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RESEARCH ARTICLE

FUNGI IN AQUAPONICS.

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Abstract

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Microorganisms are present ubiquitously, that play an important role in all the stages of aquaponic production. They may be pathogens, growth promoters or biocontrol agents with specific tasks on nitrification and mineralization of solid wastes. The effects of microbes in aquaponics need to be evaluated to optimize systems performance. The present work was carried out to understand aquaponics, with special reference to aquatic microfungi and find out the principles as beneficial micro-organisms, regarding plant growth and to test fungal infections in aquaponic environments. Experiments were conducted during the period from November 2015 to December 2016 from three different water sources with five various sites. Aquatic fungi were identified from the biofilm and water of aquaponic systems. The most common among them were Aspergillus sp, candida sp, Penicillium sp. ,Fusarium sp., and Trichoderma. No fish death was recorded and none of them were infected with fungal diseases.

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Introduction:-

Aquaponics is an intensive sustainable food production system that combines aquaculture and hydroponics in which fish and plants grow together symbiotically. In an aquaponic unit, the effluent rich in plant nutrients derived from nitrogenous waste excreted from fish, fish feed and decomposing organic matter, fertilizes hydroponic beds providing essential nutrients for plant growth. Rakocy et al.2006. It is a polyculture which increases diversity and enhances stability of the system. With the drastically reduced water and nutrients compared with soil grown crops, no chemicals, reduced growing area no problem of weeds or digging, yield organic vegetable products all year round adds up advantages of aquaponics (McMurtry et al,1997).

Fungi play a vital role in degradation of complex organic matter and recycling of nutrients.(Paliwal and Sati, 2009)The natural process of decomposition is accelerated by Aspergillus, Penicillium, Trichoderma that are cellulolytic fungi. Though watermolds are primarily saprophytic in nature, they have ability to colonize a variety of substances, forming parasitic association with living hosts, that influence on biological productivity (Sati 1997).

Aquatic microfungi in biofilms: A model for filamentous fungi was proposed by Harding et.al.,2009 with various stages of propagule adsorption, active attachment, microcolony formation, maturation and dispersion. Generally aquaticfungi have more than one planktonic form of sexual and asexual spores, sporangia, and hyphal fragments, in dispersive forms that float in water and in air to form specialised reproductive tissues. Recent study suggest that

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majority of the planktonic microorganisms live together as biofilms (Costerton et al.,1987) were advanced studies are focused on filamentous fungi in Water distribution systems (WDS) (Goncalves et al., 2006; Sammon et al., 2011). Studies report that fungal spore hydrophobicity influences their nature to adhere to biological surfaces, which depends upon culture conditions in biofilm formation Singh et,al., 2004.

Structure of microfungi: Aquatic fungi are mainly concerned with the utilization and degradation of animal and plant remains (Johnson, 1956). The microscopic structure of fungi depicts branching filament called hyphae, divided into cells by crosswalls referred to as septa .The inter oven hyphae is called as mycelium which produce tiny spores that are hydrophobic, act as a barrier to the entry of toxicants. Microfungi exhibit tube tip-growth with cell walls composed of chitin. The absence of a large, multicellular fruiting body is the distinguished feature of microfungi. The members of Chytridiomycetes and Oomycetes are mostly aquatic and commonly known as watermolds (Cummins et al, 1966). Structural characteristics of Candida sp. and Aspergillus sp. of biofilms are reported by (Villena et al., 2010).

Nutrition: Fungi grows best in dark, moist habitats, secrete hydrolytic enzymes securing their nutrients from dead organic material, as a source of carbon and energy to maintain growth and reproduction. More hydrophobic spores are produced in rich nutrient media than that with low nutrient content Holder et.al., 2007. Characterisation of biofilm matrix provide information during adverse conditions like low nutrient levels and microbial interactions.

Biofertilizers are carrier based ready to use live bacterial or fungal formulations, that help in mobilization of various nutrients. Aspergillus, Penicillium, Fusarium, Trichoderma, Mucor and Candida are efficient Phosphorus solubilizer which enhances nodulation, nitrogen fixation, crop growth and yield hence can be categorized as beneficial microorganisms. Biofertilizers are eco friendly, low cost, renewable sources of plant nutrients that ensure a healthy future and long term soil fertility and sustainability (Mishra.et al. 2015) for practicing organic farming (Bisen et al. 2015). Burton and Knight, 2005 reported the importance of Penicillium oxalicum, P. rubrum and research was conducted on Fusarium moniliforme (Manoharachary et al., 2005).

Fish health: Fresh water fishes are an important source of protein globally which are in severe decline due to population explosion(Limburg et al., 2011). Fungal infections in fresh water alarm great threat for production of aquaculture due to immune suppression and prevent hatching of fish eggs. Study has been aimed to isolate, identify the fungi that are present in the biofilm and water samples of aquaponic system to test for fungal infection.

Materials and methods:-

A study was conducted at indoor Coonoor, Nilgiris, Tamilnadu, India. The system was started with fishes and plants (from November 2015- December 2016 from three different water bodies with five various sites).Fish carp- Cyprinus carpio L. juveniles (15 no.) weighing an average of 10.0 g each, with 9cm in length were acclimated and transferred to a 40 L polystyrene tank. Standard feed of 2% of its body weight was fed twice daily. An aerator was installed with cut holes in the sheet to accommodate small plastics pots. The bottom and sides of the pots were perforated for easy movement of the plant roots into the nutrient water. Five plant pots are inserted into the holes of the styrofoam sheets. Three weeks old plant samplings were planted in the pots on the styrofoam raft with small size gravel, which acts as the media for the hydroponics component.

System components:-

Aquaponic unit is a rectangular water tank (**Fig-1**) (size-45cm breadthx33cm length x27cm height) with volume of 40L, aquarium air pump 220-240 voltage with power of 5 watts,output-6 litre/minute, frequency-100 Hz and (hydroponics part) for growing plants. Floating or raft hydroponic sub system is ideal for the cultivation of leafy and other types of vegetables (Rakocy et al.1989b)

Fig-1 Aquaponic system

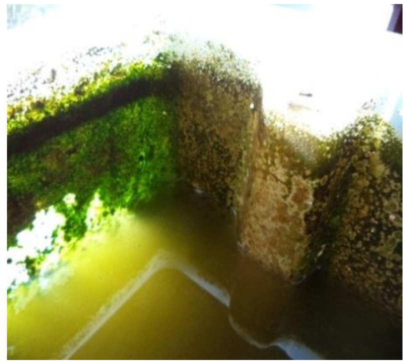


Fig-2 Biofilm

The water samples along with biofilm (**Fig-2**) were collected from the aquaponic tanks and transported immediately to plant pathology and microbiology lab, Department of Botany, Government arts college, Udhagamandalam, Tamilnadu - India for mycological studies. Culture of fungi was carried out from samples of five different experimental systems on PDA culture media supplemented with suitable antibiotics and incubated at 32c for seven days. The isolates were purified by single hypha culture method were identification and characterization, was observed on the rate of growth, texture, color and form of the colony (Brooks et al., 2001) by comparing with various authentic manuals of fungi (Cooney and Emerson 1964; Bilgrami et al; 1991) and standard monographs (Scott, 1961 and Dick, 1990). The frequency of fungal species was calculated as follows : -

$$\text{\% of frequency of species} = \frac{\text{Average number of total colonies of species in one plate}}{\text{Average number of total colonies of all the species in one plate}} \times 100$$

Result:-

In the present study, A total of 8 fungal species were isolated like Candida albicans,C. parapsilosis Aspergillus flavus, A. niger, Rhizopus, Fusarium sp, Trichoderma and Penicillium sp have been isolated of which Candida sp and Aspergillus sp. were found to be commonly occuring (**Fig(3)A and B)** Some species like Rhizopus, Fusarium sp, Trichoderma and Penicillium were obtained in low frequency(**Fig(3)C-H**). The present study revealed that there was no fish death and none of them was infected with fungal disease**.(Fig.4 a and b).**

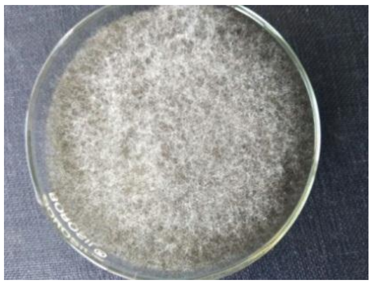
Fig-3:- Culture plates

A.culture plate of Candida albicans

B.culture plate of C. parapsilosis

C.culture plate of Aspergillus flavus

D.culture plate of A. niger



E.culture plate of Rhizopus

F. culture plate of Fusarium

G. culture plate of Trichoderma

H. culture plate of Penicillium

Fig-4a,b:- Fish Details

(a) Fish at initial stage of experiment

(b) Fish during harvest

Recently *Penicillium* sp have received significant attention in the production of bioactive compounds, including mycotoxins, antibiotics, herbicides, antioxidants, insecticides, as well as extracellular enzymes and yield of crops (Frisvad and Samson 2004). *Trichoderma* produce chelating metabolites and use redox activity for solubilizing the minerals like MnO_2, metallic zinc that act as biocontrol agent and increase in the microelement content of Cu, P, Fe, Zn, Mn and Na of plants was also observed. *Trichoderma harzianum* was capable of lysing mycelia of *Sclerotium rolfsii* and *Rhizoctonia solani* (Elad et al., 1980). Research on fungal diseases has been conducted on several species like *Penecillium sp., Alternaria sp., Fusarium sp.,* and *Aspergillus* sp. (Firoz et al., 2011) in specific regions with high organic pollutants, to study the parasitic activity.

Aquatic environment deals with minimal loss of water, lower temperature and solar radiation, accessibility of space and availability of soluble organic and inorganic nutrients (Sigee 2005) were low oxygen concentrations are a prerequisite for denitrification by aquatic fungi .In this present work, the two isolates of Aspergillus sp. and Trichoderma isolated from the biofilm of aquaponic systems showed a better capacity in terms of higher biomass than that of other fungi like Fusarium. Hyphal fragments which act as dispersal propagules were observed along with spores. Thus it is evident that formation of biofilm varied for each fungus under different culture conditions and hydrophobicity within a biofilm . Similar work was reported by (Siqueira and Lima 2012). with biofilms of Penicillium spp.

Interactions between bacteria and fungi:-

In aquaponics bacterial colonization of a fungal surface enable the bacteria to exploit the fungus as a source of nutrients (Hogan and Kolter, 2002). More over in the biofilm of aquatic communities there will be competition for nutrients between bacteria and fungi, that enhance bacterial antagonism of fungi by scavenging bacterially derived antifungal compounds thus these factors illustrates that biofilm formation on fungi leads to breakdown of complex substrates.

Conclusion:-

Increasing environmental concerns and growing demand for safer and sustainable food production leads to significant challenges in agricultural production. Recycling nutrients from organic sources and modifying farming practices towards sustainable agriculture have gained attention in recent years were the use of beneficial microbes in crop production systems is one kind of potential technique, which could help improve crop productivity without adverse impact on the environment. No fish death and fungal infection was recorded. Many economically important fungal species were present in the system. This work will be helpful to identify causal agents of fish and plant diseases and to select control methods compatible with aquaponics. Future research is needed to develop safe, reliable and cheap fungal products, which have significant effect in field applications that can be produced on the large scale.

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