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COWPEA : AN IMPORTANT CROP IN ACHIEVING FOOD SECURITY IN NIGERIA AND OTHER DEVELOPING COUNTRIES

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Summary
The multipurpose use and economic contribution of cowpea to mankind has long been known and it is considered the most economically significant indigenous African legume. Recent global development calls for nations to focus on crops in which they have competitive natural advantages. Beyond providing food, cash and animal feed for rural dwellers in addition to benefits to farms by means of ground cover and in situ decay of root residues, the development of cowpea value chain has the potential to make germane contributions to the attainment of food security.

Introduction
Grains are perhaps the most important family of agricultural crop species in the world. The genus Vigna, extensively found in the tropical and subtropical areas, possesses considerable morphological and ecological diversity (Singh, 2014) and consists of not less than one hundred different species. Cowpea, *Vigna unguiculata* (L.) Walp. is an annual versatile warmth-loving herbaceous legume indigenous to Africa where it is cultivated under an extensive range of soil and climate conditions. All cowpea varieties being currently cultivated in the world originated from East and West Africa (Xiong et al, 2016). They, however, vary in the appearance of their grain including the seed size, colour of the seed coat and eye colour. Most cowpea grown in Sub-Saharan Africa is intensively intercropped with maize, sorghum and intermittently with other crops such as pearl millet, cassava and cotton. Its high tolerance to drought means that, under very hot and dry conditions, many cowpea lines can survive for more than 40 days (Cui, 2019). The cowpea grain is the most significant part of the crop as it is a major source of affordable protein; it contains 22–23 % protein, 50%-60% starch and 63.6% carbohydrate and a appreciable quantity of niacin (vitamin B3), riboflavin (vitamin B2) and thiamine (vitamin B1)) and is richer in calcium and iron content than most cereals (Ngalamu, Odra and Tongun, 2015). Similarly, it is frequently regarded as the meat of the poor man because of the high protein content (Abdullahi, Usman, Girei & Isma'il, 2016); an approximated 38 million households (194 million people) in Sub-Saharan Africa rely on the crop as a major dietary protein source nutritionally complementing tuber crop staples and low-protein cereal (Carneiro da Silva et al., 2018). However, a small fraction are grown for fresh pods in eastern Asia or green leafy vegetables and fodder in Africa in view of the fact that the leaves represent a good source of ascorbic acid (vitamin C) and β-carotene (Okonya and Maass, 2014). Also, it plays a principally useful function as an important source of forage for livestock in many parts of Nigeria.

Cowpea Production in Nigeria
An enormous bulk of the world's cowpea production takes place in sub-Saharan Africa, with an estimated 14.5 million hectares of land cultivated and a total annual production of 6.2 million

metric tons (Kebede and Bekeko, 2020). Nigeria is the leading producer and consumer of cowpea accounting for 48% of production in Africa and 46% globally (IITA, 2017) while overall amounts imported into the country are insignificant. Niger, Northern Brazil, Peru, southwest North America and parts of India are other areas with significant amount of cowpea production. In Nigeria, cowpea is consumed nationwide (Awosanmi, Ajayi & Baffoe, 2020) and the major producing states include Niger, Nassarawa, Borno, Bauchi, Benue, Kano, Kaduna, Katsina, Kebbi, Sokoto, Zamfara, Plateau, Yobe, Kwara and Jigawa.

Economic Importance of Cowpea

In Africa, an estimated 239 million people suffer from protein calorie undernourishment (Fanzo, 2012) and food security remains a major challenge. This malnutrition can be combated by the consumption of dairy products and meat but these foods are not affordable to smallholder households in rural Africa. The nutritional composition of cowpea therefore holds high potential for the achievement of food and nutritional security as it can be used to make an assortment of foods and snacks which are consumed in different forms (mashed, fried, boiled, sauce and paste). In Nigeria, food security and poverty is a challenge resulting from an array of problems where the cultivation of 32 of the 79 million arable land is rain-fed. It is greatly impacted by food prices and availability as most residents of Sub-Saharan Africa are employed in agriculture and allied activities with a major chunk of household expenditure being taken up by food. Cowpea, as a key crop for improving livelihoods and sustaining food security is rich in minerals and phytonutrients and is thus suitable for providing healthy diet while solving problems of malnutrition among resource-poor households in Sub-Saharan Africa (Okonya and Maass, 2014). The crop represents the cheapest source of proteins for majority of the rural folk and is essential in diets for the high protein content supplying protein to both rural and urban households as a replacement for animal protein (Wakili, 2013).

What's more, a number of varieties have a short growth cycle and mature early and accordingly supply food during the “hungry period” that is, the phase at the closing stages of the wet season when feeding can become exceptionally difficult in smallholder households in semi-arid parts of sub-Saharan Africa. Furthermore, in some parts of West and Central Africa, cowpea fodder is remarkably prized since it can be harvested for feeding livestock. Its seeds are vital for the reason that the production of cowpea is entirely reliant on seed as propagation matter (Buleti, Mamati & Abukutsa-Onyango, 2019). In all, the adaptability of cowpea to diverse types of soil and climatic conditions including its resistance to drought and suitability for different intercropping combinations, its ability to complement nutritional value of cereals, its fixing of nitrogen to improve soil fertility particularly among resource poor farmers who apply little or no fertilizer and prevention of erosion through provision of land cover makes it a crop of great economic consequence in many developing countries.

Policy Recommendation

Given Nigeria’s competitive production advantage and the numerous benefits derived from the crop, the development of cowpea value chain from production to storage is imperative. The production and storage of cowpea, besides the pros highlighted above, would serve multiple purposes including helping to stabilize prices, preserving quality for future use, maintenance of regular supply throughout the year as well as being a profitable commercial venture. Storage of cowpea carried out during glut would help value chain actors obtain higher prices later in the year

since many producers sell at low prices during the harvest period rather than risk loss in storage. Efficient and effective short, medium or long term cowpea production and storage systems and structures, both on field and in store, therefore becomes a necessity because the production and consumption of cowpea does not always occur concurrently.

Conclusion

Cowpea is extensively consumed in Nigeria and many other developing countries, with its first-rate nutritional characteristics and numerous economic, ecological and agronomic benefits. Its manifold contributions and use as well as its preservation of the environment make it crucial to the attainment of food security in many respects.

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THE UNSEEN JWELLS: ENUMERATINGSOIL MICRO-ORGANISMS AS A PARAMETER FORENHANCING SOIL HEALTH AND IMPROVING SOIL BIODYNAMICS

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Abstract
Multi-nutrient deficiency in soil has been documented more frequently over the past 20 years on a global scale, and it is thought to be a significant factor affecting yield and the quality of produced goods. Microbes have an impact on the cycling and transformation of nutrients in soil, and enzyme activity can both regulate the availability of organic and inorganic nutrients to plants and microbes.Due to their significance, a significant amount of historical and modern research has been done to try to understand the ecology of soil microbial communities. Thousands of publications are produced each year in this area of study. To quantify the variety, quantity, and activity of soil microorganisms, several techniques have been devised. This article details an effective strategy for investigating the interplay between environmental conditions and the composition of soil, rhizosphere, and root endospheric microbial communities by combining field, lab, and analytical methods.

Keywords : Microbes, enzyme activity, rhizosphere

Introduction

Soil, a component of land, is the single most important factor in crop production and is also the most impacted by agricultural practices. Because crops are routinely grown in succession without much thought given to the soil's nutrient needs, soil fertility has significantly declined (Ghosh et al., 2003). Soil microbes play crucial roles in decomposing organic matter, cycling carbon and nitrogen, and forming and stabilizing soil structure, all of which have a significant impact on soil processes (Garbeva et al., 2004). Soil microorganisms and their components, such as microbial community diversity, are frequently cited as sensitive indicators of biological indices for preserving soil health and quality. One of the most crucial parts of the soil's ecosystem is its microbial diversity. To a certain extent, changes in microbial populations and activities may serve as excellent indicators of change in soil health because of the discriminatory power of microbial analyses in soil health evaluation (Kennedy et al., 1995; Pankhurst et al., 1995).

Soil Microorganism and their role in soil health

Soil organisms, such as bacteria and fungus, play an active role in the breakdown of organic materials, which frees chemical nutrients and aids plant development. Bacteria are the most common form of microorganism, however the total number of organisms in soil can vary greatly depending on the type of soil and the environmental circumstances. Different soils had bacterial densities anywhere from 4×10^6 to 2×10^9 organisms per gramof dry soil (Whitman et al., 1998).

Microbial population growth and soil activity are both influenced by the relationship between plant and soil. Microbial community composition is usually influenced by the soil type, plant species, and rhizosphere localisation. These microorganisms can be enumerated and can be used as an index to differentiate healthy and marginal soils. The count of microorganisms (bacteria, fungi and actinomycetes) was carried out by using serial dilution pour plate method (Wollum, 1982).

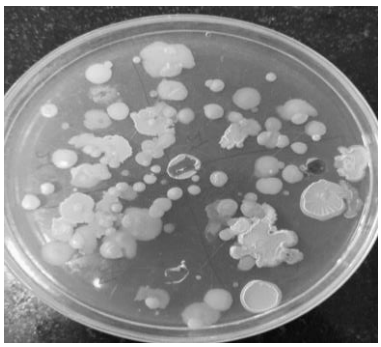
Enumerating soil biota

The process of enumerating soil biota is carried out in laboratory. The count of microorganisms (bacteria, fungi and actinomycetes) is carried out by using serial dilution pour plate method (Wollum, 1982). About ten grams of each soil sample were added to 95 mL of 0.1% (w/v) solution of sodium pyrophosphate. After homogenization for 30 min, this solution was decimally diluted (10^{-1} to 10^{-7}) depending upon the microorganism to be studied, and aliquots of the resulting solutions plated on appropriate culture media. After incubation at 25 or 30 °C, for up to 10 days, the colony forming units (CFU) are counted. Even when utilizing a variety of mediums, only a small fraction of the total, spore-forming, and Gram-negative bacteria, actinomycetes, and fungus in soil or the rhizosphere are culturable. Thus, the choice of media influences the results of the distributions and densities of groups. In addition, different incubation temperatures have been documented for the optimum development of bacteria and fungi.

Table 1: Media composition for plating of various organisms

Nutrient Agar Media (Bacteria)	Potato Dextrose Agar Media (Fungi)	Ken Knight's Agar Media (Actinomycetes)
0.5% Peptone	Potato peeled 250g	Glucose 1g
0.3% beef extract	Dextrose 20g	Monopotassium phosphate 0.1g
0.5% agar	Agar 20g	Potassium chloride 0.1g
0.5% NaCl	Distilled water 1000ml	Magnesium sulphate 0.1g
Distilled water	pH 6.5	Agar 15g
pH (7.4)		Sodium nitrate 0.1g
		Distilled water 1000ml





Enumerating soil micro-organisms in laboratory

Depth also has varied effect on the number of micro-organisms present in soil.Soil profiles are many meters deep and soil varies from place to place. The microorganism population also varies with the depth.

According to a study by James J. Hoorman and Rafiq Islam from Ohio State University, the relative number and biomass of microorganism species at 0 to 15 cm of soil depth showed the following results.

Table 2: Microorganism species at 0-15cm depth of soil.

Microorganisms	Number/g of Soil	Biomass (g/m^2)
Bacteria	10^8 - 10^9	40-500
Actinomycetes	10^7 - 10^8	40-500
Fungi	10^5 - 10^6	100-1500
Algae	10^4 - 10^5	1-50
Protozoa	10^3 - 10^4	Varies
Nematodes	10^2 - 10^3	Varies

Source :(Hoorman and Islam- Ohio State University)

Microbes in soil fertility

Agriculturally usefulmicroorganisms include N-fixing cyanobacteria, rhizobacteria, mycorrhizae are helpful bacteria that prevent plant diseases, entophytes that help plants cope with stress, and bio-degrading microbes. Under no tillage or minimum tillage conditions, the number of azotobacter, azospirillum, Rhizobium, cyanobacteria, phosphorus and potassium solubilizing microorganisms, and mycorrhizae is quite high(Bhattarai et al., 2015).Most of the enzymatic transformations in soil, including nitrification, ammonification, and others, are carried out by microorganism.While, rhizobium in symbiotic association with legume fixes between 50 and 200 kg of N_2 per hectare. When ammonia is oxidized, nitrifying bacteria of the genus Nitrosamines create nitrite ions. Nitrites may be converted to nitrates by bacteria of the genus Nitrobacter and a few other species. As obligate anaerobes, nitrogen fixers like Clostridium Pasteurian transform atmospheric nitrogen into ammonia and fix it in soil. this enhances the soil nutrient level and upgrades its productivity.

Conclusion

This article details an effective strategy for investigating the interplay between environmental conditions and the composition of soil, rhizosphere, and root endospheric microbial communities by combining field, lab, and analytical methods. Research into microbiomes, especially in agricultural settings, has a long way to go. There are still many unanswered questions about the role of the soil microbiome in influencing crop yields. These soil microbes have great potential for improving soil health, and they cooperate closely with the soil system to do so, leading to higher yields and better ecosystem preservation.

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EFFECT OF GLOBAL WARMING ON AGRICULTURAL CROP

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Abstract
The climate has a significant impact on agricultural productivity. An enormous amount of study has been conducted over the last 10 years as a result of worries about the potential effects of long-term climatic change on agriculture. This field of study looks at the physical effects of climatic change on agriculture, such as changes in crop and livestock yields, as well as the economic ramifications of anticipated changes in crop and livestock outputs. The literature that has already been written about these economic and physical implications is reviewed in this article, which then analyses it in terms of recurrent themes or findings. Particularly fascinating results relate to how humans have adapted to climate change, potential regional consequences on agricultural systems, and expected changes in food production and pricing trends. Limitations and sensitivities of these findings are examined, and important areas of ambiguity are highlighted. Finally, some speculations on subjects that may be crucial to comprehending and using data on climate change.

Keyword : Climate change, Global Warming, Agricultural productivity.

Introduction

The effects of climate change on agriculture could take many different forms. Above a certain temperature range, warming tends to reduce yields because crops mature more quickly and produce less grain as a result. Additionally, plants' ability to absorb and use rainwater is hampered by rising temperatures. Plants lose more moisture from their leaves through transpiration when temperatures rise, hastening soil evaporation. The overall effect of rising temperatures on water availability is a race between more evapotranspiration and higher precipitation because climate change is expected to lead to more rainfall. Evapotranspiration is the term for this combined effect. Usually, the competition is won by the higher evapotranspiration. Carbon emissions, one of the primary contributors to climate change, can, however, also help agriculture by increasing photosynthesis in a number of important, so-called C3 crops (such as wheat, rice, and soybeans). But scientists say it's not fully apparent what advantages carbon fertilisation has. We are aware that this occurrence does not significantly benefit C4 crops (such as sugarcane and maize), which account for around one-fourth of all crops in terms of value.

Impacts of Climate Change on the Agricultural Sector

Agricultural production is carried out by selecting crops that are compatible with the local climate and utilising efficient farming techniques. As a result, agriculture is a bio-industry that is climate-dependent and demonstrates unique regional characteristics. Ecological characteristics that are influenced by a region's climate are referred to as regional features. The agricultural environment is disrupted by climate change because it affects parameters like temperature, precipitation, and sunlight. This also has an effect on the agricultural subsectors of livestock, agriculture, and hydrology. The advantages of global warming include increased crop productivity due to the

fertilising effect caused by the increase in atmospheric carbon dioxide concentration, expansion of production areas for tropical and/or subtropical crops, expansion of two-crop farming due to the longer growing season, a reduction in damage to winter crops from cold temperatures, and a decrease in heating costs for agricultural crops grown in protected cultivation.

Crop response to climate change

Climate change affects agricultural yields differently depending on the region and crop. In a few recent research, agricultural output changes in North and South America were estimated. All estimates are produced for a select few important agricultural regions within selected nations using biophysical simulation models, particularly the CERES family of crop models. The yield and quality of food crops, which are crucial to human health, are directly impacted by climate and weather. Initial investigations into how increased levels of carbon dioxide (CO2), the average global temperature, rainfall, and nutrition affected agricultural productivity were the main focus of the research.

Adaptation and adjustment of agricultural systems to climate change

Agricultural systems adapt to the current climate, as is well known. Based on the consistent pattern of rise in world yields during the preceding 50 years (of roughly 2% per year), crop yields are anticipated to improve in the future, whether or not there is a change in climate. One of the causes of this increase is the adoption of new technology. A fundamental question is whether agriculture will respond to climate change rapidly and on its own, or if it will be slow and dependent on structural policies and programmes. The type of response is critical because analyses that do not account for adaptive responses risk either overestimating or underestimating possible positive consequences of climate change**.**

Uncertainties, costs and constraints to adaptation

Since it is impossible to predict explicit adaptation responses, no estimate of the agricultural effects of climate change can account for the full range of adaptation options that are anticipated to be available within the next century. As a result, it's likely that in some circumstances or locations, the adaption options included in the current analyses are neither technically nor financially feasible. Due to their limited access to markets for agricultural inputs or outputs as well as their poor infrastructure, developing nations generally have a lower capacity for adaptation**.**

Economic impacts of climate change on agricultural supply

The agricultural supply fluctuates as a result of variations in crop area and yields. Changes in crop yields are a function of climate change and any human mitigating actions, whereas changes in crop acreage are driven by producers' expectations of changes in relative crop prices and per-acre returns (such as increasing fertiliser or water use or adoption of new crop varieties). Food costs and accessibility are directly impacted by fluctuations in the supply of goods and the associated price adjustments. Generally speaking, when the supply of crops decreases, their price will rise. Increases in price lead to a decrease in consumption and are detrimental to consumer welfare**.**

Conclusion

The agricultural supply fluctuates as a result of variations in crop area and yields. Changes in crop yields are a function of climate change and any human mitigating actions, whereas changes in crop acreage are driven by producers' expectations of changes in relative crop prices and per-acre returns (such as increasing fertiliser or water use or adoption of new crop varieties). Food costs

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CULTIVATION OF *AZOLLA* UNDER SEMI-OUTDOOR CONDITIONS

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Introduction

Azolla commonly known as mosquito fern, duckweed fern, fairy moss, and water fern, is a small free floating aquatic fern native to Asia, Africa, and the America. It grows in swamps, ditches, and even in lakes and rivers where the water is not turbulent (Lumpkin and Plucknett, 1980). The term *Azolla* was first coined by Lamarck in 1783 derived from the two Greek words, Azo (to dry) and Ollyo (to kill) thus reflecting that the fern is killed by drought. The genus *Azolla* belongs division Pteridophyta, class Polypodiopsida and order Salviniales. However taxonomists have placed it now in monotypic family *Azolla* ceae (Konar and Kapoor, 1972). Distribution of *Azolla* varies from freshwater in tropical, subtropical, and warm-temperate regions throughout the world. There are different number of species of *Azolla* worldwide; *Azolla caroliniana*, *Azolla circinata*, *Azolla japonica*, *Azolla mexicana*, *Azolla microphylla*, *Azolla nilotica*, *Azolla pinnata*, *Azolla rubra*etc. The common species of *Azolla* in India is *Azolla* piñnata. The *Azolla* macrophyte, called a frond, ranges from 1 cm to 2.5 cm in length in species such as *A. pinnata* and to 15 cm or more in the largest species, *A. nilotica*. It is a dichotomously branched free floating aquatic fern consisting of a main rhizome, branching into secondary rhizomes, all of which bear small leaves alternately arranged. Unbranched, adventitious roots hang down into the water from nodes on the ventral surfaces of the rhizomes. The roots absorb nutrients directly from the water, though in very shallow water they may touch the soil, deriving nutrients from it. Each leaf consists of two lobes: an aerial dorsal lobe, which is chlorophyllous, and a partially submerged ventral lobe, which is colourless and cup-shaped and provides buoyancy. Each dorsal lobe contains a leaf cavity which houses the symbiotic.

Azolla (water fern) unique freshwater small-leaf floating fern, being one of the fastest growing plants on the planet due to its symbiotic relation with a cyanobacterium called Anabaena. *Azolla*-Anabaena is a symbiotic complex in which the endophytic blue - green alga Anabaena Azollae lives within the leaf cavities of the water fern *Azolla* (Lain). The endosymbiont, which is nitrogen-fixing, provides sufficient nitrogen for both itself and its host (Peters, 1978). The fern, on the other hand, provides a protected environment for the algae and also supplies it with a fixed carbon source. It has capability to fix atmospheric nitrogen as well as to produce biomass at a very high rate. Under ideal conditions it grows exponentially, doubling its biomass in early three days.

Growing conditions of *Azolla*

- Water is the primary environmental constraint to the cultivation of *Azolla*. *Azolla* is a free floating aquatic fern and is therefore limited to locations that have an abundant, stable

water supply during field cultivation. Maintenance of adequate water level (at least 10 cm depth) is essential.

- Temperature and humidity: For practical purposes, *Azolla* survives within the water temperature range of 0°C to 40°C; beyond this range, death will result, for adequate growth during field cultivation, the daytime water temperature should stay within the range of 15° to 35 'C. Generally, *Azolla* requires 25 to 50 per cent of full sunlight for its normal growth. Humidity and temperature interact in their effect on *Azolla*. The optimum relative humidity is 85 to 90 per cent..*Azolla* becomes dry and fragile at a relative humidity lower than 60% (Hasan *et al*., 2009; Lumpkin *et al*., 1980). Very high humidity and high temperature or very low humidity and low temperature are both detrimental to the growth of *Azolla*.
- pH: The pH of the water plays an important part in the ability of *Azolla* to survive. Besides directly affecting the growth of *Azolla*, pH also affects the availability of nutrie.nts, especially phosphorus. Low pH and high pH can cause formation of insoluble compounds that tie up available phosphorus; the phosphorus in such insoluble compounds is unavailable to *Azolla*. *Azolla* grows best within a pH range of 5 to 7 and can survive a range of 3.5 to 10.
- Available nutrients: *Azolla* growth depends on an adequate supply of essential elements in the water or in the surface layer of mud. These elements must also be relatively balanced, Usually the addition of phosphorus and sometimes potassium is all that is necessary to ensure good growth.About 20 ppm of phosphorus in the water is optimum.

Cultivation practice of *Azolla*

Before starting the *Azolla* culture in indoor or semi-indoor condition, there are some necessary steps taken before hand. For *Azolla* production, it requires a shallow pond or cemented water tanks.

- **Selection of Location:** The location for *Azolla* culture play a major role as making sure to have location where one can monitor the culture on regular basis. Moreover, choosing a location near to a good water source would highly benefit the culture. A site with a partial shade is preferable, reducing water evaporation and thus helps in better growth.
- **Pond Size and Construction:**The quantity of *Azolla* to be cultured decides the size of the pond or cemented water tanks. A pond sized 6 feet × 4 feet is suitable for culturing growing that can produce supplemental feed of 1 Kg/ day. The selected area should be cleaned and levelled. In case of pond, use of brick to construct the side walls of pond and using a durable plastic sheets and securing all the sides of sheets with all the sides of plastic by bricks is suggested. Moreover, the pond or the cemented water tanks should be covered with a net to provide a partial shade as well as prevents the falls of leaves and other debris into the culture area.
- **Production of *Azolla*:** Sieved fertile soil with cow dung and water should be spread evenly across the pond or tank. 1 kg of inoculum is sufficient to cover a 6 × 4 feet pond. A water depth of 5 to 6 inches is must for the culture practice. Checking the salt content, alkalinity and acidity of water is suggested for the improved growth of *Azolla*.
- **Maintenance:** Applying a mixture of 1 kg of cow dung with 100-120 g of super phosphate once in 2 weeks aids in the better growth of *Azolla*. Maintaining a constant level of water

of pond or tank with a regular removal of *Azolla* to avoid crowding which can limit *Azolla* growth is preferable. Moreover, there should be a restart of culture with fresh culture and soil to maintain a continuous production of *Azolla*.

- **Harvesting of *Azolla*:** It takes around 2 to 3 weeks for *Azolla* to attain its full growth, and ready to be harvested. One can achieve an average of 1 kg *Azolla* on daily basis from 4 × 6 feet pond. Harvested *Azolla* have various usage. When dung is used as fertilizer in backyard *Azolla* ponds, the *Azolla* should be washed thoroughly with fresh water to remove the smell of the dung (Giridhar *et al*., 2013).
- **Yield** *Azolla* is a highly productive plant. It doubles its biomass in 3-10 days, depending on conditions, and yield can reach 8-10 t fresh matter/ha in Asian rice fields. In India, yields of 37.8 t fresh weight/ha (2.78 t DM/ha) have been reported for *Azolla* pinnata (Hasan *et al*., 2009).
- **Economics** Market value of *Azolla* is varies from geographical place to place but avg. Price of *Azolla* is 150-250 rupees per kg in India market.

Case Study of *Azolla* culture

Reecha (2021) cultivated *Azolla* under semi-indoor conditions. The *Azolla* was cultivated in cemented water tanks. The tank was filled with freshwater/ sewage treated water up to a certain depth. The slurry was prepared by properly mixing 1 kg cow dung and 100 gram of super phosphate in sufficient amount of water (Figure1). The slurry so prepared was poured into the tanks. Small inoculums of *Azolla* was procured from fish farmer to raise its culture. About 1 Kg of fresh and pure culture of *Azolla* was inoculated into the water (Figure 2). After inoculation, the tank was covered with a net to provide partial shade and to prevent the falling of leaves and other debris (Figure 3). Periodic application of slurry was carried out to ensure the proper growth of the *Azolla*. Biomass was removed on every third day to avoid overcrowding.

For an investigation, Sharma *et al* (2020) produced *Azolla* in water troughs. The bottom of water trough was sealed with cement and maintained a uniform layer of water in the trough. A thin layer of about 10 cm of fine soil was spread and then water trough was filled with water and maintained the constant level of water. About 2-2.5 kg of cow manure was dissolved in 3.5liters of water and spread evenly in the water trough. Fresh *Azolla* seeds were inoculated in water troughs at 0.5kg/m2. *Azolla* was spread all over trough within 15 days and build up a thick met like structure.

Cherryl *et al.,* 2014 described *Azolla* culture by making an even floor pit with dimensions of 5 × 4 × 0.3 m with the same level of corners to maintain a uniform water level. A Silpaulin sheet was putted uniformly over the pits such are longer and broader than the pit and the outer edges of the sheets were good fixed. 10–15 cm clear soft soil was spread evenly over the sheet and filled the pit with water to a three-fourth level and regular maintenance the same level of water. About 15 kg of fermented buffalo feces in 35 L of water was dissolved and added evenly throughout the pit. A mixture of 30 g of superphosphate in 10 L of water was prepared and added it as zigzag to the previous soil. 5 Kg of fresh and pure *Azolla* was incubated in the pit and slowly sprinkled water over it. Every 15 days the application of buffaloesfeces, superphosphate and minerals was done to avoid nutrient deficiency and obtain continuous growth of *Azolla*. If the pit was affected by pests or diseases, it was cleared and a fresh inoculation of the pure culture of *Azolla* was done. *Azolla* multiplies rapidly and fills the pit within one week, so weekly fully grown *Azolla* was harvested.

Mathur *et al.,* 2013 developed a cost effective prototype of *Azolla* cultivation for mass multiplication. A 6.0 × 1.0 × 0.2 meter trench was made under partial shade and lined with silpaulin sheet or made a cemented structure. A mixture of 80-100 Kg of sieved fertile soil and 5-7 kg co dung (2-3 days old) was prepared in 10-15 litre water and poured and mixed thoroughly into the trench containing 400-500 litre of water maintaining a depth of 10 cm. About 2 Kg of fresh *Azolla* inoculum was spread on the surface of water and covered the trench with 50% nylon net. 20 g super phosphate was added every month along with 5 kg of cow-dung to maintain the daily yield of *Azolla*. After 21 days, an average of 1.5-2.0 kg *Azolla*/day was harvested.

NABARD as part of the livelihood activity under Watershed Development Fund (WDF) encouraged *Azolla* fodder plots in various watersheds.Once the bed of size 2.5 m x 1.5 m is ready, about 15 kg of fine sieved soil was spreaded over the bed. About 5 kg of pre-decomposed (2 days) cow dung is mixed with the water provided carbon source for the *Azolla*. About 40 g of nutrient mix (made by mixing 10 kg Rock phosphate, 1.5 kg Magnesium salt and 500 g of Muriate of potash) was added to the *Azolla* bed. Sufficient water was added to make the water level of the bed to 10 cm. ideally it will give 10 kg of *Azolla* within seven days. During the initial seven days *Azolla* was not harvested. Water level was maintained by applying water every day. After the seventh day, 1.5 kg of *Azolla* was harvested every day.

Nutritional Qualities of *Azolla*: *Azolla* is very rich in protein (25-35%) and minerals. A nutrient profile of Fresh *Azolla* was prepared by FAO (2015).

1. Main analysis	**Unit**	**Avg**	**Min.**	**Max**
Drymatter	% asfed	6.7	5.1	8.7
Crude protein (CP)	% DM	20.6	13.9	28.1
Crude fibre (CF)	% DM	15.0	11.3	22.8
NDF	% DM	43.8	35.4	52.3
ADF	% DM	31.8	24.0	38.9
Lignin	% DM	11.4	9.3	13.5
Etherextract	% DM	3.8	1.9	5.1
Ash	% DM	15.9	9.8	21.6
Starch(polarimetry)	% DM	4.1	2.7	5.5
Grossenergy	MJ/kgDM	17.0		
2. Minerals	**Unit**	**Avg**	**Min**	**Max**
Calcium	g/kgDM	11.0	5.8	17.0
Phosphorus	g/kgDM	6.1	0.3	15.5
Potassium	g/kgDM	17.4	10.9	22.5
Sodium	g/kgDM	9.0	2.8	12.5
Magnesium	g/kgDM	5.0	3.9	6.1
Manganese	mg/kgDM	762	208	1429
Zinc	mg/kgDM	38	11	77
Copper	mg/kgDM	16	10	28
Iron	mg/kgDM	3900	711	8200

3. Amino acids	Unit	Avg	Min	Max
Alanine	% protein	6.4	5.3	7.4
Arginine	% protein	5.9	5.1	6.6
Asparticacid	% protein	9.3	8.2	10.3
Cystine	% protein	1.6	0.7	2.3
Glutamicacid	% protein	12.6	11.6	13.5
Glycine	% protein	5.6	4.5	6.6
Histidine	% protein	2.1	1.6	2.4
Isoleucine	% protein	4.5	3.7	5.4
Leucine	% protein	8.4	7.0	9.2
Lysine	% protein	4.7	3.5	6.5
Methionine	% protein	1.4	1.2	1.9
Phenylalanine	% protein	5.4	5.2	5.6
Proline	% protein	4.9	3.5	6.8
Serine	% protein	4.5	3.9	5.6
Threonine	% protein	4.7	4.0	5.3
Tryptophan	% protein	1.8	1.5	2.0
Tyrosine	% protein	3.6	3.2	4.1
Valine	% protein	5.5	3.8	6.8

Potential of *Azolla*

The aquatic fern *Azolla*, living in symbiosis with a nitrogen fixing cyanobacteria (Anabaena) has high biomass productivity along with tremendous rate for nitrogen-fixation. There have been extensive studies to evaluate the potentials of *Azolla* to be applied as a green manure in rice fields, feed supplement for aquatic and terrestrial animals, human food, medicine, water purifier, biofertilizer, weeds and mosquitoes controlling agent, or remover of nitrogenous compounds from water (Costa *et al.*, 2009; Sadeghi Pasvisheh *et al*., 2013).

***Azolla* as Nutritional Supplement for Livestock**

Azolla is used as food supplement for variety of animals including pigs, rabbits, chickens, ducks and fish (Hove, 1989). Seultrope (1967) concluded that *Azolla* is harvested in large quantities and utilised as fodder for cattle and pigs. It was also found that broilers feed with *Azolla* resulted in growth and body weight values similar to those resulting from the use of maize-soya bean meal. Das *et al* (1994) reported that digested *Azolla* slurry remaining after biogas production was suitable as fish pond fertilizer, in the study lactating cows (Nik-khah and Motaghi-Talab, 1992) and found that *Azolla* could be used as feed ingredient with milk yields and fat percentage being maintained at the same levels as with conventional feeds.

***Azolla*in phytoremediation**

Azolla has proved to be a potent aquatic water fern for the biofiltration of various toxic metals (Cohen-Shoel*et al*., 2002; Rai, 2007) and as a biofilter to purify water, to remove nitrogen and phosphorus, elements that cause water eutrophication. Also, it can remove sulfa drugs (Forni*et al*., 2001) and radioactive elements as Uranium (Cohen-Shoel *et al*., 2002). *Azolla* exhibits a remarkable ability to concentrate metals cu, Cd, Cr, Ni, Pb and nutrients directly from pollutants

or sewage water. Noorjahan and Jamuna (2015) focused on the biomonitoring capacity of A. microphylla for purification of sewage waste water.After 96 hrs, the results showed an active reduction in physicochemical parameters and heavy metals.

Azolla as Biofertilizer in Rice Cultivation

Azolla is cultivated in the paddy field either as monocrop or as intercrop and incorporated into the mud/soil for increasing humus and nutrient content of the soil. This practice of *Azolla* cultivation is widely popular in the countries of south-east Asia like India, China, Phillipines, Indonesia etc. Peters (1978) reported that the use of *Azolla* increased rice yields by 112% over unfertilized controls when applied as a monocrop during the fallow season, by 23% when applied as an intercrop with rice, and by 216% when applied both as a monocrop and an intercrop. When *Azolla* used as a bio-fertilizer in paddy field it produces around 300 tons of green bio-hectare per year under normal subtropical climate which is comparable to 800 kg (1800 kgs of urea) of nitrogen (Wagner 1997). Raja *et al*. (2012) cultivated *Azolla* in rice field and observed an increase in rice yield by 20 to 30%

Azolla as Green Manure

Azolla can also been used as green manure in the cultivation of water bamboo, arrowhead, taro, Wheat and rice (Hove, 1989; Marwaha et al., 1992; Teckle-Haimanot, 1995). Incubation of Azolla as green manure in water logged soil resulted in rapid mineralization with a release of 60-80% of the nitrogen within two weeks (Ito and Watanabe, 1985). Sharma et al. (1999) also recorded the highest yields of wheat with application of 20 tonnes of Azolla and 60 kg nitrogen.

Azolla as Mosquito Repellent

Azolla can also be used in the control of mosquitoes, as thick *Azolla* mat on the water surface can prevent breeding and adult emergence. In a survey of pools, ponds, wells, rice fields and drains, Ansari and Sharma (1991) stated that breeding by *Anoplieles* spp. was almost completely suppressed in water bodies that were completely covered with *Azolla*. Rajendran and Reuben (1998) concluded that *A. pinnata* greatly reduced both ovipostion and adult emergence of *Culex quinquefasciatus say* and *Anopheles culicifacies giles*, but not larval survival. Egg hatchability was partially reduced.

Azolla as a Component of Space Diet

Recent research by Katyama *et al*. (2008) in collaboration with Space Agriculture Task Force suggested *Azolla* as a component of the space diet during habitation on Mars and found that *Azolla* was found to meet human nutritional requirements on Mars.

Figure 1: Slurry Preparation

Figure 2: Preparation of *Azolla* culture

Figure 3: Cemented water tanks with net cover

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SOIL HEALTH MANAGEMENT WITH AN ECOSYSTEM THROUGH ORGANIC AGRICULTURE

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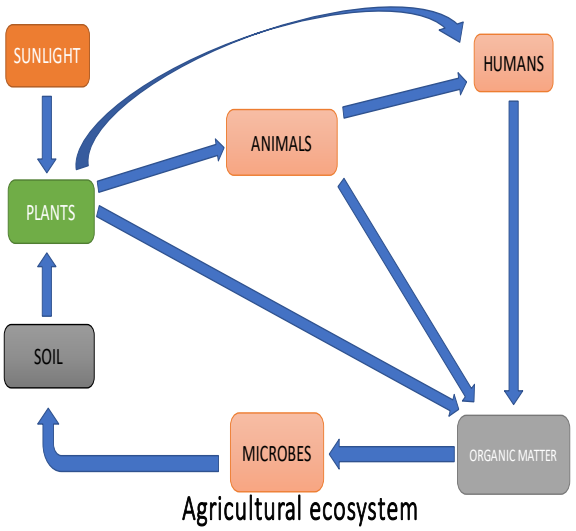
Introduction

Organic agriculture is in a nascent stage in India. About 2.78 million hectare of farmland was under organic cultivation as of March 2020, according to the Union Minister of Agriculture and Farmer's Welfare. This is two per cent of the 140.1 million ha net sown area in the country. A few states improve to organic farming area, Madhya Pradesh top of the list with 0.76 million hectare of land use for organic cultivation – that is over total organic cultivation area in India 27%. Sikkim is the fully Indian organic state, Madhya Pradesh, Rajasthan, and Maharashtra under net sown area have only around 4.9, 2.0 and 1.6 % respectively.



Agricultural ecosystem

"Organic Agriculture is a production system which improves and enhances sustains the health of soils, agro-ecosystems, including biodiversity, biological cycles, soil biological activity and people. It relies on ecological processes, biodiversitybiodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects.. Organic Agriculture combines tradition, innovation and science tobenefit the shared environment and promote fair relationshipsand a good quality of life for allinvolved." In organic Agricultural system that uses of organic sources of fertilizers and adopt todifferent practices such as green manuring, crop rotation, cropping system and uses of integrated nutrient management system, natural farming, organic farming etc.

Soil health with an ecosystem

Soil health is productive, profitable and ecofriendly with ecosystem. By understanding adding biofertilizer, compost, manures, vermicompost, and others organic substances with diversifying the growing cover crops, crop rotation, integrated cropping system with livestock and utilizing green manuring with legumes crops to provide nutrients.Soil life provides the successful farming for animal, human life and all types of terrestrial plants on the Earth.Soil is a mixture of organic Matter (5%), mineral matter (45%), soil air (25%) and soil water (25%), this mixture is a complex ecosystem where living organisms and plant roots, soil is a dynamic structure structures that regulates soil water, soil air and nutrients. In agricultural context, soil health most often refers

to the ability of the soil to sustain agricultural productivity with ecosystem and protect environmental resources. A healthy soil provides many functions to plant growth, including nutrient cycling, biological control of plant pests, and regulation of water and air supply. These functions are influenced by the interrelated physical, chemical, biological, fertility properties of soil.A diverse community of soil bacteria, fungi, actinomycetes, worms, protozoa and othermicroorganisms converts crop/plant residues in to soil organic matter and soil organic matter most important to crop growth and nutrient provide for agriculture production.

Management practices through Organic cultivation

The major components of soil health management under organic agriculture system such as integrated farming system, growing cover crop, crop rotation, uses of crop residues, addition of organic manures, farm yard manures, vermicompost, compost, biofertilizers, vermiwash, biogas slurry, maintenance and enhance of soil fertility through biological nitrogen fixation and uses of soil microorganisms etc.Vermiculture has become a major component in biological farming, which is found to be effective in enhancing the soil fertility and producing large numbers of horticultural crops in a sustainable manner (Sanjay-Swami, 2017). The various options for soil health management under organic agriculture system are being discussed here under organic agriculture.

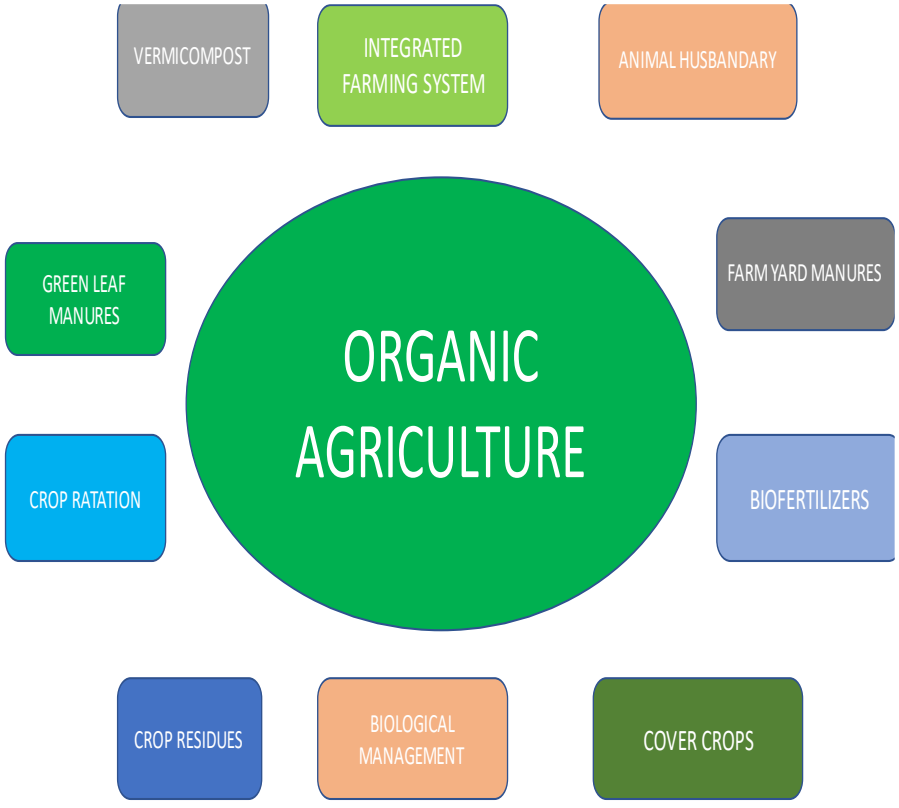


Fig: 2 Organic farming

Integrated farming system

Integrated farming systemcan be integrated with livestock, pig farming, poultry,goat, fish, and growing crops, vegetables, fruits,etc. are maintained at same place to generate employment around the year and also get additional income. For example, same place poultry in upper layer

and utilize their excreta. Pigs are in lower layer, residual water from pond was utilized for agriculture and fodder crops production. Some example:

- Integrated rice-fish vegetable system,
- Integrated pig-poultry-fish-vegetable,
- Integrated rice-fish-poultry models
- Integrated makhana-fish-singhara system

Fig: 3 Integrated farming system model

Crop rotation

Crop rotation is the cultivation of different types of crops in a specific sequence on the same field, it is required in organic cultivation because it is preventing soil diseases, insect-pests and weeds. Crop rotation is a very most important to soil heath and check the soil erosion, help to nitrogen fixation, carbon sequestration, increase soil organic matter and farm productivity. Example:- shallow rooted crop after deep rooted crop, Cereal after then pulses after than oilseed .

Fig: 4 Crop rotation

Green manure

Green undecomposed material mixed in to the soil as a source of manures is called as green manures. it is source of two way – Growing green manures crops such as sunhemp, dhaincha, clusterbeans, and sesbania rostrata. Uses green leaves and twigs of trees, shrubs, and herbs collected from elsewhere is called as green leaf manuring. Benefit of green manures increasenitrogen availability, improve soil structure and water holding capacity, decrease soil erosion, improve biological activity in soil, etc.

Fig: 5 Mixing of green manure in to soil

Crop residues

Crop residues are farm materials left in an agricultural field after the crop has been harvested. These residues include straw, stubble, stover, stalks and stems, leaves and seed pods. Good management of field residues with mixing of soil, after some time decomposed by soil organisms and release nutrients and make good soil structure and can increase efficiency of water holding capacity, control of erosion, suppress the weeds, increase nutrient availability in to the soil for proper growth of plant and increase crop productivity.

Fig- 6 Crop residues

Farm yard manures

FYM refers to the decomposed organic mixture of dung and urine of farm animals along with litter and farm left material from fodder feed to the cattle. In well decomposed FYM nutrients contains

0.5%, 0.2%, 0.5% NPK respectively. The FYM becomes ready for use in 4-6 months, it improve and maintains the soil physical, chemical, biological, and fertility properties of soil.

Fig: 7 Farm yard manures

Vermicompost

Vermicompost is the organic waste decomposed by using of earthwarms is known as vermicompost, to create a mixture of decomposing vegetable or food waste, kitchen waste, bedding materials and vermicast etc.Vermicompost rich in NPK 2-3%, 1.5-2.25%, 1.8-2.25% respectively.vermicast are rich in N, P, K, Ca, Mg, vitamins, enzymes, and growth promoting substances. The efficient species of earthworms are Eisenia foetida, Pheritima elongate, Eudriluseugeniae and Perionyx excavates.

Fig: 8 Vermicompost

Biofertilizers

Biofertilizers is a livingmicroorganism such bacteria, fungi, actinomycetes, Azola, Blue green algae etc. that uses for seed treatment, plant roots treatment, soil treatment enhance plant nutrition by either by mobilizing or increasing nutrient availability in soils, nitrogen fixing in to root nodules. Rhizobium, azotobacter, azospirillum, mycorrhiza, Various microbial taxa including beneficial bacteria and fungi are currently used as biofertilizers, as they successfully colonize the rhizosphere, rhizoplane or root interior.

Biodiversity with an ecosystem

Biodiversity is the key to the success ofagricultural system. Lack of biodiversity severely limits the potential of cropping system and increases disease and insects/pest problems. A diversified soil food web provides for nutrient, energy, and water cycling that allows a soil to express its full potential. Increasing the diversity of integrated farming system, crop rotation year after year, green manuring, and cover crops increases soil health and soil function, reduces input costs, and increases profitability.

Conclusion

Organic agriculture with an ecosystem beneficial to farmers,it providesprofitable though integrated farming system and making good soil health,recyclable nutrients (N, P, K, S, Zn, Mn, Fe and Cu) from plant and animal waste in large quantity. Thisstep managing the soil health and reducing the cost of cultivationand increases profitability as compared to conventional farming practices.

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CONTRACT FARMING : WAY OF COMMERCIAL FARMING

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Agriculture is not only a means of commerce and a source of income, but is fundamentally associated with our culture. Introducing reforms in agricultural marketing is the need of the moment to bring about the necessary changes in its structure and push the sector to take off from its low growth rate of 2-3% to at least a respectable 4-5%. Over the past few decades, agri-food chains in developing countries have undergone substantial restructuring due to changes in both demand and supply factors. On the demand side, factors such as population growth, increased urbanization, rising income levels and changing preferences have reshaped the demand for agricultural products. On the supply side, factors such as market liberalization, improve transportation and logistics, and technological improvements have affected supply chains.

Agriculture is an ancient livelihood for millions of Indians. However, there have been few systems in which farmers have been assured of a market for their produce, let alone a remunerative price. On occasion, farmers have had to throw away their produce for lack of buyers. On the other hand, there is the agro-food industry, which requires timely and adequate inputs of good quality agricultural products. This underlying paradox of the Indian agricultural scene has given rise to the concept of contract farming, which promises to provide a convenient link between 'farm and market'. Recognizing the need and the merits of such a link with the agricultural community, various companies involved in trade, processing and export, agricultural products have tried to establish practical systems that ensure the rapid and constant supply of raw materials of the desired quality and at low cost.

Contract farming

Contract farming is a system of production and supply of agricultural and horticultural products through forward contracts between producers and buyers. There are two parties in the contract farming. One party is the landowner or peasant. The other party is a contracting company. The essence of such an arrangement is the commitment of the producer or seller to supply an agricultural product of a certain type, at a time and price, and in the quantity required by a known and committed buyer.

According to the contract, the farmer is obliged to plant the contractor's crop on his land, harvest and deliver to the contractor an amount of product, depending on the expected yield and the contracted area. This could be at a pre-agreed price. For these purposes, the contractor provides inputs to farmer, including the necessary technical advice. Thus, the entrepreneur provides all the necessary inputs for cultivation, while the farmer provides the land and labour. However, the terms and nature of the contract differ according to variations in the nature of the crops to be grown, the agencies or company, the farmers, and the technologies and context in which they are practiced.

Historic Context

Contract farming is nothing new, the first evidence of contract farming dates back to British era. The East India Company had contractual farming arrangements in coffee and tea estates. And also, there were indigo plantations through contract farming. But it was exploitative. Modern contract farming is mutually beneficial. For the first time, it was introduced to Taiwan in 1895 by the Japanese government. In India, it was introduced by the Pepsi company for the cultivation of vegetables, especially tomatoes and potatoes in Hosiarpur of Rajasthan in 1927. In Karnataka, contract farming began with the cultivation of gherkin (pickle cucumber) in the 20th century.

Benefits for farmers

- Production inputs and services are often provided by the company or agency.
- Inputs and services provision is usually done on credit through advances from the company or agency.
- Contract farming often introduces new technologies and also allows farmers to learn new skills.
- Farmers price risk is often reduced as many contracts specify prices of crop in advance.
- Contract farming can open up new markets which would otherwise not accessible to small farmers.

Problems Faced byfarmers

- Especially when growing new crops, farmers face the risks of market failure and production problems.
- Inefficient management or marketing issues may mean that quotas are manipulated so that not all production under contract is purchased.
- Company or agency may be unreliable or exploit a monopoly position.
- The staff of the sponsoring organizations may be corrupt, especially in the allocation of quotas.
- Farmers can go into debt due to production problems and excessive advances.

Benefits for company or agency

- Production is more reliable than purchases on the open market and the sponsoring company faces less risk as it is not responsible for the production.
- More consistent quality can be achieved than if purchases were made on the open market.
- Contract farming with small farmers is more acceptable than large farm.
- Working with small farmers overcomes the limitations of the land.

Problems Faced by company or agency

- Contract farmers may face land constraints due to lack of security of tenure, compromising long-term sustainable operations.
- Social and cultural constraints can affect farmers ability to produce according to company or agency specifications.
- Poor management and lack of consultation with farmers can lead to farmer dissatisfaction.
- Farmers may sell outside the contract (extracontractual marketing), which reduces the output of the processing plant.
- Farmers may divert inputs provided on credit to other purposes, thereby reducing yields.

Type of contract farming models or arrangements

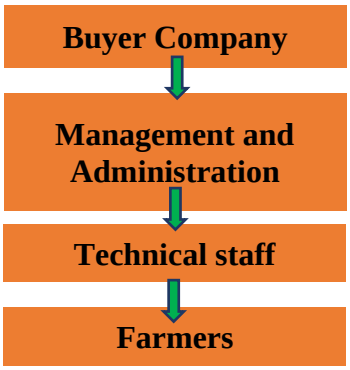
In India, there are different models of contract farming practiced. The models which are to be followed totally depend upon the buyer. In India there is no single type or set of contract farming is practiced. In the majority of cases, it is mixed of all types. In some of the countries the exact model is followed while in countries like India they are customized according to the need of buyer and seller.

1) Centralized Model

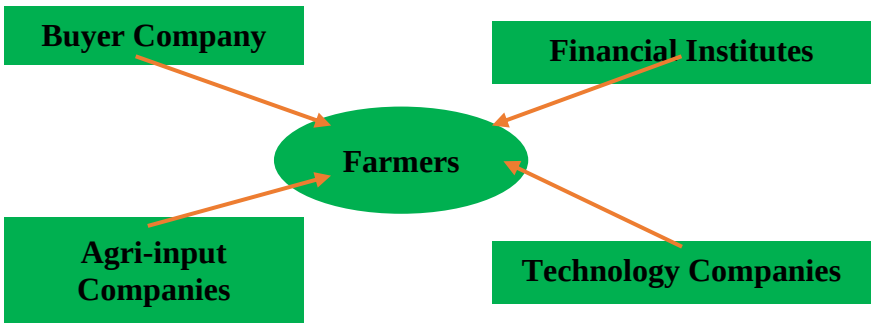
This type of model involves a centralized processor and or packer buying from a large number of small farmers and is used for tree crops, annual crops, and poultry, dairy. It is centrally monitored and managed by the buyer. All the services whether it is technical guidance or advisory is provided by them and no other stakeholder or entity is involved. The model is beneficial for small farmers. India has around 86% of the farmers coming under small and marginal levels. Hence, to give them the benefit of contract farming, a centralized model can be followed.

2) Multipartite Model

Unlike the centralized model in the multipartite model the different organizations and companies jointly take part with the farmers. The services provided by the farmer will come from different organizations according to their expertise. And at the end, the harvested produce is taken by the main buyer company. This model makes a large ecosystem where different stakeholders are involved under one project. Typically, such projects are relatively big and a large quantity of produce is exchanged between the grower and buyer. Farmers are benefited as they have access to all kinds of services.



Centralized Model



Multipartite Model

3) Informal Model

This model characterized by single entrepreneurs or small companies who enter informal contracts with the farmers for a particular season. This is majorly done for fresh vegetables and fruits. Unlike the rest of contracts which are long term, the informal model is not for long. It could be for a single season or two. Generally, the duration of such a contract depends upon the need and resource arrangement by the entrepreneurs or small companies.It often requires government support services such as research and extension. The buyer can also form contracts with farmers without giving services to them while ensuring their produce will be bought by the buyer.

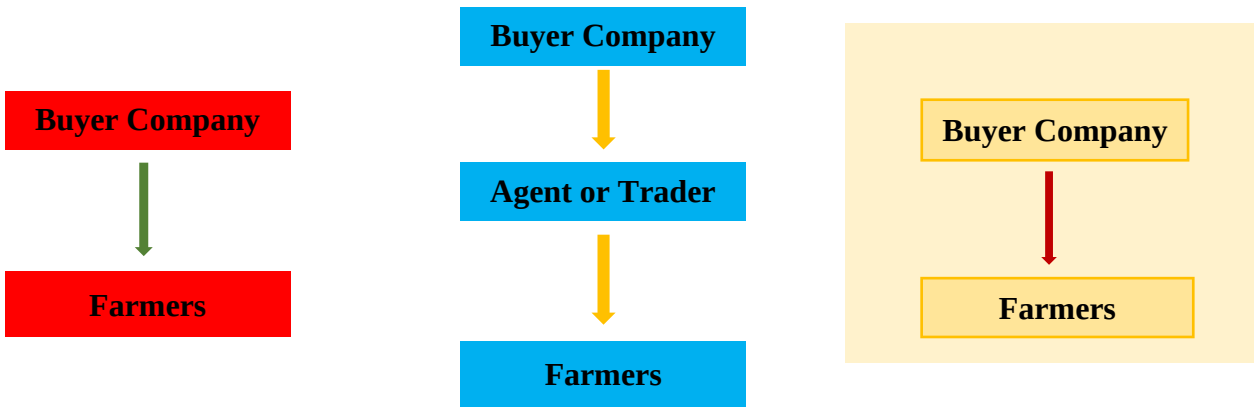
4) Intermediary Model

In the intermediary model there is involvement of intermediaries like agents or traders in the contract. In such cases, the company may not be directly in contact with the farmers. Agents or

traders are in direct contact with the farmers. The harvested produce will be taken by the agents which will eventually be given to the buyer company.

5) Nucleus Estate Model

This type of model is a variation of the centralized model where the company or agency also manages a central estate or plantation. This type of contract farming model forms a closed ecosystem where the buyer has much control on the farm as well as all the activities done throughout the season. Hence, they can expect the exact quality of farm produce after the harvest. Such a model is followed by the companies who have their own land and the quantity produced from that land fulfil their needs.



Informal Model **Intermediary Model** **Nucleus Estate Model**

Contract Farming Ventures in India

1) Pepsi Foods Ltd.

Launching its agro-business in India with special focus on exports of value-added processed foods, Pepsi Foods Ltd. ('PepsiCo') entered India in 1989 by installing a Rs. 22 crore state of the art tomato processing plant at Zahura in Hoshiarpur district of Punjab. The company intended to produce aseptically packed pastes and purees for the international market.

2) Appachi Cotton Company (ACC)

Appachi Cotton Company (ACC), the ginning and trading house from Pollachi (Coimbatore district of Tamil Nadu, India) hit the headlines in May 2002 for the street play it employed to encourage farmers in the Nachipalayam village in Kinathukadavu block of Coimbatore to sow cotton seeds in their fields. The singer in the street plays assured cotton farmers that, unlike in the past, they would not be disappointed if they cultivated cotton on their fields, as they would be backed by a model called the Integrated Cotton Cultivation (ICC), which would guarantee a market-supportive mechanism for selling their produce.

3) Ugar Sugar Works Ltd.

The Belgaum (Karnataka)-based Ugar Sugar Works Ltd., which established a successful backward linkage with farmers of Northern Karnataka for supply of barley for its malt unit, is quite interesting and insightful. Farmers surrounding Ugar Sugar in Belgaum, who had been cultivating

sugar under intensive irrigation found themselves with the problem of salinity in soils. Ugar Sugar took this opportunity to begin creating awareness among the farming community about alternative crops suitable for saline soils. Of these, barley was known to give economic yields of good quality in saline soils. The company assured the farmers of a market for their produce if they agreed to grow barley, as well as the required technical and input support.

4) Rallis India

The company provides all inputs, technical support and finance to registered growers for a specific crop and facilitates the sale of produce at reasonable prices. The company follows a consortium approach. It has tied up with banks like ICICI and SBI and with buyers of produce like HLL, Picric and Cargill.

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INSECTS PEST OF CITRUS AND THEIR MANAGEMENT

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Leaf miner

This pest infects the plants from the nursery stage. Infestation is more on tender shoots during rainy and winter seasons. The larvae lie between the layers of the leaf and scrap the green matter. On the leaves where the larvaeare expected, white, curly, scaly streaks can be observed.Wrinkling also occurs at the later leaf stages. June – July and December – January are the months when the pest infestation is highest.

Control

Spray Neemoil @ 5 ml per liter of water as soon as white streaks are noticed on the leaves. Spray Imidacloprid @ 0.5 ml or Novaluron @ 0.7 ml or Thiamethoxam @ 0.3 gm per liter of water and repeat again after 14 days if the infestation is high.

Citrusbutterfly / Caterpillar

Black bird's drop shaped larvae that hatch from the eggs feeds on young shoots and cause damage. They completely eat the leaves from the terminal to the middle of the leaves and cause heavy damage. Leaf dropping is also observed in the final stage

Control

This pest is easy to spot because it is black in its early stages and looks like a bird's droppings with black and white stripes. They should be handpicked and destroyed at the nursery stage. SprayBT

related insecticides @ 1 gmorFenvalerate @ 0.1 ml or Cypermethrin @ 0.1 ml per liter of water when insect damage is observed.

Fruit sucking moths

These moths bore holes in the fruits at night and suck the juice. Bacteria and fungi accumulate in the holes made by the moths, causing the fruits to rot as secondary infestation. Black spots are formed on the fruits at the site of moths' damage. Due to sap sucking from the fruits, they lose quality and fall off.

Control

Rotten and fallen fruits should be picked from the orchards and destroyed. Shrubs, weeds and vines around the garden should be removed and kept clean, as the larvae of themoths feed on them. At the ripening stage of the fruits, dry grass or dry leaves should be smoked under the trees to prevent the moths coming near from the trees. As moths are active at night, they should be attracted to the light traps and destroyed. One fluorescent bulb per hectare daily at 7 pm to 6 am before fruits ripen should be installed. Light baskets should be placed under lights to capture themoths. Insecticide Ethionmixed to the sugar syrup and placed under the trees in an earthen container as bait.

Mites

Two types of mites infest in citrus orchards. They are yellow and Mangumite. Small white spots are formed on green leaves and fruits due to sap sucking by yellow mite while brown or yellow spots are formed on fruits which are small with hard and brittle skin due to sap sucking by Mangu mite.

Control

Proper care should be taken in winter for mites. In areas where mites' infestation is high spray Spiromesifen@ 1.2 ml per liter of water two times at 20 days interval when the fruits are of marble size.

Aphids and Blackflies

These sucking insectsinfest the leaves and suck the sap causing the leaves to shrivel. Sometimes yellowing of leaves is also observed. The honey dew substance excreted by these insects falls on

the leaves and due to the growth of fungi, black mold is formed and the trees decay due to the lack of photosynthesis. Severe sucking of the sapresults inflower drop, reducing the size and quality of the fruits. These insects should be avoided with great care at the vegetative stage of the trees.

Control

Before the first rains, dry branches and water shoots/twigs should be cut and the trees should be well ventilated and exposed to light. Yellow colored sticky charts or traps should be placed here and there in the orchard@ 10 per acre. In the last stage spray Profenophos @ 1.5 ml or Diafenthiuron@ 1 gm per liter of water thoroughly on the leaves.

Mealy bug

This insect has a white waxy substance and sucks sap on young twigs, fruits, and leaves. They excrete honey dew substance on the leaves which turns black due to lack of photosynthesis.

Control

Spray Profenofos @ 2.5 ml per liter of water at 15 days interval. It should be sprayed twice after cutting the fruits in the months of August-December.

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FEE FISHING; A BUSINESS IDEA FOR DOUBLING THE FARMER'S INCOME

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Abstract
Recreational fishing or sport fishing is one of the most sought after adventure tourism activities and has a booming international business opportunity. Like sport fishing, fee fishing is a concept of paying for the right to fish and/or paying for any fish that are caught, is rapidly becoming popular among anglers.Fee-fishing offers many aspects like family entertainment (both fun and educational), healthy fish,no fishing license is required and fee-fishing gives younger anglers a chance to learn how to catch fish successfully.A better, more complete concept of a fee-fishing operation takes into account that the visitors, or guests, view fee-fishing in the larger context of a tourism experience, with fishing in densely stocked ponds as only one component.

Keywords Fee-fishing, sport fishing, entrainment, income source

1. Introduction

Aquaculture is culture of aquatic animals and plants in a controlled environment. Aquaculture is the important food producing segment in India as well as in the world. Due to increase in the population demand of fish is also increasing day by day and because of increased national fish consumption, aquaculture offers farmers an opportunity for enterprise diversification. In particular, fee-fishing has agriculture and tourism linkages that make it a unique aquaculture enterprise.

Fee-fishing is the practice in which angler payto catch fish in private owned ponds. Fee-fishing can provide profits for the owner, social and recreational benefits for the community, and a market for locally produced fish. Fee-fishing is more than just inviting anglers to come to fish in your densely stocked ponds. A better, more complete concept of a fee-fishing operation takes into account that the visitors, or guests, view fee-fishing in the larger context of a tourism experience, with fishing in densely stocked ponds as only one component.

In countries like US fee fishing is a very common practise because of possibility of privately owned ponds and lakes that have been stocked with fish and to which access can be gained by anglers. Charges for recreational fishing are usually assessed on the basis of the weight of fish caught. Many fee fishing operators are also fish culturists. They may produce fish only for stocking their facilities, or they may both stock their own water bodies and sell excess fish to other culturists or fee fishing operations. Fee fishing has been present in the United States for at least a few decades. In Brazil, fee fishing is a more recent development—one that absorbs a large percentage of the fish produced by commercial aquaculturists in that nation. In India we can also adopt such type of fishing techniques to generate tourism as well extra income form the available water resources.

1. Types of fee-fishing operations

There are three basic types of fee fishing operations:

1.1 Day leases or "ticket" lakes and: Day leasing involves collecting a daily use fee from anglers, allowing access to given water body and catch fishes. Owner stock fishes in ponds for the angler's. Both natural production and occasionally stocked fish support the angler's harvest. Pond management is an important factor and pond owner are responsible for that.In some cases, especially with day leasing, the ponds may be stocked with catchable-size fish such as channel catfish.

1.2 Long-term leases: Long-term leasing involves the leasing of exclusive fishing rights on a long-term basis similar to hunting leases to an individual or group. Fishing success relies on natural production of the leased water body.Medium to large ponds are best suited for long-term leases.

1.3 Fish-out operations: Fish-out ponds are stocked with high densities of catchable- size fish. The angler is then charged for each fish caught or limited as to the number that can be taken.

2. Management of Food Fish and Water Quality

Management of good water quality and fishing ponds is very important aspect in any type of fish culture system. The success of any farm depends on the management of the water quality not only to the health and matchability of the fish, but also to the corresponding economic success of the business. So it's very important to understand the basics of fisheries management to reduced profitability or financial losses. This publication suggests guidelines for management of the water and the fish to improve fish health reduce fish mortality and increase angler catch rates, thereby increasing overall profitability y of fee-fishing operations.

Water quality parameters that effect the growth of fishes should be monitered on regular basis in the fee fishing pond. Some most important parameters are dissolved oxygen, pH, alkalinity, ammonia and nitrite. Different types of chemical test kits and meters are available in market to test these water quality parameters.

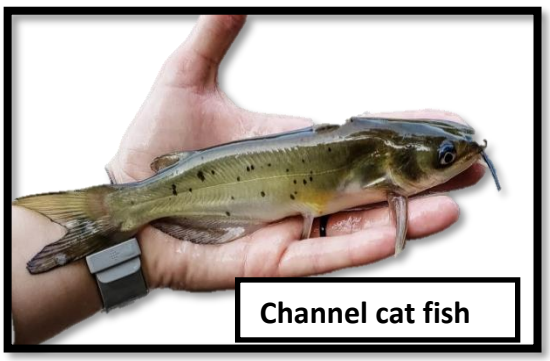
Table 1: Optimum water quality parameters

S No.	Parameters	Optimum level
1	Temperature	25-35^{o}C
2	Colour	Green-brown
3	Transparency	25-30 cm
4	Turbidity	<300 ppm
5	Dissolved oxygen	5-7 ppm
6	Carbon dioxide	<15 ppm
7	pH	7-8.5
8	Alkalinity	40-200 ppm
9	Ammonia	<0.025
10	Nitrite (NO_2)	<0.1 ppm
11	Hydrogen sulphide (H_2S)	<0.002 ppm
12	Plankton	>25 mL/m^3

3.1 Species of Fish

Stocking of desirable fishes is also an important step in fee fishing. The fishes for stocking should be done based on the local consumer and/or angler's preference. Farm raised fish are superior to wild-caught fish because farm-raised fish-are usually available in consistent quantities, are already conditioned to crowded pond environments and will consume formulated feeds. Farm-raised catfish are popular because of their availability, catchability, hardiness and desirability as a food fish. Channel catfish are the predominant farm-raised species and are, therefore, the most readily available and most commonly-stocked species. In warmer regions of the country catfish is the most logical choice for stocking fee-fishingponds, but hybrid sunfish, bass, crappie and even tilapia have been utilized (wherepermitted).If we are talking particularly about cold water sources like springs and mountain streams then rainbow trout would be the best desirable candidate species. However walleye and other species also have been used in fee fishing businesses. Again, rules and regulations of the different country and states largely determine which species can be considered for any particular operation.

Channel catfish (*Ictalurus punctatus*), largemouth bass (*Micropterus salmoides*), and trout (rainbow trout, Oncorhynchus mykiss, being perhaps the most popular) commonly used for fee fishing in United States. Historically, some crawfish (*Procambarus spp.*) producers in Louisiana have opened their ponds to those willing to pay for the privilege of trapping the desirable crustaceans. In Brazil, various native species, including some of the Amazon River region catfish, have been stocked in fee fishing ponds. Tilapias (Oreochromis spp.), which are exotic to Brazil, can also be found.



LOCATION

It's very important to keep some things in mind for successful fee-fishing that is having a good location, knowing your clientele, providing good facilities and services, and operating like any profitable business. For the fee fishing some important points should be remembers

- The site must be carefully chosen, developed and promoted to attract a large group of anglers, and once there, for them to have a successful and enjoyable fishing experience.
- The most successful fee-fishing operations are within 40-60 kilometres of a 50,000+ population center.
- Locating in a high-traffic area (major highway or intersection) increases the number of people who pass by and have a chance to see the operation.
- Donot locate near an existing fee fishing operation unless you are confident that there are enough customers to support more than one facility.
- Ponds should also be located in a "natural" setting screened from urban distractions, and have easy access and plenty space for parking.

How fee fishing system work?

The people who want to do as small scale and/or small operation should purchase the fishes and stock directly into the pond since small facility may not have sufficient physical space to maintain broodstock, hatch eggs and rear fish to table size. If the owner/operator is satisfactorily trained and has the space and personnel, maintaining spawning and rearing facilities may be the most desirable approach. Having the complete life cycle under control of the culturist helps ensure a good supply of fish of known quality and, in large facilities, may provide significant cost savings relative to purchasing fish of catchable size. A another option is that owner can purchase fingerlings size fishes and rear them in different pond to reach a size at which they can stocked into fee fishing ponds. While the fish within a fee fishing pond vary in size, any that are caught should all be considered ''keepers'' by the anglers who fish for them. This is because, in most instances, fees are assessed based on the weight of the fish caught. By stocking heavily and limiting the amount of supplemental food provided in fee fishing ponds, the fee fishing operator can ensure that most anglers will catch fish relatively quickly and easily. As time passes, fish that have been caught and surreptitiously released or hooked only to escape, will learn to avoid a lure or baited hook. As a result, over a period of time, angler success may decline, even though there are plenty of fish in the pond.

- At most fee fishing locations, anglers are required to keep all fish landed a practice that could become contentious if the fish were considered too small to take home. Another alternative is to charge a set rate and allow anglers to take home a specified maximum number of fish.
- As an incentive to keep anglers fishing once they have put a number of fish in the creel, as well as to keep the anglers returning for more, fee fishing operators may tag one or more fish that, if caught, will carry a reward rather than a cost to the angler.

Figure 1 Fish catch by angling in Kashmir
(Source; https://kashmirtourdeals.com/destinations/fishing-in-kashmir)

Other facilities

Remember people come for fishing for entertainment so with the fishing other source of entertainment would be very helpful for business. With the fee fishing a cafe and/or snack bar, bait shop should supply not only live bait, if used, but also fishing tackle for purchase or rent. Ice and coolers, sunscreen, first-aid supplies, and a number of other products that anglers might need are often available. Toilet facilities, typically in the form of portable outhouses, should be readily available to customers. Coin-operated fish-feed dispensers may also be provided near rearing ponds, so that, for a cost, anglers also have the opportunity to feed fish that are being grown for future stocking. Once the anglers decide to depart, they have their catch weighed, and the fee is assessed. Many operators will also clean the catch for an additional charge. The success of fee fishing operations depends not only on providing anglers with a successful fishing experience, but also on location and expectations of anglers. Careful study of angler preferences, in terms of the species available for capture and the amenities considered desirable or indispensable, along with the level of interest, the willingness of potential customers to use the facility, and the frequency of use, help ensure success.

Conclusion

It's very important to known that fee-fishing is both an agricultural and a tourism activity. Remember, fee fishing is a recreation business. Success will be based on repeat customers and good word-of-mouth advertising. A repeat customer is one who caught fish and "had a good time." An attractive, well-managed pond with consistently good fishing and friendly service will keep customers coming back. Other factors that determine success is location, facilities, services and management. Medium to large ponds with best management practise are best suited for long-term leasing, while small ponds can be day-leased or used as fish-out ponds.

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WATER QUALITY STANDARD FOR AQUACULTURE

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1) Introduction

Fish is an inexpensive source of protein and an important cash crop in many regions of world and water is the physical support in which they carry out their life functions such as feeding, swimming, breeding, digestion and excretion (Bronmark and Hansson, 2005). Water quality is determined by various physico-chemical and biological factors, as they may directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals (Moses, 1983). All living organisms have tolerable limits of water quality parameters in which they perform optimally. A sharp drop or an increase within these limits has adverse effects on their body functions (Davenport, 1993: Kiran, 2010). So, good water quality is very essential for survival and growth of fish.

2) Importance of water in aquaculture - If the water is "bad," plants and animals won't grow or reproduce. Animal stressed because of poor water quality are also prime targets for pathogens and parasites. Water is the medium in which fish live, and from which they derive oxygen and nutrients. So the quantity and quality of the water very much affect the prospect of fish culture. The water quality parameter get classified into three categories- 1) Physical parameter 2) Chemical parameter 3) Biological parameter

2.1) Physical Parameters of water- The major important physical parameters of water on which the productivity of a pond depends upon are-Depth, Temperature, Turbidity, Colour.

2.1.1) Depth: Depth of a pond has an important bearing on the physical and chemical qualities of water. Ideal depth for different kinds of fish ponds from the point of view of congenial biological productivity are: Nursery Pond: 1 – 1.5 m, Rearing Pond: 1.5 – 2.0 m, Stocking Pond: 2.0 –2.5 m.

Ponds shallower than 1m get over heated in tropical summers inhibiting survival of fish and other organisms. Depths greater than 5 m are also not suitable for fish culture.

2.1.2) Turbidity - Ability of water to transmit the light that restricts light penetration and limit photosynthesis is termed as turbidity and is the resultant effect of several factors such as suspended clay particles, dispersion of plankton organisms, particulate organic matters and also the pigments caused by the decomposition of organic matter. Turbidity due to high concentration of silt, mud or algal growth causes death of fishes due to choking of gills.
Desirable limits - Boyd and Lichtkoppler (1979) suggested that the clay turbidity in water to 30 cm or less may prevent development of plankton blooms, 30 to 60 cm and as below 30 cm – generally adequate for good fish production and there is an increase in the frequency of dissolved oxygen problems when values above 60 cm.

Remedies

1. Addition of more water or lime (CaO, alum Al2(SO4)314H2O @ 20 mg and 1000m³ gypsum on the entire pond water at rate of 200 Kg/ of pond can reduce turbidity

2. Suspended particles may be settled by application of lime and algal bloom can be restricted by application of Takazine – 50 (Cymazine) @ 2-4 kg / acre

2.1.3) Temperature- Temperature is defined as the degree of hotness or coldness in the body of a living organism either in water or on land (Lucinda and Martin, 1999). As fish is a cold blooded animal, its body temperature changes according to that of environment affecting its metabolism and physiology and ultimately affecting the production. Higher temperature increases the rate of bio-chemical activity of the micro biota, plant respiratory rate, and so increase in oxygen demand. It further cause decreased solubility of oxygen and also increased level of ammonia in water.
Desirable limits- Bhatnagar et al. (2004) suggested the levels of temperature as 28-32°C good for tropical major carps; < –12° C lethal but good for cold water species; 25-30°C ideal for *Penaeous monodon* culture; <20°C – sub lethal for growth and survival for fishes and >35°C lethal to maximum number of fish.

Remedies- 1. By water exchange, planting shady trees or making artificial shades during summer's thermal stratification can be prevented.

2. Mechanical aeration can prevent formation of ice build-up in large areas of the pond.
2.2) Chemical parameter of water There are so many chemical parameter of water but few are the important which govern the survival and growth rate of the fish which are –

2.2.1) Dissolved Oxygen (DO) - Dissolved oxygen affects the growth, survival, distribution, behaviour and physiology of shrimps and other aquatic organisms (Solis, 1988). Value of dissolved O2 depends on temperature, partial pressure of O2 and water salinity. When temperature increases dissolved O2 decreases. Rate of respiration is more and rate of photosynthesis is low due to high temperature. At 00C, fresh water contains slightly over 2.0 mg/l O2 than sea water (35% salinity).

Indication of low Dissolved oxygen - If fish comes to the surface of water (figure 2) and secchi disk reading falls below 20 cm, fish swim sluggishly and are weakened.

Sources of Oxygen (O2): (i) Absorption from air at the water surface.
(ii) Photosynthesis of chlorophyll bearing organism inhabiting pond.

Consumption of Oxygen (O2): (i) Respiration of aquatic animals and plants in day and night.
(ii) Decomposition of organic matter* [Do not stock fish in newly constructed pond.

Desirable limits : Bhatnagar *et al*. (2004) also suggested that 1-3 ppm has sublethal effect on growth and feed utilization**;** 0.3-0.8 ppm is lethal to fishes and **>**14 ppm is lethal to fish fry, and gas bubble disease may occur; **>**5 ppm good for the production.

Remedies

(i) Avoid over application of fertilizers and organic manure to manage DO level
(ii) Physical control aquatic plants and also management of phytoplankton biomass
(iii) Recycling of water and use of aerators.
(iv) Artificially or manually beating of water.
(v) Avoid over stocking of fishes
(vi) Introduction of the hot water gradually with pipes to reduce if DO level is high.

2.2.2) Biochemical oxygen demand (BOD) -BOD is the measurement of total dissolved oxygen consumed by microorganisms for biodegradation of organic matter such as food particles or sewage etc. The excess entry of cattle and domestic sewage from the non point sources and similarly increase in phosphate in the village ponds may be attributed to high organic load in these ponds thus causing higher level of BOD.

Desirable limits - According to Bhatnagar *et al*. (2004) the BOD level between 3.0-6.0 ppm is optimum for normal activities of fishes; 6.0-12.0 ppm is sublethal to fishes and >12.0 ppm can usually cause fish kill due to suffocation.

Remedies- 1. Add lime/more, suspending use of fertilizers, and removal of no biodegradable / floating organic matter from the pond surface, aeration, screening or skimming to reduce BOD level.

2. Before stocking, pondwater may be allowed to stabilize for few days (5-15 days).

3. Add safe quantities of manure accordingly local conditions of pond in terms of differences in type of manure, water temperature and normal dissolved oxygen.

2.2.3) Carbon-dioxide (CO2) - Free carbon dioxide, highly soluble gas in water

Sources of CO2 in natural water

i) From atmosphere:

a) Through rain water contains 0.3 – 0.6 ppm.

b) Air in contact with water surface.

ii) Respiration of aquatic plants and animals.

iii) Decomposition of organic matter in water body.

Consumption of CO2 - Photosynthesis by aquatic plants and phytoplankton for production of carbohydrates.Carbon dioxide is present in three forms bound $CO3^{--}$, half bound HCO3 and free state CO2. When CO2 comes in contact with water, it produces carbonic acid H2O + CO2 = H2CO3. This displays its weak acidic character through dissociation.

$H2CO3 = H^{+} + HCO3^{-} + HCO3^{--}$

Desirable limits - 5-8 ppm is essential for photosynthetic activity; 12-15 ppm is sub-lethal to fishes and 50-60 ppm is lethal to fishes. (Handbook of fisheries and aquaculture)

Remedies

1. Proper aeration can “blow” off the excess gas
2. Check organic load and reduce the same by adding more water (no fish) and add Muriatic acid (swimming pool acid) to adjust the pH to about 5 or if possible remove the matter by repeated nettings.
3. Use of lime (CaCO3) or sodium bicarbonate (NaHCO3)
4. Application of potassium permanganate at the rate 250 g for 0.1 hectare.

2.2.4) pH -pH is measured mathematically by, the negative logarithm of hydrogen ions concentration. The pH of natural waters is greatly influenced by the concentration of carbon dioxide which is an acidic gas (Boyd, 1979).

Desirable limits - Fish have an average blood pH of 7.4, a little deviation from this value, generally between 7.0 to 8.5 is more optimum and conducive to fish life. pH between 7 to 8.5 is ideal for biological productivity , fishes can become stressed in water with a pH ranging from 4.0 to 6.5 and

9.0 to 11.0 and death is almost certain at a pH of less than 4.0 or greater than 11.0 (Ekubo and Abowei, 2011).

Table 1. PH range of water

pH Range	Productivity of water
<4	Acid death point
4-6	Slow growth rate
6-9	Best for the growth
9-11	Slow growth, lethal to fish over a long period exposure
>11	Alkaline death point

Remedies

1. Add gypsum (CaSO4) or organic matter (cowdung, poultry droppings etc.) and initial pre-treatment or curing of a new concrete pond to reduce pH levels.
2. Use of quicklime (CaO) to rectify low pH of aquatic body.

2.2.5) Alkalinity - Alkalinity is the water's ability to resist changes in pH and is a measure of the total concentration of bases in pond water including carbonates, bicarbonates, hydroxides, phosphates and borates, dissolved calcium, magnesium, and other compounds in the water.

A mixture of bicarbonate and carbonate alkalinity is generally encountered is waters of pH ranging from 8.4 to 10.5. At pH values lies than 8.3 but more than 4.5, partially no carbonate is present, but free CO2 and bicarbonates may be present.

$H2CO3 \text{ ® } HCO3^{-} + H^{+}$
$HCO3^{-} + H2O \text{ ® } H2CO3 + OH^{-}$
$CO3^{- -} + 2H2O \text{ ® } H2CO3 + 2OH^{-}$

Desirable limits- <20ppm indicates poor status of water body, 20-50 ppm shows low to medium, 80-200 ppm is desirable for fish/prawn and >300 ppm is undesirable due to non- availability of CO2.

Remedies

1. Fertilize the ponds to check nutrient status of pondwater
2. Alkalinity can be increased by calcium carbonate, concrete blocks, oyster shells, limestone, or even egg shells depending upon soil pH and buffering capacity.

2.2.6) Hardness- Hardness is the measure of alkaline earth elements such as calcium and magnesium in an aquatic body along with other ions such as aluminium, iron, manganese, strontium, zinc, and hydrogen ions. Calcium and magnesium are essential to fish for metabolic reactions such as bone and scale formation.

Table 2. Hardness level of water

Water quality	Hardness level (mg/l)
Soft water	0-50
Moderately soft water	50-100
Moderately hard water	100-200
Hard water	200-300
Very hard water	>300

Desirable limits

Hardness above 50 mg/L is good for good aquaculture. Very hard water cause osmoregulatory stress to fish. Hardness values less than 20ppm causes stress, 75-150 ppm is optimum for fish culture and >300 ppm is lethal to fish life as it increases pH, resulting in non-availability of nutrients.

2.2.7) Salinity - Salinity is defined as the total concentration of electrically charged ions (cations – Ca++, Mg++, K+, Na+ ; anions – $CO3^-$, $HCO3^-$, $SO4^-$, Cl^- and other components such as $NO3^-$, $NH4^+$ and PO_4^-). Salinity is a major driving factor that affects the density and growth of aquatic organism's population (Jamabo, 2008).

Fish are sensitive to the salt concentration of their waters and have evolved a system that maintains a constant salt ionic balance in its bloodstream through the movement of salts and water across their gill membranes.

Desirable limits

According to Meck (1996) fresh and saltwater fish species generally show poor tolerance to large changes in water salinity. Ideal levels of salinity as 10-20 ppt for *P. monodon*; and 25-28 ppt for *P. indicus*. Barman *et al*. (2005) gave a level of 10 ppt suitable for *Mugil cephalus* and Garg *et al*. (2003) suggested 25 ppt for *Chanos chanos* (Forsskal).

Remedies

1. Salinity is increased or diluted by replenishment of water.
2. Aeration is essential to equalise the water salinity all over the water column.

2.2.8) Nitrogen: - Nitrogen is available to plants in three forms Nitrate, Nitrite and Ammonium.
Free ammonia NH3- Ammonia is the by-product from protein metabolism excreted by fish and bacterial decomposition of organic matter such as wasted food, faeces, dead planktons, sewage etc. The unionized form of ammonia (NH3) is extremely toxic while the ionized form (NH4+) is not and both the forms are grouped together as "total ammonia".

Effect- Ammonia in the range >0.1 mg/l tends to cause gill damage, destroy mucous producing membranes, "sub- lethal" effects like reduced growth, poor feed conversion, and reduced disease resistance at concentrations. Fish suffering from ammonia poisoning generally appear sluggish or often at the surface gasping for air.

Table 3. Desirable limits of ammonia

Ammonia (mg/)	Effect
0·02-0·05	Safe concentration for many tropical species
0·05-0·4	Sub-lethal effect depending on the species
0·4-2·5	Lethal to many fish species

Control and treatments

1. Increase pond aeration.
2. Addition of liming agents such as hydrated lime or quick lime decreases ammonia and this technique is effective only in ponds with low alkalinity.
3. Formaldehyde and zeolite treatment. A dosage of 50 ml per 100 gallons to chemically bind up to 1 ppm of ammonia, can be useful and but also check the manufacturer's directions before use.
4. Regular water change out.

2.2.9) Nitrite (NO_2-N) - Nitrite is an intermediate product of the aerobic nitrification bacterial process, produced by the autotrophic *Nitrosomonas* bacteria combining oxygen and ammonia.

Effects- Nitrite can be termed as an invisible killer of fish because it oxidizes haemoglobin to methemoglobin in the blood, turning the blood and gills brown and hindering respiration also damage for nervous system, liver, spleen and kidneys of the fish.

Table 4. Desirable limits of nitrite

Range	Effect
0.02-1.0 ppm	lethal to many fish species,
>1.0 ppm	lethal for many warm water fishes
<0.02 ppm	Acceptable

Reducing the level of Nitrite

1. Reduction of stocking densities, Improvement of feeding, biological filtration and general husbandry procedures, Increase aeration to maximum, Stop feeding.
2. Addition of small amounts of certain chloride salts regular water change out.
3. Use of bio fertilizers to accelerate nitrification.

Nitrate (NO3-N) -Where ammonia and nitrite were toxic to the fish, Nitrate is harmless and is produced by the autotrophic Nitrobacter bacteria combining oxygen and nitrite.

Desirable limits – Meck (1996) recommended that its concentrations from 0 to 200 ppm are acceptable in a fish pond and is generally low toxic for some species.

Reducing the level of Nitrate

Dilution by water change (ensure water used for change has a lower nitrate level), Use of ion exchange materials, Increase plant density and by the use of denitrifying biological filtration nitrate concentration can be reduced.

2.2.10) phosphorus: Phosphorus is recognised to the most critical single factor in the maintenance of pond fertility. It occurs in three forms.

1. The soluble inorganic phosphate phosphorus (PO4)
2. Soluble organic phosphorus and
3. The particulate organic phosphorus occurring in plankton, detritus and sedimentation.

Out of these three forms, form PO4 i.e. soluble inorganic phosphate phosphorus or dissolved phosphorus takes part in production. It is required for cell division, preparation of fat, protein, high energy compounds (ATP, ADP, AMP) etc in the body.

Sources of phosphorus in natural water:
(i) Weathering of phosphorus bearing rocks (apetite)
(ii) Leaching of soils of the catchment area by rain
(iii) (Cattle drop, night soil) organic manure and inorganic fertilizers (SSP,

Nitrophosphate, DAP) added to the pond. Phosphorus pentaoxide is good for production in pond water.

Table 5. Desirable limits of phosphorus

Phosphorus range	Effect
<0.010 mg/l	Low productive
0.010-0.020	Medium productive
>0.020	High productive

Remedies

Use inorganic fertilizers to increase phosphorus level (N: P=15:30).

Primary productivity

This is the rate at which photosynthesis takes place. Primary productivity may be reported as net or gross. Net primary productivity represents the total amount of new organic matter synthesized by photosynthesis less the amount the organic matter used for respiration.

Table 6. Desirable limits of primary productivity

Primary productivity (mg C/L/day)	Effect
<1.5	Poor productive
1.5-10	Medium productive
10-25	High productive
>25	Very high productive

Remedies

1. Productivity can be improved by use of organic/inorganic fertilizers in ponds.
2. In case of plankton bloom / swarm; feed/manure application can be suspended for some time.

2.2.11) Plankton - Those aquatic pelagic organisms, which are carried about by the movement of the water rather than their own ability to swim are called planktons.

Desirable limits - Bhatnagar and Singh (2010) suggested the optimum plankton population approximately 3000-4500 No/L in pond fish culture.

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SINGLE CELL PROTEIN (SCP)- IMPORTANCE IN AQUACULTURE

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Abstract
With the increasing production in aquaculture the demand for high quality auqafeed, which should be rich in proteins will continue to grow. Hence various alternatives strategies are selected for the aquafeed to be used in aquaculture. The total protein which is extracted from the pure cultures of microorganisms is known as the single cell protein. The use of microorganisms (algae, bacteria, yeast, higher fungi) and their products as SCP has many benefits and is considered sustainable for the aquaculture production.The SCP is also termed as bioprotein, microbial protein or biomass. Along with having high protein content, the SCP also consists of fats, minerals and vitamins, carbohydrates, nucleic acids, also it is rich in high level of essential amino acids (lysine, methionine, and threonine).

Introduction

Today the rapid development of aquaculture is driving demand for more protein to feed fish and crustaceans. It is reported that as compared to other animal protein sector the aquaculture sector has grown faster and is still growing @ 7% compound annual growth rate over past two decades and it is predicted that by 2050 almost 15 million tons new protein will be required for the production in aquaculture sector. So this is a question of concern as to where it is going to come from?

In the aquaculture production, feed is of major cost and at the same time proteins and its ingredients play a very vital role in the aquaculture feed cost. As the diets of farmed fish are changing according to the change in environmental conditions, an efficient feed is must to maintain and manage the production cost which will enhance the sustainability of aquaculture. Thus, in response to decreasing fish stocks and increasing production of aquaculture globally, various research has been made in SCP, considering it as an alternate protein ingredient which will replace the fish meal and will be cost effective. Traditionally, many fish farmers depends on fish meal as it the most preferred protein ingredient in the culture of aquatic organisms, fish meal is rich in crude protein and in essential amino acids, due to this, it is challenging for the aquaculture industry to find alternatives of fish meal which could be cost efficient, sustainable and a renewable high protein ingredient.

SCP is a protein, produced in microbial and algal cells. SCP is considered very nutritional as consists of high levels of proteins, essential amino acids and nucleotide which is beneficial and economic too. It enhances the amino acid absorbing capacity of animals and also improves the food conversion ratio (FCR).It is studied that almost 50% of fishmeal can be replaced if there is efficient utilization of the SCP.

In the following article, certain points are discussed related to the use and benefits of SCP in aquaculture.

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Single cell protein

The single protein is produced from single celled organisms**.** Earlier it was known as '**Microbial Protein'.** The single cell protein term was introduced by Carroll L. Wilson in 1966. It was studied that first SCP termed as Pruteen was the first commercial SCP which was used as animal feed additive. Pruteen was produced from the bacteria ***Methylophilus methylotrophus*** which had 72% of protein content. Various microbial organisms (algae, bacteria, fungi and yeast) produce SCP and among all these microbial species fungi and bacteria are considered the most as it produces more protein, and has faster growth rate as compared to other microbial species.

Sources of single cell protein

1.Bacteria : Bacteria have a rapid growth rate and contains 50–80% protein on a dry weight basis and the content of essential amino acid is also high. About 3 % of methionine is higher in bacterial SCP as compared to the fungal and algal SCP. It also has high nucleic acid of about 8-12% especially having RNA, thus it is reported that processing is essential for the bacterial SCP before using it as a food or a feed. It is reported that the following bacteria, *Bacillus mergaterium*, *B. sustilis*, *Streptococcus faecium*, *Streptomyces* sp., *Thermomonospora* sp. and *Lactobacillus* sp. showed positive results in aquaculture**.** The bacterial substrate and their protein content is illustrated in **Table. 1.**

Table 1. List of bacteria and their substrate with protein content.

S.NO.	BACTERIA	SUBSTRATE	Protein content (%)
1.	*Methylococcaceae* family	C-1 compounds	67-73
2.	*Bacillus cereus*	Ram horn	68
3.	*Rhodopseudomonas gelatinosus*	Wheat bran	60.9
4.	*Methylomonas species*	Methane broth	69
5.	*Ralstonia species*	Natural gas	67-73
6.	*Bacillus licheniformis*	Potato waste	38
7.	*Escherichia coli*	Ram horn	66
8.	*Corynebacterium glutamicum*	Glucose	57-70
9.	*Methanomonas methanica*	Methane	70-80
10.	*Methylophilus methanotrophus*	Methanol	72
11.	*Bacillus pumilis*	Potato processing waste	46
12.	*Bacillus subtilis*	Ram horn	71

2. Algae: There are various types of algae which are cultured are utilized by animals and humans. The protein content of the algae can reach upto 70%. Algae are also a good source of fats like highly rich in omega-3 fatty acids, good source of mineral salts (7%), vitamins A, B, C, and E and chlorophyll **,**despite of being rich in protein content and fats.There are many algal species which are used as feed supplements in aquaculture like *Chlorella* sp., *Chondrus* sp., *Scenedesmus* sp., *Spirulina* sp. and *Porphyrium* sp. and these are considered as the best substitutes for the costly and conventional protein sources like fishmeal and soybean meal.

It was studied that the algae *Euglena gracilis* is preferred the most in the production of SCP as it high in protein content as well as has good digestibility the fish. It is said that the production of algae is only achievable in the regions which have suitable climatic conditions.

The algal substrate and their protein content is illustrated in **Table 2.**

Table 2. List of Algae and their substrate with protein content.

S. NO.	ALGAE	SUBSTRATE	PROTEIN CONTENT (%)
1.	*Spirulina species*	Carbon dioxide	51-71
2.	*Chlorella salina*	Alkaline waste effluent	55-60
3.	*Spirulina maxima*	Sunlight and carbon dioxide	60-71
4.	*Chlorella species.*	Carbon dioxide	62-68
5.	*Sargassum*	Carbon dioxide and Sunlight	47-51
6.	*Dunaliella*	Carbon dioxide and Sunlight	34.9

3.Fungi: The protein content of fungi ranged from 30 – 50% usually when it was mainly cultivated for the production of SCP also the amino acid content of fungi followed and matched the standards of FAO. Fungi protein is rich in lysine and threonine but their protein lack cysteine and methionine. The SCP produced from fungi is rich in vitamin mainly the vitamin B-complex. In aquaculture the widely used fungal species are *Aspergillus* sp., *Penecillium* sp., *Rhizopus* sp., *Scytalidium* sp., *Trichoderma* sp. which are very beneficial for the good production of aquaculture. The oil extracted from the fungi is considered as a rich alternative source of essential fatty acids such as DHA, EPA and ARA, these are very useful in the diet of broodstock and in the larval feed.

Table 3. List of fungi and their substrate with protein content

S.NO	FUNGI	SUBSTRATE	PROTEIN CONTENT (%)
1.	*Aspergillus flavus*	Rice bran	10
2.	*Aspergillus ochraceus*	Rice bran	10
3.	*Saccharomyces cerevisiae*	Orange pulp, molasses, brewer'	24
4.	*Yarrowia lipolytica*	Inulin, crude oil, glycerol waste hydrocarbons	48-54
5.	*Aspergillus niger*	Apple pomace, Banana waste, Rice bran, Potato starch	17-20
6.	*Trichoderma virideae*	Citrus pulp	32
7.	*Trichoderma harzianum*	Cheese whey filtrate	34
8.	*Penicillium citrinum*	Rice bran	10
9.	*Aspergillus oryzae*	Rice bran	10
10.	*Kluyveromyces marxianus*	Orange pulp, molasses, brewer's spent grain, whey, potato pulp	43-59
11.	*Candida utilis*	Poultry litter; Waste capsicum powder	29
12.	*Cladosporium cladosporioides*	Rice bran	10
13.	*Monascus ruber*	Rice bran	10
14.	*Candida tropicalis*	Molasses	56

Production of single cell protein

The microorganisms grows on the available wastes to increase their cell masses, in this way the resources of inorganic waste is transformed into a high rich protein biomass. All the industrial and agricultural waste can be utilized in the production of SCP and after the further processing turns it into edible product which can be utilized by the humans. During the process of SCP production a step of fermentation takes place, fermentation here is of two types- Solid state fermentation and Submerged fermentation.

In the solid state fermentation solid waste or solid substrate is used such as paper pulp, bran and bagasse whereas in the submerged fermentation liquid substrates or liquid waste is used such as broths. After the fermentation process is over, the biomass which is received after the fermentation of the waste is collected and can be utilized further, because it consist of high protein content.Then the collected biomass undergoes certain steps like purification, cell disruption, washing followed by protein extraction, this makes the production process easier. In the fig.1 general steps of SCP production is illustrated.

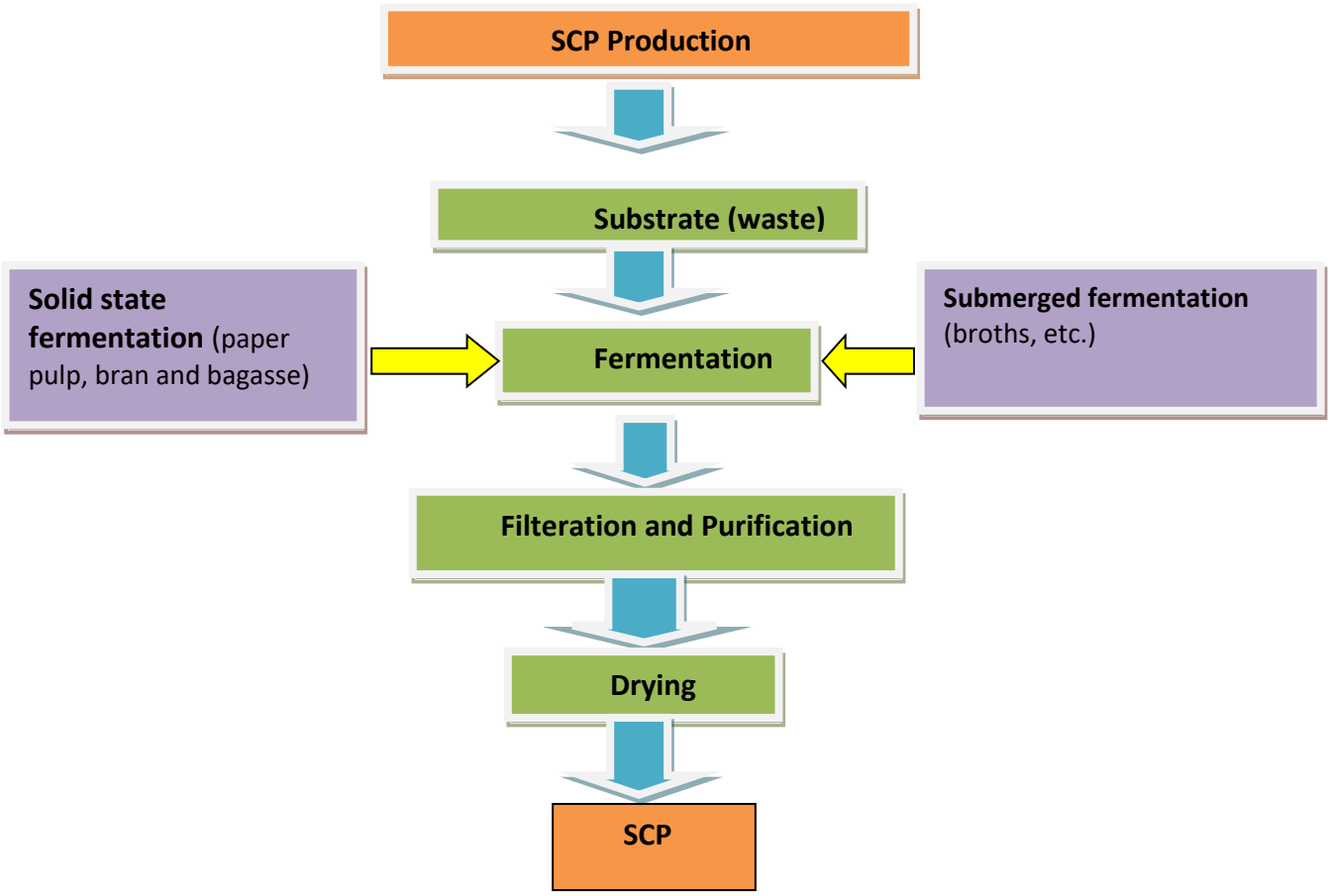

Fig 1. Steps of SCP production

Importance of single cell protein in aquaculture

The protein content in the aquafeed ranges from 35-60 wt% .And the most preferred feed in the aquaculture used as protein ingredient is fishmeal, which is also rich in essential amino acids along

with high crude protein. But today the fishmeal is being used in the feed of other animals too like in poultry, for swine feed, due to which the fishmeal is declining. In aquaculture to substitute fishmeal, farmers also use plant protein source in the feed, but to be compatible with the aquaculture diets the plant based ingredients need to be refined such as removing the phytic acid present in the plants which is anti- nutritional in nature and can harm the fish, the removal of the anti nutritional elements from the plants can be costly which many of the farmers cannot afford to do.Considering all these factors, the demand for more appropriate feed ingredient which should be rich in crude protein is increasing. Thus, SCP is considered as the most suitable protein source which can be used in the aquaculture, it benefits the aquaculture industry in many ways, improves fish health and most important is that SCP is economic.SCP being an alternative protein source in the aquafeeds, it also acts as a probiotic and as an immunostimulant which aid in the growth improvement, maintains the health of an organism and helps in disease prevention. It was studied that the nucleic acid (in the form of RNA) content is high in the SCP, which are produced from bacteria and yeast and the microorganisms which have large amount of RNA stimulate protein synthesis at a faster rate**.** The single cell microbes has two important factors, firstly the rapid protein synthesis and secondly shorter multiplication time, these factors are responsible for the high protein content in the single cell microbes.

As the SCP is rich in high nucleotide content, this when used as a aquafeed it improves the function of the fish liver and also boost the lipid metabolism in the fish. Like many other features the size and color of the fish is also regulated by the SCP which are produced from algae and bacteria because it consist of a carotenoid pigments, it is also used as a feed additive in the aquaculture. A summary of SCP sources with their special characteristics is presented in Table 4.

Table 4. SCP sources with their special characteristics

SOURCES OF SCP	Protein range (%)	CHARACTERISTICS	SPECIES
Algae	60-70	**-PRODUCTION OF:** I. omega-3 fatty acids (such as EPA and DHA). II. Carotenoids (astaxanthin) - phototrophic growth -antioxidant, -immunostimulant	*Desmodesmus* sp. *Chlorella vulgaris*
Fungi	30-50	- Production of vitamins and micronutrients.	*Candida utilis*
Bacteria	50-80	-production of high crude protein content	*Methylococcus capsulatus*

Conclusion

Single cell protein is an important source of nutrient supplement and an alternative protein ingredient in the aquaculture field also to meet the need for protein requirement for the long term alternate protein source need to be used because forage fisheries are either fully exploited to overexploited.

The microorganisms which occur naturally are used for the production of SCP, decreasing the input cost. Being a good protein source the nutritional value of SCP is very high, which improves

the immunity system of a fish. It helps in disease resistance and enhances growth and survival of an organism. The application of SCP in the feed industry helps in the production of organic food which is very beneficial for the health of a fish. Hence, the use of SCP in aquaculture increases the production which is economic and sustainable without having any negative impact.

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DIFFERENT WAYS OF FARMERS TO PAY DEBT

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Abstract
Debt is a condition in which one party owned money from another at specific interest rate and also have to pay them in certain time period. When a person take money he has two things first he has to pay the money he took and secondly interest of that loaned money or capital. In case of farmers mostly they have only farming as main source of occupation. In that case we can classify farmers into different groups or classes on the basis of the way he chooses to pay his debt. Broadly It can be classified into three groups which are- **ACTIVE PAYER, PASSIVE OR DORMANT PAYER** and lastly **INTERMEDIATE PAYER**. According to my studies it's found that intermediate payer is those who able to pay their debt at time, followed by other two.

Introduction

India is considered as LAND OF VILLAGE, where the occupation of maximum individuals is farming. A research shows that up to 70% of the farmers in India are marginal; they usually have landholding of less than 5 acres. Agriculture is considered as high input processes. It requires additional capital in different intercultural operational activity. In order to get higher yield famers must have to use different kind of resource.

Although in India government doesn't imposed tax on farmers, however in case of some resource like water and electricity they have to pay worth so as to utilize them (their price is different in different state). It observed that a median agricultural house in India has debt equivalent to 60 per cent of their annual financial gain. Consistent with the National Sample Survey, the annual financial gain of a farm house was Rs 1.23 lakh, and also the average debt was Rs 74,100 for the successive season from July 2018 to June 2019. Crops and wages are the two main source of farm income. Consistent with the survey, 50.2 per cent of Agri households in India are in debt(1).

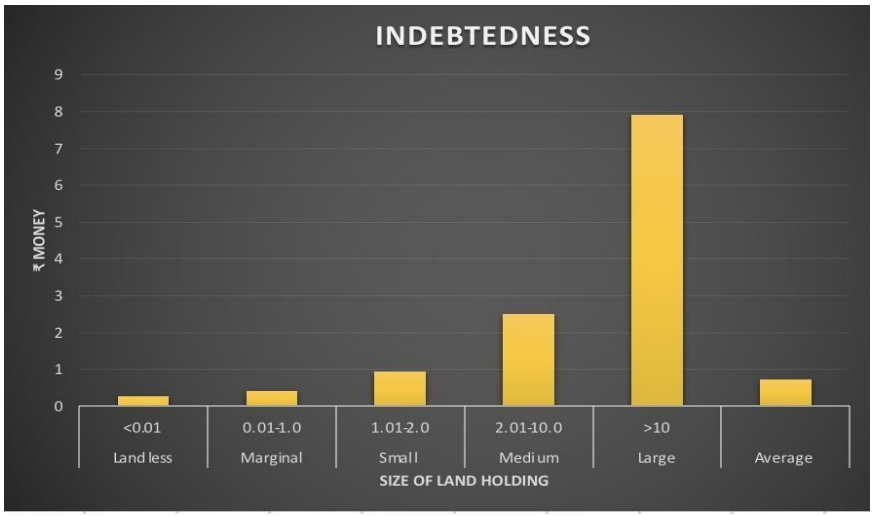

Fig.-1 show avg. annual income of farm household

Source: **https://www.indiatoday.in/amp/diu/story/indian-agriculture-debt-data-msp-farmers-protest-1878975-2021- 11-20**

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At the same time, state-wise knowledge reveals that Andhra Pradesh have higher debt percentage of about 93.2% and Avarage Farm household share debt a worth a price of Rs 2.45 lakhs, which is more then national average debt price of Rs 74,100. Followed by Telangana with debt share of 91.7 % and Kerala state secure third position with debt percentage share of 69.9. (2).

Agricultural indebtedness is one of the major issues of every developing country. Especially for those countries who have agriculture as main source of economy. Agricultural indebtedness has perpetually been a significant social and economic issue in India, despite the expansion of institutional credit to agricultural, indebtedness among farmers persists. This is often due to the transcendence of the deficit nature of rural family budgets especially the small and marginal agriculturists and all other farmers having poor means of income. The unpredictable weather, the burden of recent debt, an extended time gap between expenditure and financial gain from farming activities, the small size of land holdings, unproductive disbursement on social-ceremonies, a high rate of illiteracy are some of the important factors answerable for the agricultural indebtedness in India.

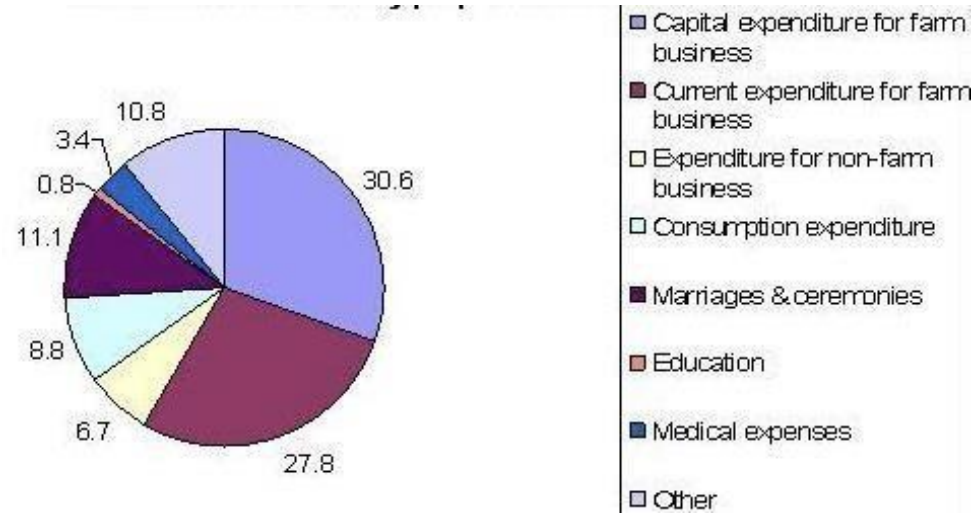

Fig.-2 Farmer's debt by purpose of loan in India
(source: https://www.macroscan.org/fet/sep05/print/prnt140905Farmers_Debt.htm)

According to NSSO 59th Round at all India level, regarding 59 per cent of the outstanding loans were taken from institutional sources, including Government (2.5 per cent), Co- operative society (19.6 per cent) and banks (35.6 per cent). Among the non-institutional sources, agricultural/ professional money lenders (25.7 per cent) had the foremost share in terms of outstanding loans. In keeping with NSSO 70th Round at all India level, about 60 per cent of the outstanding loans were taken from institutional sources which included Government (2.1 per cent), Co-operative society (14.8 per cent) and banks (42.9 per cent). Among the non-institutional sources, agricultural/ professional money lenders (25.8 per cent) had the major share in terms of outstanding loans.(3)

Source of loan	59th Round (%)	70th Round (%)	Increase/ Decrease (%)
Government	2.5	2.1	-0.4
Co-operative society	19.6	14.8	-4.8
Bank	35.6	42.9	+7.3

Source of loan	59th Round (%)	70th Round (%)	Increase/ Decrease (%)
Employer/ landlord	9	8	-1
Agricultural/Professional moneylender	25.7	25.8	+0.1
Shopkeeper/Trader	5.2	2.9	-2.3
Relatives & Friends	8.5	9.1	+0.6
Other	2.1	1.6	-0.5

Fig 3 : It show the comparative study between NSSO round 59th and round 70th, for the different sources of loan.
Source: http://www.allsubjectjournal.com/download/1316/110.pdf

In today's fastest growing world as development is at its peak, every sector is boosting so do agriculture sector also but this development result in increase the cost of resources. As the increase in cost of cultivation left farmers no choice but to invest more. A wealthy farmer can manage money crisis as they have previous saving but it's a huge concern for small or marginal farmers, as they left with no choice but to take loan or money from other sources. Once a farmer take loan then there are many ways one can pay it back and on this basis we classify them in different groups.

1. **ACTIVE PAYER:** This are those type of farmer who want to pay their debt as soon as possible but their approach is unproductive or unprofitable. They usually sale whole portion of agricultural produced soon after harvesting at ongoing market price. Here it's found that they won't save any quantity of their yield for future consumption and also not wait for market price to increase. For them price doesn't effect. Although its grate way of paying debt but the drawbacks with this type of payer is that – as they sale whole produced without saving any portion of it or money so in that scenario they again have to take loan or money for his future needs. ultimately they remain in debt all time but again this depend on the amount of previous debt or quantity of loan taken for future needs with respect to the agricultural produced.

   It is also found that this type of practice is more effective or profitable for those types of farmers whose income or financial gain is more than their debt.

2. **PASSIVE or DORMANT PAYER:** They are that sort of farmers or payer which doesn't sale their crop after harvesting or even sometime at MSP, however to keep them and solely sale once price of their crop is what they expected. It is found that they are in more loss then active payer, because as they don't sale their crop on time and wait for price to get high or what they expected price but it's not perpetually attainable and sometimes they even give up the good price in hoping for more. And on the other hand, due to not selling the crop at first place and not giving the loan refund on time, their interest amounts keep on increases. But this again depends on person experience and demand of its produced in its particular area and place. This approach is all about probability, there is half chance that famers might get good price or expected price for their produced and pay their loan money soon.

3. **INTERMEDIATE PAYER**: They are people with good management and financial skills. They

repay their debt soon from above both type of payer. This type of farmer basically sell whole crop after harvesting by keep a portion of crop or money which will full fill his future needs and requirement. In this group payer again can be classified into different classes on the basis of portion of crop or quantity they sale and at which time:

a. **Substantial seller** – This are those who sell much or maximum portion of crop at one's by saving only those or limited portion which will full fill needs.
b. **Abstract seller** – Although they also sell maximum portion of crop but they don't sell them together instead they sale them in chunks.

Equivalent seller -In this farmer's sell half of it's produced by saving other half of it.

Conclusion

In agriculture the one of the most resource is investment. If a farmer has enough money, he can use modern technology to increase its yield or make more profit.

When we talk about investment the first thing come to mind is debt.

According to my research in general all defaulter farmer can be broadly grouped into three classes on the basis of way to pay debt.

1) **Active payer**
2) **Intermediate payer**
3) **Dormant or passive Payer.**

In active payer they usually sell all the grain or crop without saving for future consumption or needs.

This kind of payer is also considered as RENEWAL PAYER because as they don't save anything for consumption purpose so they have to take again loan in order to fulfill their needs.

In case of dormant or passive payer they are usually don't sale their crop but instead they save them in order to sale when the price is high but the thing they don't look that their interest is also increasing so this type of payer hardly able to pay their debt.

Intermediate payer they are those who think and act precisely and effectively. They save some crop and saving for future consumption purposes. They usually sale maximum portion of their yield and save only which part that will help to run they basic family needs and farmer financial. The intermediate paying is best way to overcome from debt because by timely paying debt money will help in interest to lower down and also by saving money for future need eliminate future loan possibilities.

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