similar to that of the larvarium (25-35 degrees Celsius) as long as the substrate remains moist.

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[1] https://population.un.org/wpp/Download/Standard/Population/

[2] Chia, Shaphan Y., Tanga, Chrysantus M., Loon, Joop JA van, Dicke, M. 2019. *Insects for sustainable animal feed: inclusive business models involving smallholder farmers.* Current opinion in Environmental Sustainability 41: 23 http://doi.org/10.1016/j.jclepro.2020.121871

[3] http://www.fao.org/3/a-bo092e.pdf

[4] Chia, Shaphan Y., Tanga, Chrysantus M., Loon, Joop JA van, Dicke, M. 2019. *Insects for sustainable animal feed: inclusive business models involving smallholder farmers.* Current opinion in Environmental Sustainability 41: 23 http://doi.org/10.1016/j.jclepro.2020.121871

[5] Van Huis A., Van Itterbeeck J, Klunder H, Mertens, E. Halloran A, Muir G, Vantomme P. 2013. *Edible Insects: Future Prospects for Food and Feed Security.* Pp 201 FAO http://fao.org/3/i3253e/i3253e.pdf

[6] Chia, Shaphan Y., Tanga, Chrysantus M., Loon, Joop JA van, Dicke, M. 2019. *Insects for sustainable animal feed: inclusive business models involving smallholder farmers.* Current opinion in Environmental Sustainability 41: 23 http://doi.org/10.1016/j.jclepro.2020.121871

[7] Abro Z. Kassie M, Tanga C. Beesigamukama D, Diiro G. 2020. *Socio-economic and environmental implications of replacing conventional poultry feed with insect-based feed in Kenya.* Journal of Cleaner Production 265 (2020) 121871, pp. 2

[8] Shumo, M., Khamis, F., Tanga, C., Fiaboe, K., Subramanian, S., Ekesi, S., van Huis, A., et al. (2019). Influence of Temperature on Selected Life-History Traits of Black Soldier Fly (Hermetia illucens) Reared on Two Common Urban Organic Waste Streams in Kenya. *Animals*, *9*(3), 79. MDPI AG. Retrieved from http://dx.doi.org/10.3390/ani9030079

[9] https://www.insectschool.com/production/what-are-the-ideal-temperature-conditions-for-farming-black-soldier-fly-larvae/

In general, Kenya has a favorable climate for BSF farming. However, climatic conditions differ across Kenya and throughout the year. In Eldoret where F&S's pilot farm is located for example, we observe how during the rainy season and at night temperatures drop too low, while in dry seasons it becomes too hot and dry for BSF to develop properly. Therefore, without adequate climate control tools production levels fluctuate heavily depending on the weather. Smaller scale BSF businesses are impacted mostly due to a lack of knowledge on, and access to, affordable climate control measures that can mitigate outside climatic factors. As a result, smaller scale BSF businesses face significant challenges optimizing their production and creating a reliable supply for their offtakers which directly impacts their success as a business at large.

1.1 Project aim and methodology

This research was carried out by Fair & Sustainable as a part of a larger project for Netherlands Food Partnership. The research aims to map affordable, low-tech climate control solutions for BSF greenhouses. Within the realm of climate control, this research focuses humidity and temperature in greenhouses as these are the two key climatic factors in BSF rearing.

The data was collected through a mixed-method approach of desk-research and key-informant interviews. In total, 7 interviews were held with key-informants and companies after which saturation was reached. The interview notes can be found in appendix A. Desk research was conducted both preliminary and to dive deeper into some of the solutions the key-informants proposed. Furthermore, information was gathered from experiences of Everlyne Songoi at F&S's pilot farm in Eldoret (Fair & Sustainable Insect Farms Nekesa Ltd).

1.2 Limitations of the study

Time limit and scope

To the consultant's knowledge, the research at hand is at the time of writing the first of its kind and is thus of merely explorative nature. It does not claim to be exhaustive and additional research is recommended to further explore the feasibility and impact of the proposed measures (see paragraph 3.3). Furthermore, the research scope is limited to climate mitigation tools for temperature and humidity in BSF greenhouses. It has to be noted that temperature and humidity are merely two factors of a large body of interlinked and correlated parameters that influence BSF production which do not fit into the scope of this research (e.g. waste source, substrate temperature and moisture, type of attractant used, quality of materials, quality and consistency of staff, and more).

Focus on high-tech from most companies

It was observed how most companies and Dutch experts gravitated strongly towards high-tech climate control solutions that were simply not feasible for the target group and aim of this study. The proposed tools in this research are based on the realities and challenges of a low-tech farm with limited financial resources in Kenya. Hence, proposed solutions needed to be very practical and try to incorporate locally available materials as much as possible. Evidently, as these companies and experts made clear there are other, more efficient, climate mitigation tools for greenhouses available if resources allow higher-tech solutions to be adopted.

2. Results

In this chapter, the results of the study are presented. The solutions and tools that were found are split into two categories. Paragraph 2.1 disusses tools and solutions in greenhouse structure and building. In paragraph 2.2 tools and solutions inside greenhouses are elaborated on.

2.1 Tools and solutions in greenhouse structure and building

Shadenets

Shadenets are a common way to manage temperature in greenhouses. The thread density percentage determines how much sunlight the shadenets blocks off. Studies researching the effect of shadenets on air and soil temperature have shown a decrease of several degrees when using shadenets between 40-60%[10]. It has be noted that most studies are conducted on plants and Black Soldier Flies need sufficient sunlight in order to mate. Thus a balance needs to be found between lowering the temperature while still letting in enough light.

Airvents and double layer greenhouse side panels

The side panels of the greenhouse should be open- and closeable for airflow and climate control. Ideally, the side panels consists of two layers. Firstly, an inside layer of transparent mesh that is fixed and not removable. Secondly, an outside layer of greenhouse paper which can be rolled up to open the panel for increased airflow, reducing the inside air temperature. Furthermore, an open and closeable airshaft in the top of the greenhouse can be installed (on both short sides) to allow hot air to escape.

Flooring

Some of the interviewed experts explained that it is important to 'activate' the mass in a greenhouse to contain heat. Greenhouses that are directly build on the ground, without any flooring or just a polythene paper, lose a lot of heat through the ground and temperatures drop rapidly. A solution could therefore be to increase the mass in a greenhouse that collects heat during the day and slowly releases this heat at night. Ceramic, stone and concrete tiles are known to have a high level of thermal conductivity and would therefore be materials to consider (based on local availability and prices). If flooring the entire greenhouse is too costly, it can be considered to only floor strategic parts.

Alternative greenhouse designs

Being such a new and innovative sector in Kenya, BSF farmers usually build simple greenhouses with locally available materials (greenhouse paper, wood or aluminium frames) that are traditionally used for horticulture. However, it is worth looking into some alternative greenhouse designs that are possibly better suited to create optimal circumstances for BSF. Some of these alternative designs make use of the abovementioned principle of 'acitivating' mass by using heat retaining materials.

Chinese passive solar greenhouse

An interesting alternative greenhouse structure was mentioned by Egon Janssen from TNO.

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[10] Jajang Sauman Hamdani, Kusumiyati and Syariful Mubarok, 2018. Effect of Shading Net and Interval of Watering Increase Plant Growth and Yield of Potatoes 'Atlantic'. *Journal of Applied Sciences, 18: 19-24.*

He suggested to look into the Chinese passive solar greenhouse design. Chinese passive solar greenhouses have a distinct design (see image 1 below) that uses a passive way of climate control by maximizing sun light and containing its heat.

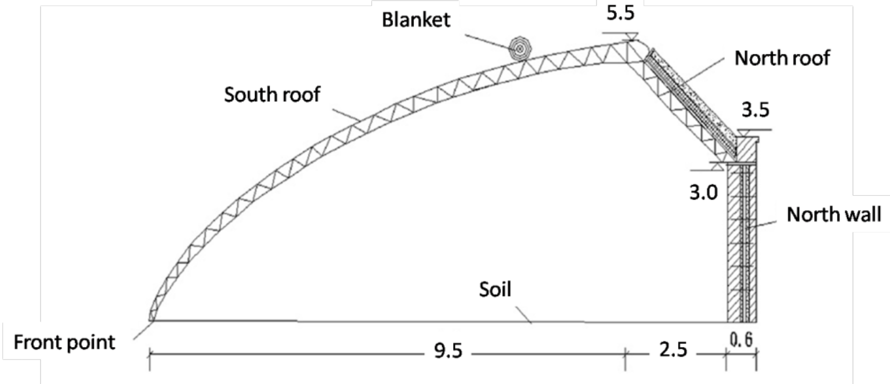

Image 1 Chinese Passive Solar Greenhouse design[11]

From the additional deskresearch conducted it seems that this type of greenhouse is typically build to retain heat to increase crop yields in colder areas. One study showed that inside temperature in a Chinese Solar Greenhouse is typically 10-15 degrees Celsius higher than outside temperature[12]. This type of greenhouse has not yet been tested with Black Soldier Fly rearing and it's features have to be adapted to fit the specific needs and conditions of the BSF. It could possibly work well in colder areas or, if adapted properly, a twist on the design could be made to keep out heat during hot periods and contain heat during cold periods/nights which would be more suited to address the climate control challenges BSF farming in Kenya.

Screenhouse

One of the interviewed companies, Syneffa, offers screenhouses for BSF rearing. A screenhouse is a greenhouse completely made out of mesh panels to maximize airflow while keeping insects inside (see image 2). However, the interviewed team at Syneffa mentioned that they usually cover the screenhouses with another layer of greenhouse paper for BSF rearing to protect the flies and larvae from rain and colder periods. A screenhouse is potentially an interesting base structure for BSF farmers in hotter regions (North of Kenya, coastal region).

[11] https://energyfarms.wordpress.com/2010/04/05/solar-greenhouses-chinese-style/

[12] https://energyfarms.wordpress.com/2010/04/05/solar-greenhouses-chinese-style/

Image 2 Screenhouse Syneffa[13]

Partial wall greenhouse
The third alternative greenhouse design that was mentioned by experts is a partial or ‘dwarf’ wall greenhouse in which the wall is build with either bricks or mud. The use of a wall in the greenhouse structure will increase the mass that can be activated.

A slight variation on this is a partially sunken greenhouse dat is essentially dug out. The deskresearch conducted has shown that this type of greenhouse is usually made with the purpose of containing heat in cold areas. However, in hotter climates (like Kenya) traditional mud structures are used to keep heat out. Thus, this type of greenhouse could possibly help with cooling down air temperature of greenhouses in extremely hot regions (e.g. North of Kenya, coastal region). In that case it should logically be paired with some of the other solutions mentioned in this research, like air vents and flexible side panels.


Image 3 Sunken greenhouse[14]

2.2 Tools and solutions inside greenhouses

Basic temperature and humidity sensors
Battery powered sensors that collect humidity and temperature data are widely available in Kenya against affordable prices. Although these sensors are not a tool to actively influence climate, they allow for accurate measurement of the climate conditions in the greenhouse(s) so that farmers can make informed decsisions on which tools or solutions to employ.

Portable heaters
In colder periods or in areas where night temperatures fall below the desired threshold, portable heaters can be used to keep the temperature inside the greenhouse(s) stable. A prerequisite to this tool is that there is a reliable electricity connection on site. Furthermore, heaters have to be placed strategically to maximize the impact while also taking fire hazards into account (especially when combined with humidity solutions that spray/distribute water). This solution was observed during the field visit to Mana Bio Industries where heaters were placed in the aisle between their love cages.

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[13] https://www.synnefa.io/screenhouses
[14] https://insteading.com/blog/underground-greenhouse/

Blankets over crates
A very simple idea to contain heat at night in the larvarium was proposed by Marian Peters from NGN. She suggested to cover the crates with blankets and by doing so making use of the heat that larvae produce naturally.

Misting system
One of the interviewed companies called Irri-Hub offers a misting system for greenhouses. A misting system is the most favorable sprinkler system for BSF as flies do not like direct contact with large drops of water and wetness, but require high levels of humidity. The misting system comes with a booster pump to combat the issue of low water pressure in Kenya that usually prevent misting/sprinkler systems from working optimally. Compared to imported misting systems, Irri-Hub offers an affordable option (ca. 75,000 Ksh) with local support and servicing.

Ballast on floor
Everlyne, the entrepreneur who runs F&S IF Nekesa Ltd. in Eldoret, proposed the idea of using ballast (pebble stones) to increase humidity in the love cages. She had seen this idea put to practice in other BSF farms in her area, where a farmer put ballast on the floors of the love cage and a few times a day water was sprayed on the rocks. The rocks then slowly release the water throughout the day, increasing humidity.

Carpet floor with dripline
One of the creative ways to increase humidity in the love cages of F&S IF Nekesa Ltd. was to put a thick carpet (made from scrap fabrics) on the floor and run a drip line over it that was turned on several times a day. The carpet soaks up the water and slowly releases it, increasing humidity significantly throughout the day. By implementing this solution, humidity was increased with at least 10-15%. However, it has to be noted that the carpet needs yearly replacing as it gets dirty quickly.

Barrels with water
In the love cages of F&S IF Nekesa Ltd. in Eldoret, large barrels with water are placed in the walkways betweens love cages. The water evaporates slowly during the hot hours of the day, increasing humidity. An add on to this could be hanging cloths from the ceiling with the ends dipped into the barrel. Water will be soaked up by the cloth and evaporate easier.

3. Conclusion and recommendations

Based on the findings in chapter two, several conclusions and recommendations can be made. In paragraph 3.1 the **overall conclusion** of the research given in which the tools and solutions for climate control are aggregated and divided into three main climate control intervention categories. Paragraph 3.2 discusses a few **general recommendations regarding climate control for starting and existing BSF farmers in Kenya**. Lastly, in paragraph 3.3 **recommendation for future research and/or projects** are formulated.

3.1 Conclusion

The research at hand has focused on three main climate control categories. Firstly, increasing temperature in cold periods (whether seasonal or at night). Secondly, decrease temperature in hot periods and/or locations. Thirdly, increasing humidity in both cold and hot periods. Within each category, several interventions can be found in which the proposed practical solutions fall. Below, an overview is given for each category, its intervention and the tools/solutions belonging to it. This overview can be used as a 'menu' for existing and aspiring BSF farmers to pick and choose their climate control strategy. For most BSF farmers in Kenya, a combination of tools and solutions from each category is necessary to mitigate the diverse weather conditions throughout the year.

Increasing temperature

The first category is increasing temperature. Within this category, three main interventions are identified.

1. Passive heat retention through activating the 'mass' in a greenhouse

Tools and solutions that can be considered:

- Building greenhouses with more usuable mass. This means building with materials and designs that have a higher thermal conductivity than the usual greenhouse paper. Examples of this are a Chinese Passive Solar Greenhouse or a dwarf wall greenhouse;
- Flooring (parts of) the greenhouses

2. Isolation of greenhouses or crates

Tools and solutions that can be considered:

- Putting blankets over the crates in the larvarium, pupae suite and hatchery. Either only at night or also during the day in cold periods/areas.
- Putting an isolating cover material on top of the greenhouse. Either only at night or also during the day in cold period/areas.
- Flexible side panels and air vents in conventional greenhouses that can be closed at night or when temperatures drop.

3. Active heating

Tools and solutions that can be considered:

- Putting portable heaters in (parts of) the greenhouses. Only applicable if there is a reliable power source and safety can be guaranteed.

Decreasing temperature

The second category is decreasing temperature. Withing this category, two main interventions were identified.

1. Increasing airflow in greenhouse

Tools and solutions that can be considered:

- Greenhouse design with airvents. This includes having double-sided greenhouse walls with one layer of mesh/screen and one layer of greenhouse paper. The greenhouse paper layer can be open and closed for increased airflow.

- Alternative greenhouse design: screenhouse. A screenhouse can be built instead of a greenhouse for maximum airflow.

2. Keeping out heat
Tools and solutions that can be considered:

- Shadenets can be installed on top of the existing structure to block out sunlight and thus reducing inside temperatures. When selecting a shadenet for the love cages, it is important that the right percentage is selected to allow enough sunlight.

- Alternative greenhouse design: adapted Chinese greenhouse or sunken greenhouse. Even though these types of greenhouses are generally build in colder areas to keep heat in, it is worth looking into adaptations to these designs that have an opposite function of keeping heat out.

Increase humidity

The third category is increasing humidity. Within this category, two main interventions are identified.

1. Active humidifyers
Tools and solutions that can be considered:

- A misting system as described in this research can be installed to increase humidity in the greenhouses. This is especially an interesting tool for the love cages as flies cannot withstand direct water and highly prefer mist.

- Drip lines another active humidifying option. They can be placed on the ground and/or installed in the ceiling of the greenhouse.

To increase the impact of these active humidifyers they can be combined with some of the passive humidifying options mentioned below.

2. Passive humidifyers
Tools and solutions that can be considered:

- Putting ballast (pebbles) on the floor that holds water and slowly releases it to the air throughout the day.

- Putting a blanket on the floor that is being wet several times a day (this is a good option to combine with a dripline).

- Placing barrels with water throughout the greenhouse.

3.2 Recommendations to BSF businesses

- **Always invest in (basic) climate sensors if possible.**
  This allows for more accurate and adequate intervention strategies at different points in time and throughout different seasons.

- **Get informed before building your greenhouse and make strategic decisions.**
  If resources allow work with a local climate control expert/greenhouse builder. Some general tips are: speak to (BSF) farmers in the area with greenhouses and research the climatic conditions/challenges regarding climate control they have. Then base your design on that. Building greenhouses on a piece of land that allows for enough **fresh air circulation**. This means that it has to be an open space without high buildings or walls close to the greenhouse. Furthermore, it is advised to build **separate greenhouses** for different stages in the process as each stage requires different circumstances and climate to reach the optimal production level. Climate parameters are easier to control in relatively smaller spaces.

3.3 Recommendations for future research and projects

- **Adapting Dutch expert knowledge on climate control in greenhouses to Kenyan context.** There is a lot of knowledge in The Netherlands on climate smart agriculture and greenhouse design. However, during this research it became clear that most Dutch businesses and experts are focused on high-tech solutions that are not feasible for small-scale businesses in Kenya. I believe it could be valuable to see how Dutch knowledge and technology can be adapted to fit the low-tech and scarce resources in Kenya. One idea could be to develop practical, lower-tech, climate control kits for greenhouses. A demo farm can be set up to train farmers and businesses.

- **Testing the impact of certain (sets of) tools/solutions to quantify impact and do a cost/benefit analysis to facilitate better advise to farmers.** As the nature of this research was merely explorative, no tests have been done to determine the impact of the proposed tools/solutions on the climate and thus on the production of BSF. It is advised to do a follow-up research with the aim to generate a comprehensive cost/benefit analysis which can help farmers make adequate decisions based on their resources, location and business model. During the interview, TNO mentioned to have extensive experience in such cost/benefit modelling and impact calculations.

- **Conduct more in-depth research into alternative greenhouse designs and how to adapt them to a Kenyan context.** Instead of merely trying to 'import' knowledge from Western settings, we should aim to combine contemporary (high-tech) knowledge with traditional knowledge on architecture, materials and structures (e.g. mud and straw structures) as this will generate knowledge on low-cost greenhouse designs that optimize the Kenyan climate, landscape and local materials.

4. Appendix A – Interview Notes

Attendees: Ian Mutua - Agricultural engineer
Company: Falraw Green Technologies
Date: 25-01-2023

Information provided via WhatsApp

Here are some of the solutions you can consider:
1. Appropriately sized fans that are placed strategically to maximize air circulation and hence temperature control.
2. Eldoret can receive a lot of sunlight during the day, so you can invest in a black shade-net (choose an appropriate light screening percentage)
3. Install some sprinklers to help with humidity control (I can recommend 60-80% for BSF in your location). It can also help cool the greenhouse a bit.
4. Modify the structure. Increase the vent area, install bigger doors, put rollup-sides on all sides or replace the plastic with insect netting

I think this is the best I can do based on the information I have. If you need customized solutions for your particular operation, then we can have an expert come over and help you. We provide the most affordable solutions in the market guaranteed to give you value for your buck!

Interview TNO / NGN
Attendees: Marian Peters NGN – CEO – edible insects specialist, market strategies for insect businesses – demo farms in Spain, NL, Nigeria and projects across Africa.
Egon Janssen TNO – High-tech Greenhouse expert targeting suppliers of greenhouse materials/constructions
Mathilde Miedema TNO – Innovation for development – protein transition
Date: 06/02/2023

SIOM modelling for greenhouse construction and climate control adaptation

- Larvae do not need sunlight so a shade net would work to keep temperatures lower.
- Screenhouse
- In colder periods, you have to make sure that you can 'activate' the mass in a greenhouse to contain heat. This can be done with ceramic or concrete floor tiles or to construct half walls of mud/bricks .
- Chinese muurkassen (sun has to be on the round side)

- Egon would not necessarily recommend using ventilators/fans as they use a lot of power. It is better to use natural ventilation where possible, e.g. the combination of airflow from flaps on the side and the shaft in the top of the greenhouse.
- To keep temperatures lower, it is even better to keep the sun out by placing shade nets directly on top of the greenhouse.
- Mathilde mentioned that to keep temperatures higher during cold nights you could look into using thermic solar panels (used in Kenyan households) that pump hot water through pipes and heat the air. However, you will need to have quite a substantial amount of 'collectors' to heat the whole space. The pipes have to run throughout the whole greenhouse to have an effect.
- The ratio between crates and space should be utilized to regulate temperatures. In mealworm production this is already a commonly used technique (Marian). Different ages of larvae are place together to generate and deduct heat from the natural process.
- Since larvae can sustain easily with limited air, crates can be covered with a blanket at night (this can also immediately hold water for humidity)
- TNO is willing to see how they can contribute by calculating some of the models/cost and benefits of certain solutions.

Interview Syneffa

Attendees: Vanessa Komone

Date: 27/01/2023

Syneffa offers tools for climate smart agriculture. Vanessa is mainly focused on the technology they sell called Farm Cloud/Farm Shield which is a data collection system using sensors that upload data onto their platform. Farmers can monitor using a dashboard. BSF clients are Sanergy and ICIPE. They use the system to measure for example: substrate moisture levels, nitrogen levels, light intensity, temperature and humidity, Co2 levels.

Sensors work either on solar energy or electricity.

It is a one off payment for the system and the team offers support.

Vanessa does not know a lot about structural adjustments in greenhouses so she promised to connect me to their CTO Paul.

Interview Irri-Hub

Date: 10/02/2023

Attendees: Eric – Project Manager

Irri-Hub is specialized in irrigation systems, greenhouse construction and solar pumps. They usually build metallic frame greenhouses. For BSF they build the tunnel shaped greenhouses with insect nets 360 degrees and polythene paper on the top. This shape is mostly chosen because of economical reasons (less material is used compared to the vent shaped one).

Eric suggests air vents can be installed in the roof of the greenhouse to promote air circulation and cool down in hot periods. These are fully mechanical vents and easy to install in the roof.

They also offer mister systems that uses a booster pump to pressure out the water making it a very fine mist. This would be perfect for humidifying BSF greenhouses. For an 8mx30m greenhouse he said it would cost around 60,000 KSh + 15,000 KSh (booster pump). They service the system but so far none have needed servicing in 5 years. The system comes with a filter to ensure water is clean.

Shadenets are also a good option to lower temperature.

He suggested I can also interview Amiran Kenya and Elgon Kenya.

Field visit and interview Mana Bio Industries
Attendees: Emma Feenstra (F&S), Larry Kotch (Mana Bio Industries)
Date: 01/02/2023

Observed climate control tool and solutions at Mana Bio Industries:

- Radiators in between the love cages – only used at night
- Don’t work in greenhouses but in a industrial warehouse. Concrete flooring, big space and high roof.
- Their main business is designing and manufacturing climate controlled BSF units in shipping containers including AC/heater and humidifier. However, this is a high capital investment as one container costs around 20.000 USD.
- Shadenet on top – seems to be a medium shade percentage
- Sprinkler system – switched on several times a day
- Climate data collected through sensors and uploaded onto dashboards automatically