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Black Soldier Fly, *Hermetia illucens* – An Important Insect for Compost Production

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ABSTRACT

The increasing number of Livestocks, Agricultural and Municipality wastes has led to a great deal of waste generation, and its improper treatment results in threats to the environment. Black soldier fly larvae (BSFL), *Hermetia illucens* (Stratiomyidae: Diptera) have the potential to convert waste into high-quality compost effectively. The larval stage feeds off organic matter and offers a rich protein source naturally consumed by animals. In favourable conditions, BSF technology has significant potential to solve existing problems associated with waste management.

INTRODUCTION

Rapid industrialization and urbanization have accelerated the pace of waste generation. Improper waste management practices, such as incineration and land fillings, create environmental pollution. Hence, there is a need to develop an environment-friendly technique to manage waste. Many technologies have been developed for waste management, in which the most practiced one is composting technology. Composting is the process of converting the waste into a useful product such as humus or manure, which can be further used for plant nutrient management. It involves the amalgamation of various physical, chemical and biological parameters. Biological parameters involve both the micro and macro organisms that take part at different stages and play a vital role in biodegradation of the waste, converting it into a useful end product. Many investigations have been done on the micro and macro organisms, and one such macro organism found during the composting process is the black soldier fly, *Hermetia illucens* (Ritika *et al.*, 2015).

Description of Black soldier fly

BSF is a fly (Diptera) belonging to a family Stratiomyidae, and the species *Hermetia illucens* (Plate: 1d). It is a large fly ranging in size from 13 to 20 mm and looks like a wasp. However, an unmistakable difference between the two is that a wasp has four wings, whereas BSF has only two wings. Another striking difference is that BSF does not possess a sting or proboscis, whereas a wasp does.

The female fly lays a package of 400 to 800 eggs (Plate 1a) close to decomposing organic matter, into small, dry, sheltered cavities. On average, the eggs hatch after four days and the emerged larvae, which are barely a few millimetres in size, will search for food and start feeding on the organic waste nearby. The larvae feed voraciously on the decomposing organic matter and grow from a few millimetres size to around 2.5 cm length and 0.5 cm width, and are of cream-like colour (Plate: 1b).

Under optimal conditions, growth of the larva requires a period of 14-16 days. However, the BSF larva is a very resilient organism and has the ability to extend its life cycle under unfavourable conditions. The larval stage is the only stage during which the BSF feeds and, therefore, it is during this time of larval development that enough fat reserves and protein are stored that allow the larvae to undergo pupation (Plate 1c), emerge as flies, find mates, copulate and lay eggs before dying (Dortmans *et al.*, 2017).

a

b

c

d

Plate1: Different life stages of black soldier fly

a) Egg, b) Maggot, c) Pupa, d) Adult

Growth conditions of BSF

BSF undergoes complete metamorphosis. The longest part of their life is spent their larval and pupa stages, whereas their egg and adult stages are relatively shorter (Popa and Green, 2012). The adult BSF which brings some benefits is that they do not have functional mouthparts; thus they do not feed (do not eat waste) but rely on the fat stored during their larval stage (Tomberlin and Sheppard, 2002). Hence the importance of adequate and dedicated feeding at the larval stage. Within two days of emerging from the pupal case, adults can mate (Diclaro and Kaufman, 2009). After mating, a female lays eggs in cracks and crevices which are separated a bit from the food source.

Food sources and why BSF maggots were suitable for compost production

Once hatched from the eggs, larvae crawl into the food source (Fruits and Vegetables, Food waste, Municipality waste, Slaughter waste, Chicken manure and Human faeces). The larvae have a unique composition of gut microbes, enabling them to handle a wide range of such food sources (Banks, 2014). The larval stage happens to be the most vital stage of BSF pertaining to waste management as this is the stage at which the waste is fed upon and converted to compost products. They have to feed enough to store adequate fat which becomes the food source for adult. The larvae feed for about two weeks before becoming prepupae. Due to high larval densities, voracious appetite of the larvae and abundant amount of gut microbiota, fresh material is processed extremely fast and bacteria growth suppressed or restrained, thereby reducing production of bad odour to a minimum.

Compost production procedure

Container roofed by a corrugated metal sheet and enclosed by a wire net. Population of the black soldier fly, was maintained in a small green houses, roofed with transparent plastic foil fitted with a sun shading net and nylon netted sidewalls. These were exposed daily to direct sunlight for about eight hours. The trays (80 cm x 200 cm x 30 cm), built with zinc-coated steel sheets. For exiting prepupae, two ramps at a 28° angle led from the base plate (100 x 80 cm) to the upper end of each shorter side panel. A plastic pipe (11 cm x 94 cm) was fixed along the top of this edge. A slit (5 x 80 cm) cut into the pipe allowed migrating soldier fly prepupae to enter and crawl along the pipe leading to downspouts at each end of the pipe from where they fell into harvesting containers (Diener *et al.*, (2011)..

Pre-processing:

Rough sorting**:** To reduce particle size, it will make easily accessible to the larvae and the associated bacteria

Dewatering step: Moisture content of the waste should maintain below 85 %.

Treatment:

Waste treatment takes place in plastic boxes piled on top of each other in stacks. The treatment process takes 13 days. A specified number of 5 days old larvae from the rearing facility are added to a certain amount of waste in each plastic box. The larvae consume the organic waste and grow. Each plastic box contains 10,000 larvae and 15 kg of bio waste is fed manually in three feeding events.

Product harvesting and separation of larvae:

After 13 days, larvae are manually separated from residue using a sieve. Thereby the mixture of larvae and residue is spread out onto the sieve, where then larvae crawl through sieves holes to a recipient below to avoid sunlight. A pressurized water system is used to clean the recipient and flush larvae to a harvesting system.

Residue composting: After larvae harvesting, the remaining residue is composted and used for farming purposes

Nutrient content of the compost derived from the food waste bioconversion process by *H. illucens*

Compost comes out from the decomposition process by BSF and has met all the minimum fertilizer control order, 1985 as presented in the Table. 1

Table 1: Fertilizer Control Order (FCO), standard values compared with the compost obtained from BSF (Choudhury *et al.*, 2018).

Parameters	Units	BSF Compost test values	FCO standards
Particle size	%	96.28	Minimum 90 % material should pass through 4.00 mm sieve
C: N Ratio	-	11.81	20.0 Max
Bulk Density	gm/cm^3	0.81	< 1.0
Moisture	%	24.19	15.0 – 25.0
Total Organic Carbon	%	31.2	12.0 Min
Total Nitrogen as N	%	0.90	0.8 Min
Total Phosphate as P_2O_5	%	0.98	0.4 Min
Total Potash as K_2O	%	1.03	0.4 Min
Copper	mg/kg	57	300 Max
Nickel	mg/kg	10	50 Max
Zinc	mg/kg	206	1000 Max

Optimal environmental conditions for the larvae of BSF:

Warm climate: The ideal temperature is between 24 and 30°C. If too hot, the larvae will crawl away from the food in search of a cooler location. If too cold, the larvae will slow down their metabolism, eat less and develop slower.

Shaded environment: Larvae avoid the light and always search for a dark environment, away from light. If the food source is exposed to sunlight, they move to deeper food layers to escape the light.

The food source's water content: The food source has to be quite moist with water content between 60 and 90 % so that the larvae can ingest the substance.

Nutrient requirements of the food: Substrates rich in protein and easily available carbohydrates result in good larval growth. Research studies indicated that the larvae might more easily consume waste if it has already undergone some bacterial or fungal decomposition process.

The particle size of the food: as the larvae have no chewing mouthparts, access to nutrients is easier if the substrate available in small pieces or even in a liquid or pasty form.

CONCLUSION

This processing method is an emerging biowaste treatment technology, which can produce marketable high-value compost products that can contribute towards sustainable and financially viable resource recovery-based waste management systems. This black soldier fly technology reduces the waste amounts significantly by minimizing the possible pollution and improving environmental sanitation.

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