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COLLABORATIVE PROJECT DEVELOPMENT ON

AQUAPHONICS IN CHITWAN: INTEGRATION OF BIOFLOC WITH HYDROPONICS

IN ASSOCIATION WITH

INTEGRATED AGRICULTURE AND FORESTRY RESEARCH CENETR PVT. LTD.

INTRODUCTION

Integration of biofloc with Hydroponics is the concept of maximum utilization of available resources such that both aquaculture and Hydroponics is promoted simultaneously. With the ongoing trend of urbanization and population increment it has become difficult to maintain proper food security and meet the nutritional demands of human being. Biofloc integration with Hydroponics can be the best alternative to face this challenge.

Biofloc technology follows the concept of conversion of ammonium in addition to organic nitrogenous wastes into bacterial biomass when carbon: nitrogen ratio is balanced in the solution(Neupane et al 2020).Heterotrophic bacterial growth is stimulated and nitrogen uptake through the production of microbial proteins is promoted by addition of carbohydrates to the pond (Avnimelech,1999).As a result of bacterial growth, a decrease in ammonium concentration is more rapid than nitrification because the growth rate and microbial biomass yield per unit substrate of heterotroph are factor 10 higher than nitrifying bacteria(Hargreaves,2006).Carbon sources such as molasses, wheat bran and cellulose are responsible for bacterial growth and maintaining the C:N ratio in the culture system. Biofloc not only maintain water quality but also provide essential and higher quality nutrition to shrimps and fishes in achieving fast growth, lesser FCR and possibility to prevent diseases (Suneetha et al. 2018). Almost all plant can grow hydroponically but it is not a good idea. Crops like lettuce, Spinach, Strawberry and many other herbaceous vegetable can be grown successfully.

Aquaponics is the integration of hydroponics plant production into recirculating fish aquaculture system (fish tank, biofilter, hydroponic system),during which the excretes of the fish become fertilizers for the plants and the nitrifying bacteria in the biofilter convert nitrogen from ammonia to nitrate, which the plants absorb(Graber&Junge,2009).Fishes that can be grown in biofloc are tilapia, catfish, carp, bass, trout and salmon. With the addition of supplement fertilizers crops can be grown successfully in this integrated system.

NEED OF THE TECHNOLOGY

High feed costs, limited water and land availability are key issues addressed in aquaculture. Only feed accounts for 60% of overall production costs.(*Practices of Fish Farming in Biofloc Culture*,

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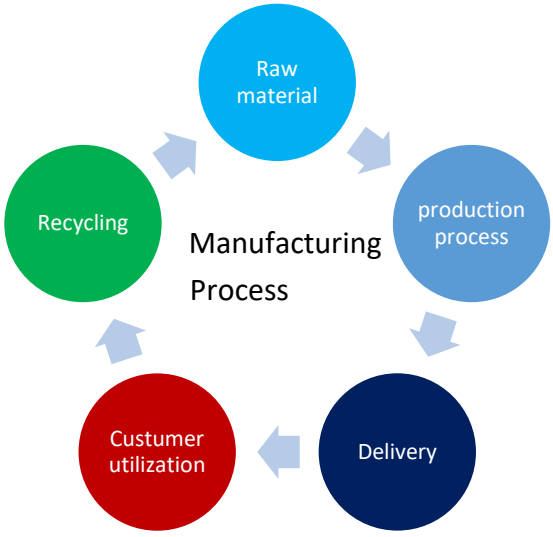
n.d.) This has prompted the next generation to look for a different solution. Biofloc technology, which originated in Indonesia, is becoming increasingly popular. This method is both cost-effective and ideal for areas where water is scarce. Biofloc is a mixture of bacteria, algae, fungi, and other microorganisms, as well as some suspended particles held together by mucus. It's fed to the fish. The technology is also environmentally friendly and increases the efficiency of land use. One of the most serious issues with biofloc technology is the formation of excessive ammonia gas, which is harmful to fish and can lead to death in severe cases. As a result, we must change the water in the tank on a regular basis, resulting in the loss of biofloc prepared. The idea is to create a technique that combines the benefits of biofloc and hydroponics while removing the drawbacks of biofloc technology. This method not only solves the problem of ammonia gas accumulation, but it also allows plants to use the additional nitrogen. People are becoming increasingly worried about their health, and this integrated technology produces only organic products, therefore there is the potential for a large market in the future. Furthermore, more profit might be made with less land, and every drop of waste water may be well utilized. Food could be cultivated all year, there would be less weeding, and plant growth would be expedited with hydroponics. People who live in developed cities could experiment with this technology in their own homes because it does not necessitate more land. The number of people living in metropolitan areas is growing every day, and in this situation, growing food by this method would be the greatest option.

MANUFACTURING PROCESS AND PRODUCT CHARACTERISTICS

Manufacturing Process:

The manufacturing process technologies include equipment, people and system that are used to produce a firm's product or services. The sequence of activities to achieve the desired activities is called manufacturing process. In the manufacturing process, the input factor like labour, capital, raw material is converted into output. Process selection is a key issue at the time of adoption of new ideas. Out of the five-manufacturing process integration of bio-floc and hydroponics is the continuous flow technology and the process is shown in the following chart:



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1.Raw materials: Various raw material like feed, aerator, mineral, nutrient, oxygen, water, bio-filter, raft, tank, pipe , micro-organisms ,seed etc which are used to produce fish and fresh vegetable with the minimum area of land.

2.Production Process: Integration of bio-floc and hydroponics is based on the principle of water and nutrient re-cycle. By the interaction of the micro-organisms and ammonia gas, protein is formed in the bio-floc tank and this protein is consumed by fish and survive. Extra nutrients and minerals are supplied directly if needed. At first, water gets collected in the flood tank. Then with the help of motor, water is supplied to the raft tank fitted in hydroponics system where the green leafy vegetables are grown. And bacteria present in this raft tank aids in nitrification process. By the help of Bio-filter and motor, the pure water is again recycle and passed in the fish tank. And, hence the cycle is running again and again.

3.Delivery: For the efficient marketing channel, Farm act as Wholesaler and supply directly to the consumer. Various type of products variety like Live fish, dried fish, fry fish as soon as possible.

4.Customer Utilization: the choice of consumer is region specific Eg. In European country Frozen fish is more demanded, in Nepal live fish is more demanded, also consumer facilitated with the leafy vegetables.

5.Recycling: Recycling of by-product is managed in different regions by various ways. In Nepal, by-product is mainly utilized by pig and also as ingredient of fish meal.

Product characteristics

This technology is aimed for the general public who have been eating products laced with high levels of pesticides for a long time. This technology would result in a pesticide-free, 100% organic product. Due to COVID, the public's concern for their health is growing, and in this situation, this would be the wisest alternative. There is a belief that using advanced technology in farming will raise the final price of the product, forcing the consumer to pay a hefty price. Consumers would not require to pay any additional price to that of they are already paying. We are already active in the production of different biopesticides and other technologies that aid in the production of organic and environmentally friendly products. This assists us in satisfying consumer expectations. As a result of this technology the products can consume all around the year, where it is not possible in conventional farming technique.

And the overall design of the integration of bio-floc and hydroponics :

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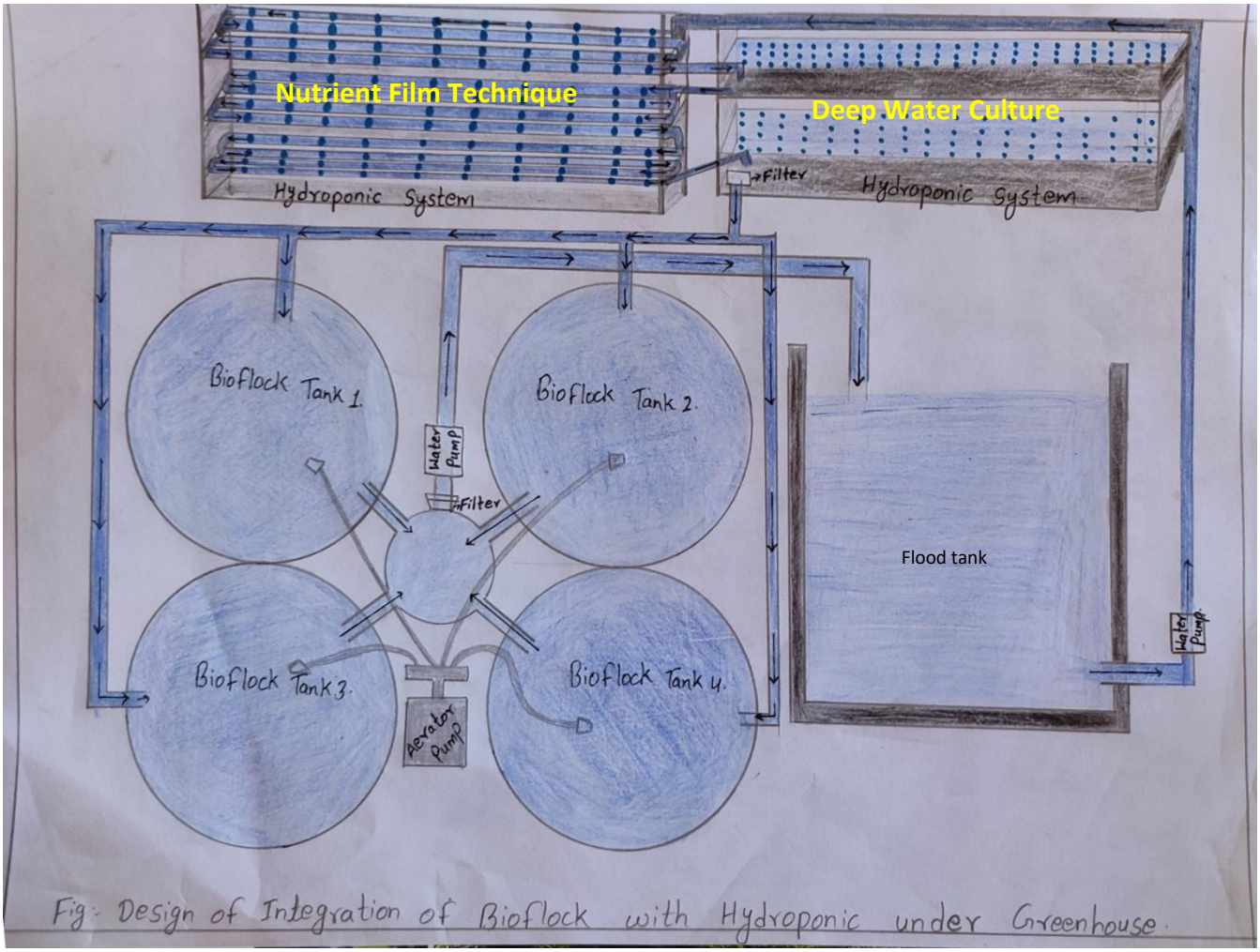

Figure 1: Design of biofloc technology development

COST RETURN AND PROFIT ESTIMATE

Aquaponic system require set up of two system i.e. Aquaculture System for aquatic rearing and Hydroponics for Crops cultivating. Hence the cost of Aquaponic system requires integrating cost of two different system setup i.e. Aquaculture system and Hydroponic system. In this study Biofloc fish farming (types of aquaculture) and Nutrient film technique & Deep water culture (Types of Hydroponic). The purpose of this study is to integrate Biofloc fish farming, Nutrient Film Technique and Deep water culture; To increase the efficiency of resources used by reutilizing output, minimizing cost and maximizing return in Aquaponic system. Biofloc culture is a leading-edge and cost-efficient technology within which waste material of fish materials like Nitrate, Nitrite, Ammonia may be born-again into a helpful product, ie., super molecule feed. Biofloc system requires following costs-

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Table. Cost, return and profit estimates of the biofloc technology development

S.N	Required materials	Quantity	Rate	Total (NRs)
1	Biobloc tank	4	*2200*	*8800*
2	Aerator pump with silicon stone	*4*	*7000*	28000
3	Test kit box	2	1400	2800
4	Water pump	*1*	*5000*	*5000*
5	Probiotics	4	1400	5600
6	Feeds	1000	45	45000
7	Fisg fingerlings	*3400*	*7*	*23800*
8	Bioball as bio filter	2	400	800
	Total			119800

Other Cost includes following-

S. N	Required Materials	Quantity	Rate	Total	Remarks
1	Nutrient Film Technique apparatus with Water pump, Supporting media, bucket , Net pot, Stand	*1*	*65000*	*65000*	
2	Deep water culture apparatus	*1*	*10000*	*10000*	*Double layred*
3	Nitrosomonas and Nitrobactor	*2*	*1000*	*2000*	
4	Floating raft	*5*	*1000*	*5000*	*For 10m2*
5	Seeds of Spinach	*1*	*20*	*20*	
6	seedlings of strawberry	*108*	*60*	*6480*	
7	Additional Organic fertilizers	*1*	*1000*	*1000*	
	Total			89500	

- Electricity and Cable- 6000
- Lab, feed room, instant room, Medicine room rent-6000
- Pipe connecting Biofloc tanks to Bucket(From where Water is supplied to Hydroponic system)-2000
- Green house Structure-40000
- Cemented floor and iron rod structure for Bioflock tank and other expences-70000
- Assumed Total Starting Cost- NRs.333300

Operating Cost from Beginning to First Harvest of Fish (upto six month)

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Statements	Cost (Nrs)	Remarks
Electricity charged by Aerator	4800	
Electricity charged by water pump	10000	
Test kit box	2800	
Fish fingerlings	23800	
Fish Feed		
Nitrosomonas and Nitrobacter	2000	
Seedlings of Strawberry	6480	
Seeds of Spinach	200	4 times in 6 months
Additional Organic Ferlilizers	1000	
Labour Charge	10000	
Total operating Cost	61080	

Production from Given Set up in 6 month
Assumed,

production of fish from a biofloc tank-850kg
production of fish from 4 biofloc tank- 850*4=3400
Production of spinach grown in Deep water culture from one lot- 30kg
Production of Spinach grown in Deep water culture from 4 lot- 120kg
Production of Strawberry in Nutrient Film technique in 6 month- 33kg

Assumed Income in Six month from given setup of Four Biofloc tanks, an NFT system with 108 holes and Deep water culture system of area 10 m^2

Income from Fish- 3400*160=Rs.544000
Income from Spinach- 120*50=Rs.6000
Income from Strawberry- 33*700=Rs.23100

Total Income from given setup in 6 months- Rs.573100

Profit= Total Income-Total cost=573100-333300= NRs.239800

TEST OF AQUAPONICS TECHNOLOGY

Aquaponics is the medium through which all essential nutrients are transported to the plants and it is where the fish live.

API freshwater Master Test Kit is highly recommended for all aquaponics systems. It includes all test for all aquaponic system. It inculdes all test required to test the nitrogen cycle . This kit tests water for different parameters that affect the health of freshwater fish i.e. measures pH, ammonia, nitrite and nitrate.

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- PH Level:-

  The pH level in aquaponics is a measure of the acidity and alkalinity of the water. It is important to check pH because aquaponic fish, plants and bacteria prefer a particular pH. Fish and bacteria prefer a pH between 6 and 8, plants however will absorb more nutrients if the pH is between 5.5 and 6.5. It is generally accepted the best pH for an aquaponic system is between 6 and 7, with 6.5 being the ideal. It is important to check the pH every week as the system matures, after such time a pH trend can be seen and testing can be done once a month. The API pH Test measures from 6 to 7.6, if the pH measures 7.6, the high range pH test can be used to measure between 7.4 and 8.8 to accurately determine the pH. If we are getting readings below 6.0, a hydroponic test kit, such as the Hygen pH, will measure down to 4.0.

- Ammonia Levels

  In aquaponics, the fish release ammonia into the water from their gills, urine and excrement. Ammonia damages gill membranes and prevents respiration. It also reduces their immune system, thereby increasing the chance of disease. It is recommended to test ammonia in the early stages, usually every few days for the first month, as the system matures ammonia should only need to be tested if the fish lose their appetite or acting unusual. The API Ammonia Test measures from 0.25 to 8.0ppm of ammonia, this test also measures ammonium, a less toxic form of ammonia.

- Nitrite Levels

  Beneficial bacteria in the filter and grow bed convert nitrite into nitrate. Nitrite reduces the blood's ability to carry oxygen. It also reduces the immune system of a fish, thereby increasing the chance of disease. It is recommended to test nitrite in the early stages, usually every few days for the first month but as the system matures nitrite should only need to be tested if the aquaponic fish lose their appetite or are acting unusual. The API Nitrite Test measures from 0.25 to 5.0ppm of nitrite.

- Nitrate Levels

  The beneficial bacteria in the filter and/or grow bed convert nitrite into nitrate. Nitrate is far less toxic to aquaponic fish than ammonia and nitrite. However at a high level it can reduce their immune system, thereby increasing the chance of disease. It is recommended to test nitrate each week in the early stages, then each month as the system matures. The API Nitrate Test measures from 5 to 160ppm of nitrate.

  General Hardness (GH) and Carbonate Hardness (KH)

  Calcium and magnesium make up general hardness, both these minerals are essential for the health of fish, plants and bacteria. Carbonates of different minerals, including calcium, magnesium and potassium, make up carbonate hardness. Rain water is pure and does not contain minerals. Adding Potassium bicarbonate to rainwater will raise GH and KH to a level which is suitable for Aquaponics.

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The level of GH and KH in tap water varies, depending on its water source. Different water has different GH and KH levels, the API GH & KH Test can determine the GH and KH of both our aquaponic water as well as our water source. The ideal GH and KH level in an aquaponic system is 4 degrees (using an AP GH test kit). If the GH or KH is higher than 8 degrees, half of the aquaponic water can be replaced with rainwater to reduce GH and KH levels half.

Potassium Levels

Water in an aquaponics system is often low in potassium; plants show this deficiency with dying leaf edges and holes in older leaves. This deficiency is due to aquaponic fish food not containing a surplus of potassium to supply enough nutrients for both fish and plants. Potassium is important because it is involved in the respiration and carbohydrate system, which if functioning properly supports a healthy plant. Potassium can be added to an aquaponic system in either organic or inorganic form. Foods such as spinach, chard, kale and soybeans are rich in potassium and can be added to home-made aquaponic fish food to introduce organically-encapsulated potassium into the system. Alternately, Potassium bicarbonate, or Potassium Hydroxide (Hy-gen pH Up) can be added.

Potassium Bicarbonate is a food grade supplement used in horticulture, which will also prevent the pH from falling too low. Use 1 teaspoon of potassium bicarbonate per 100 litres to raise potassium by 10ppm, when required. As each aquaponic system varies, the amount of potassium to add will vary according to the plants that are growing.

Potassium hydroxide is a hydroponics pH raiser that adds potassium to our system but does not add carbonates. It should be used with care, as this product is caustic and highly concentrated.

- Iron Levels

This is another nutrient which is often low in aquaponics. As with potassium, the reason for this is due to fish food not containing enough iron for both fish and plants. Plants show iron deficiency by growing yellow leaves with green veins. Iron is a vital element for plants, it has a number of important functions in the overall metabolism of the plant and is essential for the synthesis of chlorophyll. Also like potassium, iron can be supplemented organically and inorganically. Liver, soybeans, lentils, spinach, chard and kale are rich in iron and can be added to home-made fish food. Growth Technology Chelated Iron supplements iron in an inorganic form, it is a food-grade nutrient for hydroponics but can also be used for aquaponics at a reduced dose. Use 5ml of Liquid Iron per 100 litres to raise iron by 0.5ppm, test and dose as required.

SOCIAL, ENVIRONMENTAL AND ECOLOGICAL ASPECT OF THE TECHNOLOGY

Integration of bio-floc with hydroponic improves water quality conditions of fish and plant nutrients use efficiency of hydroponic system and it includes social, environmental, technological and legal aspects. On the one hand, this integration provides an opportunity to earn more profit by integrating two different techniques in one system. On the other hand, it

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provides an opportunity to the people of urban areas having small space in their backyard or roof to set up this model in small scale and can earn money all year round. It also provides them fresh fish as well as vegetables. Moreover, this integration involves the use and set up of various technologies. The wastes from bio floc is utilized for hydroponic system and the excess water from hydroponic system is filtered through different set up of bio-filter and allowed to pass to bio-floc. The ammonia produced from bio-flock is drained and passed to the hydroponic system by reducing it into nitrate by the use of different media containing nitrifying bacteria such as nitrosomonas and nitrobacter. This provides nutrient to the plant. However, in the lacking of proper drainage of ammonia into hydroponic system, it mixes into atmosphere and will cause greenhouse effect and it is considered as less sustainable. Therefore, draining of ammonia properly through proper set up is inevitable in this integration. In Nepal, different insurance companies are providing different schemes to the farmer so that they can minimize their risk. Moreover, grant is also provided by Nepalese government for the farmers to motivate them. However, Nepalese government has banned the import of liquid fertilizer, due to which there is difficulty of fertilization in the integration through solid fertilizer.

MARKETING STRATEGY OF THE PRODUCT

- A product produced using a new technology is always a topic of concern and interest among the people. So, the products i.e. vegetables and fishes can be advertised featuring its production technology to catch attention of consumers in these products and health benefits of consuming these products.

- The technology we have innovated supports organic farming. It provides ease to implement principles of organic farming, Integrated Pest Management (IPM) and Integrated Nutrient Management (INM). Remnants of fish feed and excreta acts as a nutrient source with essential nutrients supplemented as per the necessity. So, this idea follows principles of recycle and reuse. These products have great health benefits upon consumption. Flashing these benefits upon the consumers, these products can be promoted.

- Upon production, these products can be made available in super markets, departmental stores, local markets creating a network and the merits of these products can be advertised among the consumers using social medias like tv, radio, internet and newspapers.

MARKETING STRATEGY OF THE TECHNOLOGY

- We can collaborate with various stakeholders in running protype farms in various regions all over Nepal. They can also be developed as hub of agritourism with various sorts of attractive privileges for visitors.
- We innovators as representative of the university can collaborate with agro-enterprises, business houses and corporates to commence successful startup on the way to promoting this technology.

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- Also, the government of Nepal can facilitate various grants and subsidies for farmers interested to commercialize this technology.
- Collaboration with NGOs and INGOs for promotion of this technology can help in promoting it in a substantial way.
- Trainings and seminars about this technology in major agricultural areas of the country can help farmers to understand this technology, its prospects and challenges and motivate them to step out.

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