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Application of Vermitechnology in Aquaculture

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ABSTRACT

Sustainable aquaculture is one in which the goal is permanence, achieved through the utilization of renewable resources. This leads to development of concept of organic and natural farming. Among various components of organic and natural farming, vermicomposting is a key component for making compost through earthworms. Organic aquaculture is a production system, which avoids or largely excludes the use of synthetically compound fertilizers, pesticides, growth regulators and feed additives. The low cost organic aquaculture system mainly depends on the use of vermicompost and vermiproducts (vermiwash, earthworm, cocoon, etc.) which are produced naturally. There is urgent need to enhance the culture of earthworms since they are utilized as live fish food, bait and fishmeal supplement. Earthworms are unique as fish food as they contain many essential amino acids along with hemoglobin in their blood serum, which provide the required iron for developing fish. Adult earthworm, cocoons and vermiwash can serve the purpose of fish feed in different ways. So, the application of vermitechnology is required for the development of organic aquaculture.

Keywords: earthworm, organic pisciculture, variable substrate, vermiculture, vermiwash

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INTRODUCTION

The fresh water fin fish have very high potential as protein food and are among the increasing number of aquatic animals that have been coming to the fore as candidate species for aquaculture (Jhingran 1997). The fish are free from the dreaded contagious diseases like bird flu, anthrax, rabies and mad cow disease. The protein obtainable from fish is palatable, easily digestible and suitable for human of all age groups.

It is evident that the return from aquaculture is 2 to 15 times higher than that obtained through traditional agriculture. In aquaculture, principal investment apart, there are also operating express, mainly for seed, fertilizer, feed and labour. Among these, the cost of feed and fertilizer constitute about 70% of the total operating expenses (Deolaiikar 1997). So to make aquaculture more economical, especially to the small farmer and the rural community, there is a need for finding out alternative cheap sources for feed and fertilizers. The most vital challenge of the day is to produce more food with the least possible utilization of energy and resources. The growing concern for the conservation of energy and optimum but economical utilization of available resource, with simultaneous pollution control measures has led to the development of integrated farming systems. With advancements in science and technology, the concepts of waste resource recycling have come up and newer technologies are continually developed to cater the needs of the various industries in this regard.

For the treatment of solid waste the most commonly used method till now is land spreading of solid waste. The method has various disadvantages as it causes contamination of soil, vegetation and both ground and surface waters. Other disadvantages are the scarcity of land available for this purpose. With the recent developments in biotechnology many biological methods have come up for solid waste treatment, one of the major ones being 'vermicomposting'. Vermicomposting is the process of harnessing of earthworm for the stabilization of a variety of organic wastes. A subject of intensive research in many countries, vermicomposting is one of the most important aspects of earthworm biotechnology at present (Ghosh 2004; Sujatha *et al.* 2003; Singh 2004; Guerrero and Guerrero-del Castillo 2006). Earthworms are considered as excellent bioreactors for waste recycling and vermicomposting is thus an effective mode of waste management, nutrient recycling and sustainable organic farming. Vermicomposting technology can be particularly useful for the management of waste from agriculture, city garbage, livestock, sewage and industrial organic wastes, etc. (Tsukamoto and Watanabe 1977; Rand 1995). Vermicompost is already in use in agriculture. So, in aquaculture waste can be more profitably utilized and commercialized for gains through vermicomposting.

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Invited Mini-Review

INTEGRATED VERMICULTURE AND AQUACULTURE FARMING

A composite agriculture-aquaculture-vermiculture farm can be entirely synergistic. The aquatic body where aqua farming is practiced can be at least a part receptacle of animal excrement both solid and liquid, silk worm pupae, earthworms remains and human food grain product, which can form fish feeds of first-rate quality. The water of reservoir can be used for irrigating agricultural crop planted in the reservoir embankment and reused for aquaculture. A vermiculture-sericulture-carnivorous fish culture is an important approach. Experiences have shown in some small ditches, where *Clarias batrachus* (Linnaeus 1758; Common Name: Magur) and *Heteropneous fassilis* (Bloch 1794; Common Name: Singhi) have fed with earthworms and silkworm pupae prevented them from cannibalism even in high stocking density (Chakrabarty 2009).

In a vermicompost farm in Akshay Krishi Vikash, Mahisbathan, Nadia successfully yielded organically produced agriculture, aquaculture using vermicompost as manure (Chakrabarty *et al.* 2007a). Review materials (Pullin and Shehadeh 1980; Jhingran 1997) are on hand on aquaculture in paddy fields and irrigation systems; on animal-fish farming and on special consideration of aquatic macrophytes and on health constraints to man via fish or water in integrated animal fish in various south eastern Asian countries. These review works bring out the concept of feeds and fuels from waste, and encompassing every conceivable organic commodity producible from land and water use. It is bewildering indeed how in a coprophagous system basing itself on animal dung use and reuse, fish can appear as a practically free by product deriving free energy from the sun available to the developing and developed nation alike (Jhingran 1997).

The biomass generated as a byproduct of vermicomposting has been found to be a good source of protein for fish (Tacon *et al.* 1983; Stafford and Tacon 1984a, 1984b, 1985; Nandeesha *et al.* 1988; Cruz 2006; Khwairakpam and Bhargava 2007; Joshi and Aga 2009). In fish culture industries, attempts are now being made to replace the costly fish meal which is normally incorporated in diets by alternative cheaper sources of protein. In Japan, the demand for processed earthworms as feed for eel fry is 180,000 tonnes year^{-1} (Deolaiikar 1997).

Although in aquaculture various organic sources have been utilized, utilization of domestic and organic waste is limited. The waste from animal husbandry and other domestic wastes are misplaced resource, causing pollution. Raw waste, animal dung when directly applied to water body increases BOD (Chakrabarty *et al.* 2007a) and also increases risk of pathogen transmission. Vermicompost is free from such side effects. However, if recent developments in India are any indication, earthworm will soon be used on an industrial scale for solid waste management and other pollution control mechanisms (Senapati and Dash 1983; Ghosh 2004; Naddafi *et al.* 2004; Karmegam and Daniel 2007). Vermicompost is also used as organic manure in agricultural fields though its efficacy in the aquaculture system has not yet been properly evaluated. Considering all these points, studies on utilization of the product i.e., vermicompost and earthworm in aquaculture are of great importance.

Vermicompost as feed and fertilizer

Organic manuring is widely practiced in fish farming ponds for high yield as well as to reduce expenditure on costly feeds and fertilizers (Chakrabarty 1994; Brown and Gilloy 2003). Various types of organic manures are used for this purpose such as livestock manure; poultry manure grass, leaves, sewage water, etc. Chakrabarty *et al.* (2007a) successfully applied vermicompost as direct application organic manure in fish farming ponds. Vermicompost can be utilized as food for invertebrate fish food organisms as well as for fishes for direct consumption; they are intended primarily to release inorganic nutrients in water body for phyto and zooplankton growth (Chakrabarty 2009). According to Sujatha *et al.* (2003) earthworm casts contain 2–5 times more organic matter, total nitrogen and exchangeable cations than soil which improves sediment quality. So, vermicompost not only supply nutrients but also improve the physico-chemical properties of water as well as the qualities of sediment base. Several methods have been developed to convert these agro-bio wastes into organic manure to replace costly and hazardous chemical fertilizer. Vermicompost preparation is the best method for converting agro-bio waste into effective manure. The expected productivity of a water body can greatly be enhanced by the use of vermicompost which may provide essentially desirable nutrients, minerals, vitamins, etc., required for the production of aquatic biota and serving either directly or indirectly through involved ecosystem as food for fishes. The rest amount of vermicompost, which is not directly devoured as food, play the role as manure. The phytoplanktons form the important key link in the food chain of fishes. The goal of fertilization ought to be to direct all primary, secondary and tertiary levels of productivity towards maximum yield of fish (Jhingran 1997).

Use of artificial fish feeds

Synthetic fish feeds are species specific, but a polyculture system implies common feeds for all species cultured together in the same water body.

When artificial feed is to supplement natural food in a polyculture system, the natural and supplementary food should be complementary to each other, the latter meeting the deficiency of the former. The supplementary artificial food has to meet the balance of the required total fish nutrition. The other sources of fish nutrition which the artificial feed has to supplement and complement are a result of pond manuring and fertilization, which promote generation of natural fish food organisms such as phytoplankton, zooplankton and other biota as well as detritus (Jhingran 1997). Vermicompost is naturally devoured by fish and contains high amount of bacterial mass, which is a good source of protein, and the rest material gets dissolved in water and serves as nutrient for water body (Chakrabarty *et al*. 2007b) and promotes phytoplankton growth. So, vermicompost could serve as artificial feed and fertilizer.

There should be an arrangement for feeding of juvenile fish; if small and large fish are cultured together in an aquatic body. Vermiwash can serve as excellent direct application feed for juvenile fish in such case (Chakrabarty *et al.* 2009a).

Chakrabarty *et al.* (2009a) showed that the growth and survival rate of fish were significantly higher in the verminwash applied aquariums possibly because the presence of several micronutrients, metabolites, vitamins (Pro vitamin D and B complex) and also for some free amino acids in vermiwash (Springett and Syers 1979; Kale 1998; Ping and Boland 2004). The juvenile fish are able to take very small food particles present in vermiwash. The common food particles like live plankton feed or market available feed pallet, are much higher (3 times higher when compared with particles present in vermiwash under ocular microscope) in size in comparison to food particles the juvenile fish can consume (Chakrabarty *et al.* 2009a). Vermiwash contain major and micronutrients along with cocoons small worms, debris of body parts mainly in edible forms. Vermiwash is reported to contain growth hormones, antibiotics and vitamins (Atlavinyte and Daclulyte 1969; Lee 1985; Ismail 1997), which are beneficial for growth of the fish. This has also been shown that probably these substances helped the fish to remain disease free in a laboratory experiment by Chakrabarty *et al.* (2009a).

Preparation of fish feed using vermitechnology

Organic pisciculture is a production system, which avoids or largely excludes the use of synthetically compound fertilizers, pesticides, growth regulators and feed additives. To the maximum extent feasible organic pisciculture systems rely upon animal manures, vermicompost and vermiproducts, green manures, off-farm organic wastes, mineral-bearing rocks, etc.

However, there is urgent need to enhance the culture of earthworm since its utilization as live fish food, bait and fishmeal supplements (Akiyama *et al.* 1984; Bankole *et al.* 1985; Omorinkoba *et al.* 1985; Stafford and Tacon 1985; Tacon 1987; Chakrabarty *et al.* 2009b). Earthworms are unique as fish food as they contain many essential amino acids along with hemoglobin in their blood serum, which provide the required iron for developing fish. Adult earthworm, cocoons and vermiwash can serve the purpose of fish feed in different ways. A special feed using excess and old worms from vermipit mixing poultry egg shell dust and plant rhizome is being tested by the present author as direct application (Chakrabarty *et al.* 2009d) fish food in fish farming ponds. Poultry eggshell can be collected from fast food centers at free of cost. These thrown away shells contain a little amount of albumin adhered with the shell and valuable calcium required for development of bone in fish. Trials are also required to test the efficiency of this low cost fish feed against market available costly fish feed. The possible association of some N fixing bacteria with vermicompost provides necessary protein for carnivorous as well as bottom grazing fish. However, changing the substrate composition various types of vermicompost can be produced, which may be useful as direct application feed for different fish.

Earthworm management in vermicomposting

Sustainable aquaculture is one in which the goal is permanence, achieved through the utilization of renewable resources. This leads to development of concept of organic natural farming. Among various components of organic/natural farming, vermicomposting is a key component for making compost through earthworms. The first systematic study on earthworms reported in the literature is by Charles Darwin (1881). After that several workers have done (Senapati and Dash 1982; Gupta *et al.* 2007; Khwairakpam and Bhargava 2007; Chakrabarty 2009; Joshi and Aga 2009) a major contribution in this field. According to their work there is wide diversity in their biology, behavior pattern, food habits, environmental requirements, etc. Unless the underlying science of earthworms is understood, the efficient application of vermin-technology will remain a difficult task.

Hence, vermiculture the century old practice is now being revived worldwide for waste management, sustainable organic agriculture and aquaculture (Sinha *et al.* 2002; Chakrabarty *et al.* 2007a; Chakrabarty 2009). However, earthworms have high tendency to bioaccumulate toxic organic residues (like pesticides, herbicides and antibiotics) and heavy metals like cadmium, nickel, lead and zinc into their tissue (Ramu 2001). These toxicants can biomagnify their effects through use of vermicompost. To avoid the bioaccumulation hazard proper substrate should be used in vermiculture. Vermicompost of varying quality for satisfying required need may be produced using variable substrate.

The three species of earthworms, which have been studied intensively by various researchers worldwide vermicomposting, are *Perionyx excavatus*, *Eudrilus eugeniae* and *Eisenia foetida* compared to the other two species *E. foetida* has a more rapid rate of growth and reproduction (Chakrabarty *et al.* 2009c), a wider range of temperature tolerance (0 to 40) is found in the man made environment and plays a remarkable role in the decomposition of compost and dump. Although *E. eugeniae* is mostly used by vermiculturists for vermiculture, several species of earthworms are being used in vermiculture and sometimes 2-3 different species of earthworms are simultaneously used for better results. Many factories e.g. paper wool and food industries in Japan reportedly utilize this lumbricid worm as a decomposer of organic waste (Deolaiikar 1997). Feasibility studies should be made on consortium of earthworms for effective and uniform vermicomposting in different season throughout the year as well as for optimum utilization of resource.

CONCLUSIONS

In organic aquaculture Systems, vermicomposting provides the use of a holistic farming system, which is an autonomous organic agro-ecosystem, based on partnership with nature (Gupta *et al.* 2007). For improving environment huge quantities of domestic agricultural and rural industrial wastes can be recycled through process, which is an urgent need of the day. At global level the concept of food quality has changed during the recent years. There is an increased awareness for accepting organically produced food among all section of people. USA is one of the most prospective markets for organic products followed by Germany, Japan, France, Italy and Britain. World wide, there is an escalating awareness about sustainable agricultural and aqua cultural practices in view of energy shortage, food safety and environmental concerns, arising out of chemical farming.

Naturally, the organically produced fish will have high demand among all section of consumers. There are several ways for the marketing of organically produced food as it claims a high demand among people. Much emphasis has been laid on intensive agriculture and sustainable practices because of indiscriminate use of chemical fertilizers and pesticides have led to the deterioration of soil health, contamination of air, water and food. But much emphasis has not been laid on intensive aquaculture and sustainable practices. It is an alarming issue at global level. Therefore, attention has to be given to organically managed system of aquaculture for achievement of harmful chemicals-free and safe food for human consumption.

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