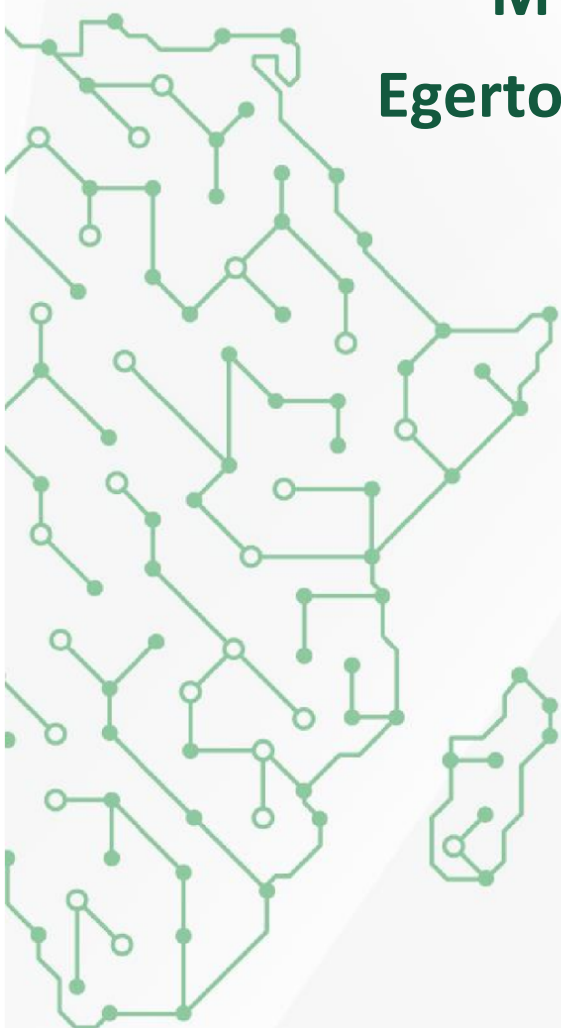




Black soldier fly liquid fertilizer

MVP Documentation

Egerton University Living Lab



incitis-food.eu



Funded by
the European Union

1. Overview

Principal Investigator: Monica Omondi

Co-investigators: Bernard Karanja & Arnold Opiyo

Location: Egerton University

Duration: November 2024 to March 2025

Keywords: Black Soldier Fly frass; liquid organic fertilizer; soilless farming; pumice substrate; African Indigenous Vegetables; circular agriculture; root-zone nutrient application

1.1. Abstract

This Minimum Viable Product (MVP) introduces a low-cost, farmer-friendly liquid fertilizer derived from Black Soldier Fly (BSF) frass for use in soilless vegetable production systems. The production of the fertilizer is less labor- and time-intensive than conventional methods for producing liquid fertilizer from frass, as long fermentation times, repeated stirring, and filtration steps are not required. This improves its practicality directly on the farm. The innovation transforms solid frass into a nutrient-rich liquid formulation that can be applied directly to the root zone of crops grown (soil or substrate drench) in pumice, ensuring efficient nutrient delivery and preventing foliar scorching. Designed specifically for African Indigenous Vegetables (AIVs), the fertilizer supports optimal growth in bioponic setups where conventional soil-based nutrient inputs are unsuitable. By utilizing locally available materials and simple extraction methods, the MVP enhances circular agriculture through organic waste recycling, reduces dependence on synthetic fertilizers, and promotes environmentally responsible production of nutrient-dense leafy vegetables. This approach offers smallholder farmers an accessible pathway to sustainable, climate-smart soilless cultivation.

Brief Procedure for Preparing Liquid Fertilizer (Tea) From BSF Frass

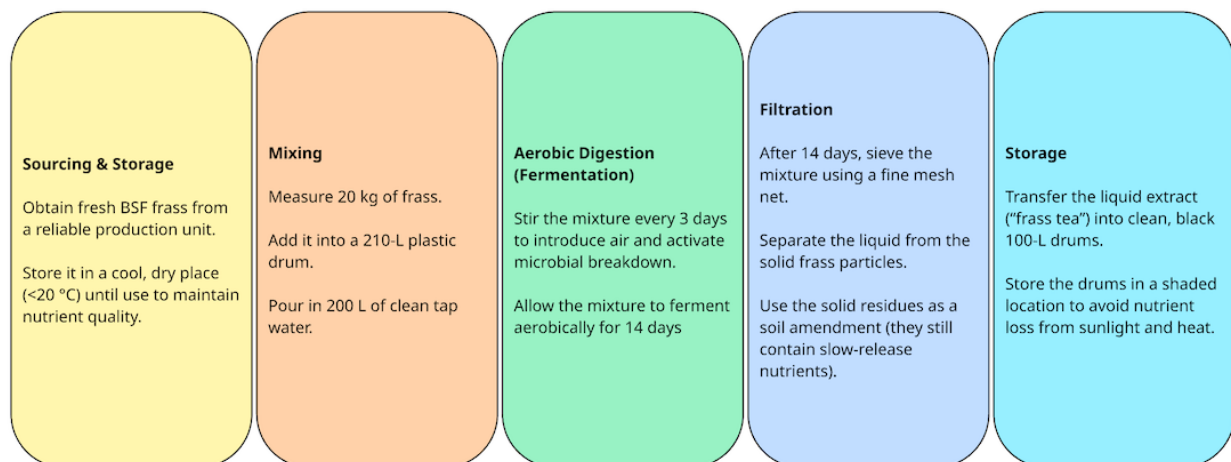


Figure 1: Brief Procedure for Preparing Liquid Fertilizer (Tea) From BSF Frass

1.2. Photos



Figure 2: Liquid fertilizer preparation



Figure 3: Application of the fertilizer

1.3 Motivation and Challenges Tackled

African Indigenous Vegetables (AIVs) are rich in vitamins, minerals, and antioxidants, essential for human nutrition and combating malnutrition. However, conventional soil-based production yields are low (1–3 t/ha) and inconsistent. Controlled environments, such as bioponic systems, can increase yields up to 30 t/ha, making them highly suitable for urban and peri-urban food security.

This MVP focuses on developing a liquid fertilizer from Black Soldier Fly (BSF) frass as a low-cost, organic alternative to synthetic fertilizers. Using BSF frass as a liquid fertilizer:

- Enhances nutrient availability at the root zone, avoiding foliar damage.
- Promotes circular agriculture by converting organic waste into a usable resource.
- The plants showed visible positive responses with increased vigor and darker green foliage.
- Supports Sustainable Development Goals: SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action).

Overall, the BSF liquid fertilizer MVP addresses challenges in nutrition, sustainability, and urban food security.

1.4 Feedback Process

- Technical Guidance: LL staff supported the setup of the bioponic system and provided advice on preparing and handling BSF liquid fertilizer.
- Farmer Input: Innovation actors contributed practical feedback on operational feasibility, labor requirements, and safe handling of the fertilizer.

- Iterative Adjustments: Observations from each production cycle informed improvements in fermentation, dilution, irrigation scheduling, and nutrient delivery, ensuring optimal plant growth and resource efficiency.

2. Implementation

2.1 MVP Design

The MVP is a BSF liquid fertilizer-based bioponic circulatory system designed to enhance yield, nutritional quality, and safety of AIVs. Selected crops include Amaranth, African Nightshade, and Cowpea, chosen for resilience, rapid growth, and nutritional value.

Key features of the MVP:

- Grow beds: Rectangular timber frames lined with LDPE plastic, filled three-quarters with pumice.
- Fertilizer: BSF frass fermented into a liquid formulation and applied at the root zone.
- Design: 36 grow beds arranged in a 4×3 factorial RCBD with three replications.

Controlled bioponic conditions with BSF liquid fertilizer can achieve yields up to 30 t/ha, compared to 1–3 t/ha under conventional soil-based agriculture. Iteration focused on optimizing liquid fertilizer preparation, nutrient delivery, and irrigation protocols, ensuring high efficiency, operational feasibility, and maximizing the benefits of circular agriculture.

2.2 Operations

Working Steps for Producing Liquid Fertilizer from BSF Frass

The method was adapted from existing protocols and refined through repeated practical application, aiming for improved nutrient solubilization while maintaining simplicity and practicality.

1. Weighing the Frass
 - Measure 20 kg of BSF frass using a weighing scale.
2. Preparing the Mixing Container
 - Use a 210-litre plastic drum as the fermentation vessel.
 - Ensure the drum is cleaned and rinsed before use.
3. Combining Frass and Water
 - Pour the 20 kg of frass into the drum.
 - Add 200 liters of clean tap water to fully submerge the frass.
4. Initial Stirring
 - Stir the mixture thoroughly with a long wooden or metal paddle to break up clumps and ensure uniform mixing.
5. Aerobic Digestion Process
 - Cover the drum loosely (to allow air exchange but prevent contamination).
 - Stir the mixture every three days to maintain oxygen supply for aerobic decomposition.
 - Allow the mixture to ferment for 14 days under aerobic conditions.
6. Sieving the Mixture
 - After 14 days, pour the fermented slurry through a fine mesh sieve or net.
 - Separate the liquid extract from the solid particles.
7. Handling Solid Residues

- Collect the remaining solid frass residues.
 - Use them as a soil amendment to improve soil organic matter and nutrient recycling.
8. Collecting the Liquid Fertilizer
- Transfer the filtered liquid (“frass tea”) into clean, black 100-litre containers.
 - Place containers in a shaded area to protect nutrients from sunlight and temperature fluctuations.
9. Preparing for Use
- Before application, mix or shake the stored fertilizer tea to ensure even nutrient distribution. The finished fertilizer remains effective for up to three months when stored in a cool, dark place, as confirmed by the experience of a neighboring farmer.
 - Practical guidance is to apply 250 ml per plant every two weeks, adjusting the dosage based on plant species, growth stage, and observed response.

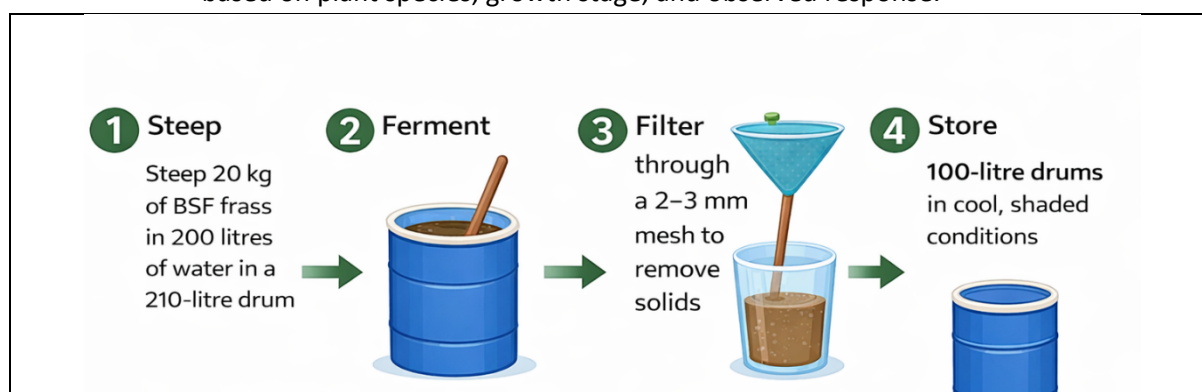


Figure 4: Step-by-step procedure for the preparation of Black Soldier Fly (BSF) frass liquid extract: (1) steeping 20 kg of BSF frass in 200 L of water in a 210-L drum, (2) fermentation for 14 days with stirring every three days, (3) filtration through a 2–3 mm mesh to remove solids, and (4) storage of the filtrate in 100-L drums under cool, shaded conditions.

Each batch of Frass Tea was analyzed in the project for macronutrient content and pH (Table 1 shows value ranges due to batch-to-batch variability); this is intended to help farmers apply the fertilizer correctly.

Table 1. Nutrient composition and application characteristics of Black Soldier Fly (BSF) frass tea used in the study. Reported ranges reflect batch-to-batch variability during tea preparation.

Parameter	Concentration in sample	Practical meaning for farmers
Nutrient composition of dried BSF frass tea		
Total nitrogen (N)	5.37 % DM	Supports leafy growth
Total phosphorus (P)	1.24 % DM	Supports root development and early growth
Potassium (K) as K ₂ O	6.31 % DM	Improves leaf quality and stress tolerance
Application characteristics of liquid BSF frass tea		
pH of frass tea	6.95–7.16	Near-neutral, suitable for vegetables
Nitrogen concentration of frass tea	270–824 mg N L ⁻¹	Expected N range depending on preparation
Standard target N supply	625 mg N plant ⁻¹ week ⁻¹	Rate used to calculate application volume

2.3 MVP Setup: Materials & Tools

Table 2. Materials & Consumables

Item	Quantity	Unit	Unit Cost (KES)	Total Cost (KES)
Black Soldier Fly frass (BSF)	3	50 kg/bag	3,000	9,000
Plastic tanks (210 L)	4	pieces	5,000	20,000
Plastic tanks (100 L)	3	pieces	3,000	9,000
Water	5,000	L	10 per 20 L	2,500
Buckets	3	pieces	700	2,100
Jerricans (10 L)	36	pieces	500	18,000
Wooden stirring paddles / rods	2	pieces	300	600
Protective gear (gloves, masks, apron)	3	sets	1,200	3,600
Fertilizer measuring tools	1	set	1,200	1,200
Labels / markers	10	pieces	50	500
Subtotal — Materials & Consumables				67,000

Table 3. Durable Equipment & PPE

Item	Quantity	Unit	Unit Cost (KES)	Total Cost (KES)
Shovels / scoops	2	pieces	800	1,600
Watering cans	3	pieces	600	1,800
Measuring jugs	2	pieces	400	800
Thermometer / Hygrometer combo	1	piece	2,000	2,000
Ruler	3	pieces	200	600
Pencil	3	pieces	50	150
Subtotal — Tools & PPE				6,950

Grand Total MVP Setup Cost: 73,950 KES

3. Economics

3.1 Business Model Canvas – MVP for African Indigenous Vegetables

Key Partners - Local organic input suppliers (BSF frass, chicken manure, fish sludge) - Universities and research institutions (technical support, training) - NGOs and farmer cooperatives (outreach, distribution)	Key Activities - Production of AIVs using bioptic systems - Organic fertilizer formulation and application - Monitoring crop growth, water quality, and nutrients	Value Proposition - Nutrient-rich, high-quality vegetables - Environmentally sustainable and circular production - Training, demonstration workshops - Cost-effective, scalable, and replicable small-scale model	Customer Relationships - Urban and peri-urban consumers - Smallholder farmers and peri-urban growers - Hotels, restaurants and catering businesses	Customer Segments - Urban and peri-urban consumers - Smallholder farmers and peri-urban growers - Hotels, restaurants and catering businesses - Research and educational institutions
	Key Resources Bioptic grow beds and pumice substrate		Channels Direct sales at local markets	
Cost Structure - Variable costs: Fertilizers, water, seeds, labor - Fixed costs: Grow beds, tanks, monitoring equipment		Revenue Streams - Sale of harvested AIVs (Amaranth, Cowpea, Nigella) - Farmer cooperatives and smallholder networks		Environmental Impact - Reduced chemical fertilizer use - Valorization of organic waste streams

Figure 5: BMC – MVP for African Indigenous Vegetables (AIV)

4 Future Improvements

4.1 SWOT Analysis: BSF Liquid Fertilizer MVP



Figure 6: SWOT – EGE LL – BSF Frass liquid fertilizer

Strengths

- Circular reuse of organic waste (BSF frass)
- Sustainable, low-chemical vegetable production
- Enhances nutrient availability and vegetable quality

Weaknesses

- Initial investment, though lower than conventional systems, can still be significant
- Labor-intensive during MVP stage
- Reliance on a specific organic input (BSF frass)

Opportunities

- Scaling up to commercial farms and farmer cooperatives
- Collaboration with universities, NGOs, and extension programs
- Sale of BSF liquid fertilizer and farmer training services
- Faster ROI and improved profitability due to lower capital costs

Threats

- Seasonal variation in BSF frass availability
- Pest or disease outbreaks affecting crops
- Market price fluctuations for vegetables

4.2 Optimization Strategies

- Automate fertilizer mixing, irrigation, and drainage to reduce labor and water usage.
- Explore alternative organic inputs (e.g., composted market waste) to supplement BSF frass and improve resilience.
- Expand tank and grow bed capacity to increase liquid fertilizer production efficiency per m².
- Implement simple monitoring tools (temperature, humidity, and basic water meters) to optimize nutrient and water management without relying solely on research equipment.

4.3 Threat Mitigation

- Diversify organic input sources to ensure consistent BSF frass supply.
- Train farm workers and partner farmers on safe fertilizer handling, circular waste recycling, and food safety practices.
- Continuously monitor greenhouse microclimate conditions (temperature, humidity) to reduce crop stress and minimize production losses.



Figure 7: Data collection on height of the plants



Figure 8: Two months grown vegetables for biomass analysis



Figure 9: Harvesting cowpea for partial leaf yield analysis Figure 10: Fresh weight and dry weight analysis in the laboratory

5.3 Additional Notes

Table 2: Key Troubleshooting Issues for the BSF Liquid Fertilizer Bioponic MVP

Problem / Question	Possible Cause	Explanation / Solution
Clogging in irrigation/drainage pipes	Fine particles in BSF liquid fertilizer	Sieve the BSF liquid before application; install mesh filters on inlets and outlets; flush pipes regularly to prevent buildup.
Labor-intensive watering	Manual watering of 36 grow beds	Use drip irrigation or timed watering systems to reduce labor and ensure uniform application of BSF liquid fertilizer.
Yellowing of cowpea leaves	Iron deficiency	Monitor plant iron status; supplement BSF liquid fertilizer with iron chelates if necessary; ensure proper pH (5.5–6.5) for iron availability; maintain consistent irrigation (e.g., 250 mL/plant).

Footnote: These challenges were observed during implementation of the BSF liquid fertilizer MVP for African Indigenous Vegetables (AIVs) and highlight areas for improvement in future cycles.