Minimum Viable Product (MVP) Documentation
OAQS-BSFF Organic Fertilizer
UI Living Lab

incitis-food.eu

Funded by
the European Union

1. Overview

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Innovation Actor: None Yet
Location: University of Ibadan, Ibadan, Nigeria
Keywords: Liquid Organic Fertilizer, Valorization of Wastes, Aquaponic Sludge, Insect Frass, Vegetable Production input

1.1. Abstract

Definition of Minimum Viable Product (MVP):
This Minimum Viable Product (MVP) "Organic Aquaponic Sludge-Black Soldier Fly Frass Fertilizer" (OAQS-BSFF fertilizer) is an organic fertilizer formulation made from the solid waste (sludge) of the simplified aquaponic system combined with the solid waste (frass) from the Black Soldier Fly (BSF) production unit of the INCITIS-FOOD project. It addresses the problem that integrated aquaponic and insect production systems generate wastes such as aquaponic sludge and BSF frass, which can cause environmental burdens if handled improperly, even though they contain valuable nutrients, and farmers often lack simple and practical options for their safe and effective reuse as fertilizer. Aquaponic sludge is relatively rich in nitrogen from fish feed and metabolic waste, while BSF frass contains higher levels of minerals, particularly potassium, phosphorus, and magnesium. Combining the two wastes creates a more balanced fertilizer that helps close nutrient cycles. The formula for the combination and the protocol for turning it into a liquid fertilizer were developed. The fertilizer represents one of the various ways to valorize the residual wastes in a circular agriculture production system, thereby further closing the circular loop of a circular production system, and transforming agricultural wastes into wealth creation. Currently, the MVP has been tested against a synthetic fertilizer formula in laboratory conditions. The first trial on leafy vegetables (*Amaranthus sp* and *Solanum macrocarpon*) indicates a great potential as organic fertilizers to significantly substitute synthetic fertilizers, thus contributing to healthy food production and an environmentally friendly agriculture production system.

1.2. Photos

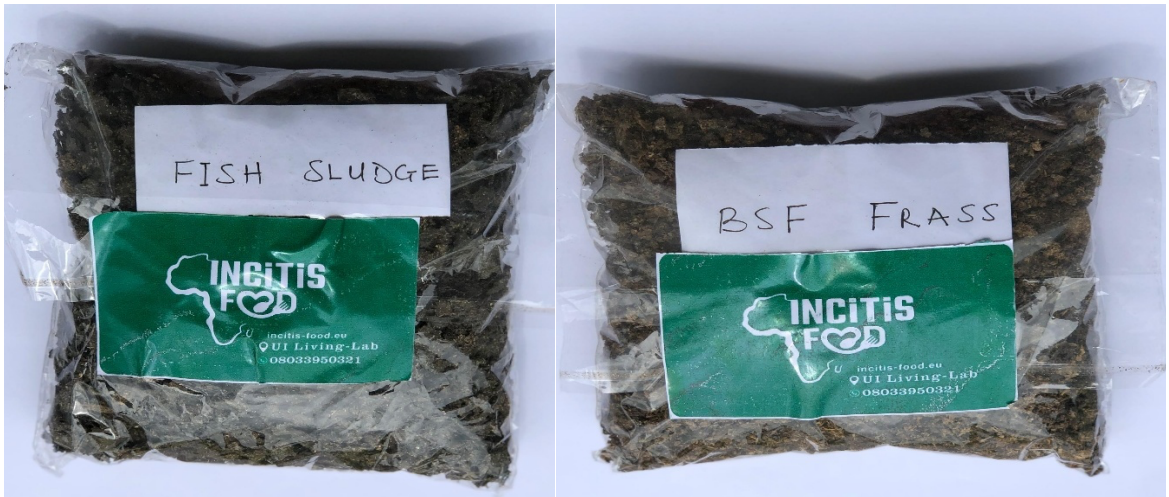

Figure 1: Packaged Organic Aquaponic-based Sludge (OAQS) and Packaged BSF Frass (BSFF)

1.3. Motivation and challenges tackled

The MVP was motivated by the need to: 1) valorize waste into a valuable product, 2) reduce the use of synthetic fertilizer in food production, 3) reduce the cost of production of crops emanating from fertilizer purchase, and 4) create more revenue and jobs along the agricultural production value chain.

There are challenges in managing solid waste, especially in urban food production, as the problem of waste limits the sustainability of urban agriculture. While circular production systems help to mitigate this problem to some extent, residual wastes still exist, leaving the loop not fully closed. The development of innovations that turn waste into value can help address this challenge. At the same time, solid wastes contain different components, so a deficiency in one waste source can be complemented by nutrients from another source. Against this background, sludge from the aquaponic system and frass from insect production were combined in the circular production model of the INCITIS-FOOD project to produce the OAQS-BSFF fertilizer.

This provides several benefits for farmers, including productive use of local waste materials, reduced dependence on external fertilizer inputs, provision of nitrogen and essential minerals, and simple preparation using basic tools and containers. At the same time, the use of this fertilizer supports circular and environmentally friendly production systems. The OAQS-BSFF formula is particularly suitable for small and medium-sized farms that already operate aquaponic or insect production units. Overall, the combination of aquaponic sludge and BSF frass offers a practical and cost-effective method for nutrient recycling and enables the production of an organic fertilizer that integrates well into circular food production systems.

1.4. Feedback process

The concept of the OAQS-BSFF-fertilizer has been shared at different dissemination fora of the INCITIS-FOOD and with the innovator actors for their uptake when finally deployed. Further iteration is ongoing.

2. Implementation

2.1. MVP Design

Sludge

The wastes were collected from the aquaponic system used to culture African catfish, *Clarias gariepinus.* Solid waste collected on a daily basis was weighed and subsequently dried in the shade. The dried sludge flake is characterized for nutrient /mineral content and packaged inside polyethylene nylon and kept till use.

Frass

Frass are the solid waste emanating from the feeding and rearing process of BSF. The feeding of the BSF utilized brewery waste. BSF larvae are produced from the egg stage inside a 60x40cm rectangular trough, where water and brewery wastes are added to feed the BSF for growth daily. The waste of the feed and excretory wastes of the BSF makes the frass. The composition in each cycle is characterized for nutrient/mineral content and packaged inside polyethylene nylon and kept till use.

The Combination Formulation

The sludge-frass combination formula was determined based on the result of the nutrient/mineral content using Total Kjeldahl Nitrogen (TKN) and Ash content (mineral source) in proximate analysis as indicators. Total Kjeldahl nitrogen (TKN) was determined by Kjeldahl digestion and is reported as N rather than converted to crude protein using the conventional factor of 6.25, because the analysed frass–aquaculture-sludge matrices contain potentially substantial non-protein nitrogen. The combination was in a ratio of frass/sludge that gave the optimum ash content. The recommended mixing ratio for the OAQS-BSFF formula is approximately 35% sludge and 65% frass. To prepare the liquid fertilizer, 0.7–1.0 kg of this mixture should be soaked in 200 L of water, with a soaking time of about 24 hours, which has been experimentally determined as the minimum duration. Before application to plants, the liquid fertilizer should be decanted or filtered.

Volume and Soaking Duration of OAQS-BSFF Formula for Liquid Fertilizer Production

The determination of OAQS-BSFF-fertilizer formula volume and soaking time for its liquid form production was implemented. The OAQS-BSFF-fertilizer was soaked in a known volume of water, then the EC was monitored for days. The time of peak EC was determined. Same water-fertilizer mix for the OAQS-BSFF and that of a standard inorganic fertilizer formula were set up and EC was monitored. The concentration of the OAQS-BSFF-fertilizer per water volume was adjusted based on the ratio of inorganic fertilizers' EC to the test organic fertilizer.

How was it studied

Samples of aquaponic sludge (composite samples from the aquaponic digester, radial flow floating sludge, and tank floor) and BSF frass were collected from a circular aquaponic–insect production system. Their nutrient composition, mineral content, and microbial characteristics were analyzed under controlled storage conditions (Tables 1 and 2). Different sludge–frass combinations were tested to identify mixtures with favorable nutrient profiles. Based on these analyses, a practical combination was selected that provides both nitrogen and key minerals needed for crop production. The study methodology included sample collection from the digester, floating sludge, and tank floor, analysis of nutrient composition, mineral content, and microbial characteristics under controlled storage conditions, testing of various sludge–frass combinations to identify favorable nutrient profiles, and selection of the optimal mixture based on these analyses.

Table 1: Chemical Composition of Combinations of Black Soldier Fly Frass to Aquaponic Sludge for Production of Organic Liquid Fertiliser.

Parameter	A (100% Frass)	B (75% Frass)	C (50% Frass)	D (25% Frass)	E (100% sludge)
Moisture content (%)	7.77 ± 0.06 [c]	9.09 ± 0.04 [d]	9.48 ± 0.06 [e]	7.31 ± 0.06 [b]	6.75 ± 0.05 [a]
TKN (%)	4,5 ± 0,018	5,10 ± 0,026	5,63 ± 0,014	6,78 ± 0,026	7,55 ± 0,018
Ash /Mineral Content (%)	27.15 ± 0.35 [d]	25.90± 0.42 [c]	26.15 ± 0.08 [c]	20.96 ± 0.22 [b]	20.15 ± 0.07 [a]
Crude Fat/Ether Extract (%)	1.05 ± 0.03 [c]	1.86 ± 0.05 [d]	0.92 ± 0.04 [b]	3.58 ± 0.06 [e]	0.78 ± 0.05 [a]
Crude Fiber (%)	11.60 ± 0.14 [d]	10.45 ± 0.21 [c]	10.95 ± 0.21 [c]	8.60 ± 0.28 [b]	7.35 ± 0.21 [a]
Nitrogen-free extract/ Carbohydrate content (%)	35.87 ± 0.16 [e]	31.32 ± 0.25 [d]	28.28 ± 0.16 [c]	25.81 ± 0.06 [b]	25.13 ± 0.04 [a]

Mean with the same alphabet along the row is not significantly different at p>0.05. Cells highlighted yellow show the minimum, while calls highlighted green show the maximum value across the table.

Table 2. Mineral content of different combinations of Black Soldier Fly Frass and Aquaponic Sludge.

Minerals (mg/100g)	A (100% Frass)	B (75% Frass)	C (50% Frass)	D (25% Frass)	E (100% Sludge)
N	4506 ±17^{a}	5095 ±24^{b}	5628 ± 14^{c}	6782 ±19^{d}	7552 ± 18^{e}
Na	226.5 ± 2.1^{a}	240.0 ± 1.4^{b}	247.5 ± 0.7^{c}	260.5 ± 3.5^{d}	270.0 ± 1.4^{d}
K	377.5 ± 2.1^{b}	569.0 ± 1.4^{c}	594.0 ± 2.8^{d}	610.5 ± 2.1^{e}	270.0 ± 1.4^{a}
Ca	241.5 ± 0.7^{a}	263.5 ± 2.1^{b}	270.5 ± 2.1^{c}	277.0 ± 1.4^{d}	738.0 ± 2.8^{e}
Mg	268.5 ± 2.1^{a}	282.5 ± 2.1^{b}	287.5 ± 0.7^{bc}	295.0 ± 1.4^{d}	291.5 ± 3.5^{cd}
P	317.0 ± 4.2^{a}	346.5 ± 2.1^{b}	350.0 ± 1.4^{bc}	356.5 ± 0.7^{c}	313.0 ± 2.8^{a}
Fe	12.88 ± 0.00^{a}	13.59 ± 0.01^{b}	13.83 ± 0.01^{c}	14.17 ± 0.01^{d}	15.70 ± 0.02^{e}
Zn	5.62 ± 0.01^{a}	6.33 ± 0.00^{b}	6.75 ± 0.07^{c}	7.29 ± 0.00^{d}	7.54 ± 0.01^{e}
Cu	1.32 ± 0.00^{a}	1.49 ± 0.01^{b}	1.59 ± 0.00^{c}	1.68 ± 0.01^{d}	1.83 ± 0.01^{e}
Mn	2.96 ± 0.01^{a}	3.36 ± 0.01^{b}	3.50 ± 0.01^{c}	3.68 ± 0.01^{d}	3.86 ± 0.01^{e}

Mean with the same alphabet along the row is not significantly different at p>0.05. Cells highlighted yellow show the minimum, while calls highlighted green show the maximum value across the table.

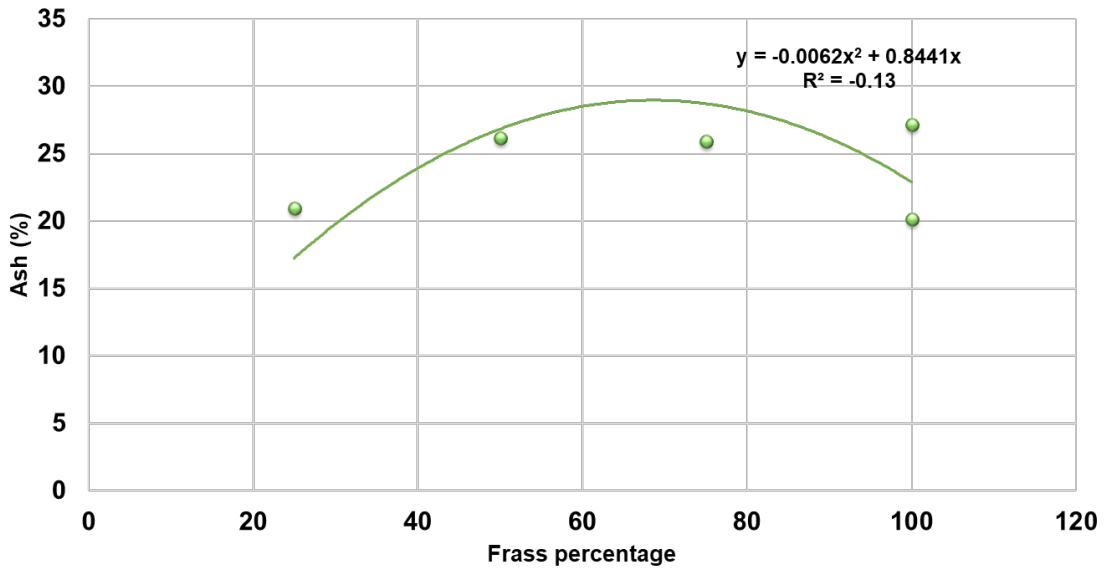

Figure 2: Optimal Frass/Sludge inclusion level

Pattern of frass percentage on Ash content in Frass to sludge combination for 144 hours anaerobic condition. The proposed ratio was selected based on the crude ash content of each mixture. Crude ash is an indicator of mineral content which supplies essential micro and macronutrients needed for plant growth. The combination that provided the optimum mineral indicated by crude ash content was therefore selected for the frass-sludge combination fertiliser.

2.2. Operations

The steps to be followed in the application of the OAQS-BSFF organic fertilizer to plants:

1. Obtain the solid-state OAQS-BSFF-fertilizer pack
2. Soak 720g per 200L of water
3. Allow to soak for 24 hours under aerobic conditions
4. Before use, homogenize the solution by stirring
5. Draw out the desired volume into a watering can
6. Apply liquid fertilizer to the plant's substrate

2.3. Bill of materials and required tools

Table 3. Bill of material

Item	Quantity*/ 200L mix	Cost (Naira)/kg	Total Cost	Total in Euro
Frass	500 g	300	150.9	0.091
Sludge	215 g	500	107.75	0.065
Total			**258.65**	**0.156**

Table 4. Tools required

Item	Quantity	Unit cost (Naira)	Total cost (Naira)	Total cost (Euro)
Sludge collector/sieve	1	200	200	0.12
Bowl for collection	1	1000	1000	0.60
Drying platform	1	1000	1000	0.60
Frass and sludge sacks	2	200	400	0.24
Polyethylene Nylon	1 pack	2000	2000	1.20
Mixing Drum (200L)	1	20000	20000	12.00
Watering can	1	7500	7500	4.50
Total			**32100**	**19.26**

3. Economics

3.1. Business model

The following business idea is envisaged:

a) Production and marketing of organic OAQS-BSFF-fertilizer packs
b) Marketing of raw sludge and frass for end users in OAQS-BSFF-fertilizer production
c) Production and marketing of a healthy crop produced using the liquid OAQS-BSFF-fertilizer

4. Future improvements

4.1. SWOT analysis

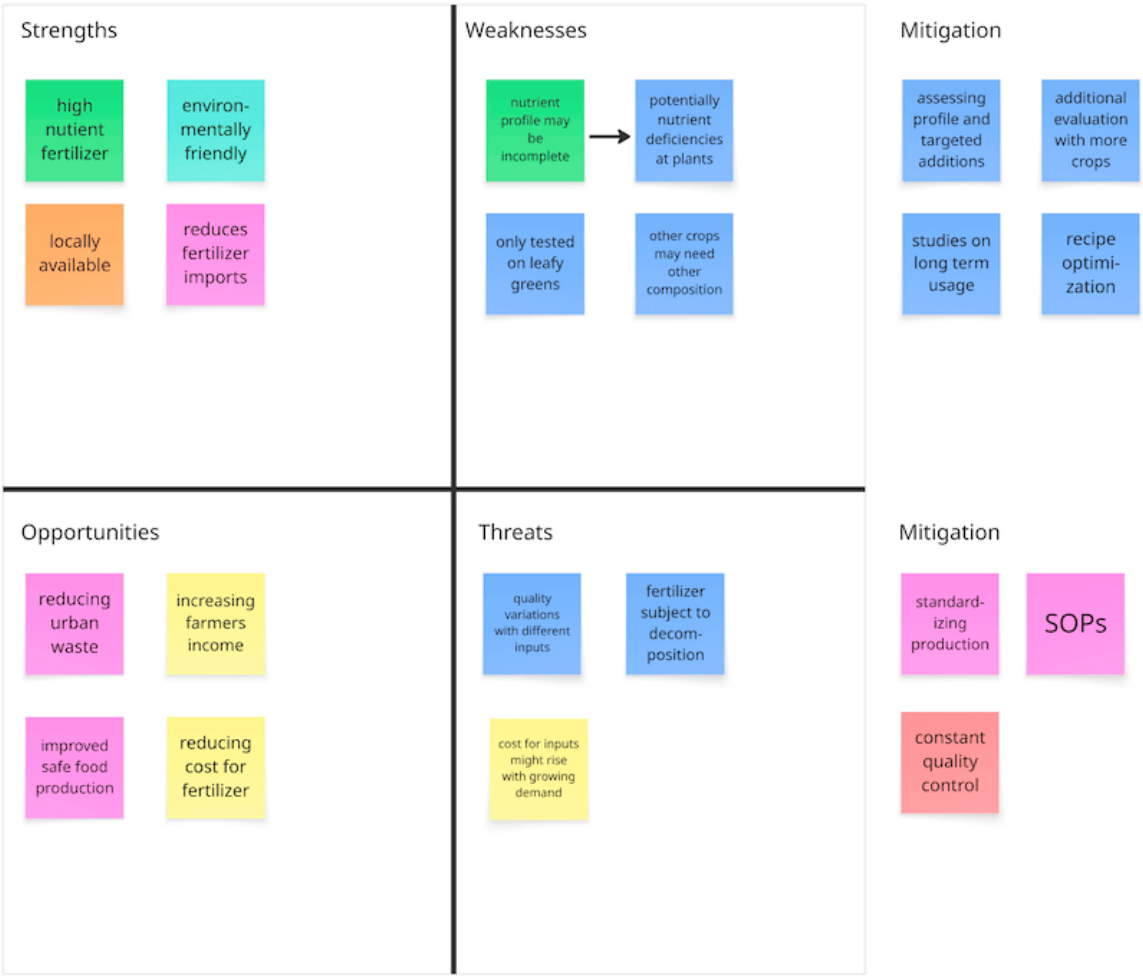

Figure 3: SWOT – UI LL – OAQS-BSFF Organic fertilizer

Strengths

- Organic fertilizer is effective in healthy food production.
- It offers environmentally friendly fertilizer for plant use.
- It supports sustainable and local crop production through locally available fertilizer
- Reduces the volume of imports of inorganic fertilizers.

Weaknesses

- It is a composite and may not have all nutrients compared with inorganic fertilizer, whose nutrients are in concentrated forms
- Due to the above, there could be some nutrient deficiency symptoms and a relatively lower growth rate in crops grown using the organic fertilizer
- It has been tested on some leafy vegetables but may not do well in all vegetable and fruit crops, as different crops may require different levels of nutrients

Opportunities

- Reducing urban wastes,
- Increased SMEs and farmers' income
- Improved safe food production
- Reduced the costs of fertilizer in crop production.

Threats

- Quality of the fertilizer may change per batch due to fish feed, fish species, season, frass quality, and frass source.
- Being an organic material, the fertilizer is subject to decomposition when environmental conditions change, hence, it requires proper drying and storage conditions.
- Cost of production and of raw material may soar when many more people start its production.

4.2. Optimization

- Assessment of limiting nutrients and supplying to the composite formula would take care of deficiency issues. And improve the growth of the crops.
- More tests of the fertilizer to ascertain the needed improvement and meet them would be useful in determining the specific crops it should be used on.
- Conducting further studies on iterations would support its long-term use. There is also a need to scale the results in the field
- There is a need to optimize the organic fertilizer mixture to ensure it consistently maximizes key crop yield parameters, such as leaf production, where synthetic fertilizer had a slight advantage.

4.3. Threat mitigation

- There will be a need to ascertain the quality per batch of production
- Protocol can be updated based on further research

5. Appendices

5.1. Additional Photographs

Figure 4: Plants fertilized with BSF fertilizer