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THERMOTHERAPY: A NON-CHEMICAL OPTION FOR MANAGING SEED-BORNE BACTERIAL DISEASES

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Summary

Plant pathogenic bacteria are known to cause many important plant diseases resulting into about 6-100% yield losses. These losses can be minimized with use of healthy seeds and also using different methods of seed treatment. As, in the present day agriculture, use of eco-friendly measures for management of diseases are being practiced for crop production and use of chemicals are discouraged. For the management of seed borne bacterial diseases, thermotherapy is used. This is one of the best alternatives of chemical for seed treatment, as here heat is applied for managing seed borne pathogens.

Introduction

Seeds are regarded as highly effective means for the transport of pathogens over long distances. There are various examples in the past where contaminated and infected seeds were responsible for spread of plant disease over natural barriers and political borders (Table 1).Most bacterial diseases of annual plants are seed-borne and seed-transmission provides numerous foci of primary infection in the field and only a relatively small amount of infested seeds is sufficient to promote serious disease outbreaks. The bacterial diseases are of particular concern for the seeds because it is very difficult to control once they become established in the field as compared to the seed borne fungal diseases.

Table 1 : Seed-borne bacterial diseases of quarantine significance.

Pathogen/Disease	Origin	Year
Xanthomonas campestris pv. *campestris* (Black rot of crucifers)	Java	1929
Pseudomonas syringae(Leaf spot of sorghum)	South Africa	1934
Erwinia amylovora(Fire blight of pear)	England	1940
Agrobacterium tumefaciens (Crown gall of apple/pear)	England	1940
Xanthomonas oryzae pv. *oryzae* (Bacterial blight of paddy)	Philippines	1959

The pathogen associated with seeds are either transmitted as an infection or an infestation (Agarwal and Sinclair, 1996). Various bacteria commonly infect seeds internally often resulting in the destruction of endosperm and embryo or it may be simply external contamination where the pathogen remain associated with the seed coat. Use of chemical treatments, which sterilize the seed surface are often used, however, these chemicals do not reach the bacteria within the seed and not ecofriendly. Therefore, there are various methods used for the seed treatment and thermotherapy is one of the effective physical method for the control of seed borne diseases. Thermotherapy is based on the principle that"parasitic microorganisms often are killed, or viruses inhibited, at temperature time regimes only slightly injurious to the host" (Baker, 1962). Treating planting materials with heat is a one-century-old method of disease control that has proved to be efficient against various pathogenic microorganisms. Seed sanitization from diseases by heat treatment is used in the cases, where the pathogens have a lower tolerance to high temperatures than the infected seeds.

Methods of Heat Treatment

Hot water treatment : It is a technique of immersion of plant material in agitated water at temperature level detrimental for the pathogen but not for the seed. This hot water treatment is widely used for bacterial diseases of carrot, cassava, cotton, cowpea, crucifers, cucumber**,** guar, pumpkin, rice, sesamum, tobacco and tomato Table 2). This treatment can eradicate bacteria known to reside both inside and outside the seed (Sharma, 1981; Fatmi *et al*., 1991). For hot water of some seeds preheating of seeds is done and then actual heat treatment is given. For example, tomato seeds are treated against *Clavibacter michiganensis* subsp. *michiganensis*, *X. campestris* pv. *vesicatoria* and *P.syringae* pv. *tomato*, the seeds are pre-warmed in water at 37°C for ten minutes then placed in a water bath at 50°C for 25 minutes (Mtui*et al*.,2010). The effect of hot water treatment is variable with the type of seed like hot water treatment of tomato seed does not affect seed performance negatively, in fact seed viability and vigour is improved (Musazura and Bertling, 2012) on the other hand, pepper seeds do not respond well to hot water treatment; a decline in seed germination and vigour seems likely following such treatment. The advantage of hot water treatment is that the time of exposure is generally short because water is a good heat conductor. Moreover, as the treatment can penetrate the plant tissue, internal parasites are more likely to be affected. If proper drying of seeds is not done after hot water treatment, there are chances of development of saprophytic microbes. So the drying of treated material must be done rapidly after soaking. Drying may take a few hours or 1 or 2 days.

Fig. 1: Treatment tank for hot water treatment of different crops

Hot air treatment : The hot air treatment can be applied in simple ovens. This treatment is less injurious to seed and easy to operate. Heat transfer in hot air is less efficient than in water and treatments lasts longer than hot water treatments. For this treatment seeds can become dehydrated and they may require rehydration. Dry heat treatment has been successfully applied for management of bacterial diseases in barley, bean, cassava, cucumber, kidney, bean, pea and rice. Disadvantage of hot air treatment is the time of exposure, which is generally much longer than with hot water soaking; and after long exposures, progressive rehydration of the treated seeds may be necessary to get good seed germination.

Vapour heat treatment : An equipment is used for vapour treatment, where seeds are successively placed in a thin layer and treated homogeneously for some time with vapour injected from a steam generator. After treatment, seeds are placed in a cooling chamber for quick cool down and drying (Forsberg, 2004).The use of aerated steam is safer than hot water and more effective than hot air in controlling seed borne infections. The heating capacity of water vapour is about half that of water and 2.5 times that temperature control and no damage to seed coat of seeds. It has been used against citrus greening and for angular leaf spot of cucumber. The main disadvantages of vapour heat are that using this type of thermotherapy requires specific equipment that can be expensive, and that some kinds of plant material would be seriously damaged.

Microwave treatment : Microwave radiation may be a low-cost addition to current chemical treatments in reducing or eliminating seed-borne pathogens, without affecting seed germination. These practices have been used to eradicate seed borne bacterial pathogens of Bean, tobacco, cassava and some other agricultural crops, but results are variable.

Table 2 : Hot water treatment schedule adopted for seed-borne bacterial pathogens.

Pathogen	Disease	Crop	Temp. (˚C) (time)
Clavibacter michiganensis subsp.*michiganensis*	Bacterial canker of *tomato*	Tomato	HW 53-56 (10-60 min)
Pectobacterium carotovorum subsp. *carotovorum*	Soft rot and black leg	Tobacco	HW 50 (12 min), Microwave radiation (20 min)
Pseudomonas fuscovaginae	Sheath brown rot of rice	Rice	DH 65 (6 days)
Pseudomonas glumae	Bacterial Grain Rot of rice	Rice	DH 65 (6 days)
Pseudomonas savastani pv. *glycinea*	Bacterial blight of soybean	Soybean	Naturally infected seeds are stored for 3 days at 50 and 75% relative humidity
Pseudomonas syringae pv. *lachrymans*	Angular Leaf Spot of cucumber	Cucumber	HW 53(60 min) or steam 85(60 min) HW 52 (10 min) or 54 (5 min)
Pseudomonas syringae pv. *phaseolicola*	Halo blight of bean	Bean	Inoculated seeds (vacuum infiltration) are stored 3 days at 50 and 75% relative humidity DH 50 (72 h) or 60 (24 h)
Pseudomonas syringae pv. *pisi*	Pea bacterial blight.	Pea	DH 65 (72 h) HW 55 (15 min)
Pseudomonas syringae pv. *tomato*	Bacterial speck disease of tomato	Tomato	HW 48 (60 min), 50 (30 min)

Pathogen	Disease	Crop	Temp. (˚C) (time)
Xanthomonas axonopodis pv. *phaseoli*	Common bacterial blight	Bean	HW 60 (20 min)
Xanthomonas campestris pv. *campestris*	Black rot	Crucifers	HW 50 (20 or 30 min) or 52 (30 min)
Xanthomonas axonopodis pv. *cyamopsidis*	Bacterial blight of guar	Guar	HW 56 (10 min)
Xanthomonas axonopodis pv. *manihotis*	Cassava bacterial blight	Cassava	HW 50-60 (30 min) Microwave oven treatment (1400 W) heating power, 2450 MHz) for 120 s
Xanthomonas axonopodis pv. *viginicola*	Cowpea bacterial blight	Cowpea	HW 50 (30 min) HW 52 (10 min)
Xanthomonas campestris pv. *cucurbitae*	Bacterial spot	Pumpkin	HW 54 and 56 (30 min)
Xanthomonas campestris pv. *malvacearum*	Angular leaf spot of cotton	Cotton	HW 56 (10 min)
Xanthomonas campestris pv. *sesami*	Bacterial Blight of sesamum	Sesamum	HW 52 (10 min)
Xanthomonas campestris pv. *translucens*	Leaf streak disease of rice	Rice	HW 52 for 30 min
Xanthomonas campestris pv. *translucens*	Bacterial blight of barley	Barley	DH 72 (4 days)
Xanthomonas campestris pv. *vesicatoria*	Bacterial leaf spot	Tomato	Seeds extracted without fermentation and treated in hot water
Xanthomonas hortorum p v. *carotae*	Bacterial blight of carrot.	Carrot	HW 52 (10 min), HW 52 (25 min)
Xanthomonas oryzae pv. *oryzae*	Bacterial blight of rice	Rice	Soaking seeds at room temperature for 12 h, then 53 (30 min)

**HW- Hot water and DH- Dry Heat* *(Source: Grondeau et al., 1994)*

Small size seeds are good candidates for thermotherapy because there are common bacterial diseases of these small seeded crops (tomato, tobacco, rice, barley, cucumber, crucifers, pumpkin, guar, and cotton) mostly caused by the genera Xanthomonas and Pseudomonas and large seeded crops (beans, cucurbits, peas, soybean, etc.) can not be effectively treated with hot water because the temperature required to heat the whole seed inside and out would kill the outer seed tissue and affect the seed germination. Nega *et al.* (2003) recommended that for high treatment temperatures a shorter duration is needed especially with sensitive crops such as brassicas.

Conclusion

The infected seeds act as inoculum in the field, besides traditional seed treatment with chemicals other eco-friendly methods like thermotherapy is proved to reduce the primary inoculum of the bacteria, thus a very important prophylactic measure for the management of the disease. This method is an easy to use, inexpensive and environment friendly method of seed treatment. This method is very useful when the disease is difficult to control by any other mean and provides improved stand quality and yield of the crop. This article provides easy method to the farmers to protect various crop with different seed borne bacterial diseases.

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CONTRIBUTION OF ORGANIC FERTILIZERS IN ORGANIC FARMING

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Many problems are associated with the increased use of chemical fertilizers in farming. As a result, emphasis is being laid on organic farming and the use of bio-fertilizers. Recently, a large number of bio-fertilizers have started becoming available in the market in India. Farmers are constantly using them in their fields. It is also reducing soil nutrient replenishment and dependence on chemical fertilizers. While the use of chemical fertilizers increases the yield, but more use also adversely affects the fertility and structure of the soil, so the possibilities of using bio fertilizers along with chemical fertilizers are increasing. With the supply of nutrients to the crop using soil biofertilizers, the soil increases the yield.

It was known to people for a long time that pulses increase the fertility of the soil. But the scientific demonstration of this fact was achieved only after half of the 19th century had passed. The knots are formed for nitrogen fixation in the roots of pulses plants. The family leguminosae is divided into three subclass - Mimosidi, Sijalpinidi and Papilionidi. Nodes are formed for nitrogen fixation in the roots of 90 percent of mimosidi and 23 percent of cajalpinidi and 97 percent of the members of papillonidi.

Microorganisms as organic fertilizers

Bio-fertilizers are a type of organisms that enhance the nutritional quality of the soil. These are the main sources of bacteria, fungi and cyanobacteria. The glands located on the roots of the dicotyledonous plants are formed by symbiotic association of Rhizobium. These bacteria stabilize atmospheric nitrogen and convert it into organic form, which plants use as nutrients. Other bacteria (such as Azospirillum and Azotobacter) live in the soil. It can also stabilize atmospheric nitrogen. Thus the nitrogen content in the soil increases.

Friendly fungi (such as mycorrhiza) establish symbiotic relationships with plants. Many members of the genus Glomus make mycorrhiza. In this symbiosis, fungi absorb phosphorus from the soil and send it to the plants. Tactile plants from such relationships exhibit many other benefits such as immunity to root-bearing pathogens, salinity and tolerance to drought, and growth and development.

Cyanobacteria are autotrophic microorganisms that are widely found in aquatic and terrestrial atmospheres. Many of these can stabilize atmospheric nitrogen, such as Anabina, Nostock, Oscillatoria, etc. Cyanobacteria play an important biofertilizer role in paddy fields. Blue green algae also add organic matter to the soil. Which increases its fertility.

Bio fertilizer

By using bio-fertilizers in crops, nitrogen present in the atmosphere is readily available (in the form of ammonia) to the plants and the nutrients already present in the soil are easily available to the plants by changing the soluble state to insoluble phosphorus. Since microorganisms are natural, hence their use increases the fertility of the land and does not adversely affect the environment. One can get better results by using biofertilizers as a supplement to chemical fertilizers (not as an alternative).

In fact, bio-fertilizers are a mixture of special and any moisture-bearing substances. Bio-fertilizers are prepared by mixing specified amounts of special micro-organisms in a moisture-bearing dusty substance (charcoal, lignite, etc.). It is usually available in the market in the name of 'pure culture' which is a natural product. They can be used for partial supply of nitrogen and phosphorus in various crops. By their use, the physical and biological properties of the land are improved and its fertility increases. Bio-fertilizers have an important role in organic farming.

The first legume Rhizobium symbiosis in India was studied by Shri NV Joshi. Its first commercial production started in the year 1956. During the 9th Five Year Plan of the Government of India, the Ministry of Agriculture started the work of generating awareness among the people by promoting it realistically through a national project for the use and development of bio-fertilizers.

Types of Organic Fertilizers

1. Azolla : Azolla is a floating fern of the group Teridophyta. Azola is generally grown in paddy fields or shallow water. It grows rapidly. The petals of Azolla contain a microorganism belonging to the genus Neel green moss called Anabina which fixes atmospheric nitrogen in sunlight and supplies nitrogen to the crop like green manure. The specialty of Azolla is that it grows twice as large in 5 days in a favorable environment. If it is allowed to grow throughout the year, more than 300 tonnes of azolla can be produced per hectare i.e. 40 kg of nitrogen per hectare. Azolla contains 3.5 percent nitrogen and a variety of organic materials that increase the fertility of the soil. With the use of Azolla, 5-15% production growth is possible in paddy crop.

It can be used easily in paddy field. In a field filled with 2-4 inches of water, 10 tons of fresh azolla is put before planting. Along with this, 30-40 kg of super phosphate is sprayed on it. The temperature of 30-35 degree Celsius is very favorable for its growth.

2. Algae : Indigo green algae (cyanobacteria) is a bacterium that produces energy from photosynthesis. It is named cyano (Greek meaning blue) due to the blue color of the bacteria here. Cyanobacteria secrete vitamin 12a auxin and ascorbic acid, which aid the growth of paddy plants.

Neil green algae supplement the nitrogen in paddy crop in partial quantity by rationalizing atmospheric nitrogen. This organic fertilizer is a cheap and accessible alternative to nitrogen-containing chemical fertilizer, which not only supplies 25-30 kg of nitrogen per hectare to the paddy crop, but also the quality and quality of the fertilizer made from the fertilizer of indigo green moss in that paddy field. Proves to be helpful in maintaining fertility.

3. Azotobacter : Azotobacter is a highly heterotrophic bacterium. These are free-living micro and pneumatic bacteria that freely carry out biological immobilization of nitrogen without any symbiosis. It is found only in the rhizosphere. This property is not commonly found in the rhizoplane. Basic secretions that contain amino acids, sugars, vitamins, and organic acids are helpful in the multiplication of Azotobacter.It also secures nitrogen fixation as well as plant growth hormones (indole acetic acid and gibberellic acid) and some antibiotics that are used in plant growth. Which has a good effect on the germination of seeds and prevents many diseases occurring in the roots. Azotobacter can be used in all non-pulse crops. In which cereal crops, vegetables, cotton and sugarcane are the main ones. ***Bijeric*** first discovered and described the bacterium Azotobacter.

4. Azospirillum : It is also a nitrogen fixing microbial which is beneficial for non-pulse plants. These microorganisms also secrete organic nitrogen fixation as well as plant growth hormones which are beneficial from germination to plant growth.

5. Phosphate soluble microorganisms : It is a group of micro-organisms that increase the efficiency of fertilizer by converting it into insoluble phosphate present in the soil. In alkaline soil, phosphate availability is low. This microbe is very beneficial in reversing the whole process. When PSM is used with rock phosphate, the requirement of phosphatic fertilizer like single super phosphate can be reduced by about 50 percent. The culture of phosphate solubilizing bacteria is found in the market as PSB culture. This culture is a compound of phosphorus dissolving bacteria. This increases both production and productivity without pollution, as well as health of the soil.

Plants easily absorb phosphorus using PSB. By using it, 10-20 percent production is increased and at the same time 30-40 percent phosphorus fertilizer can be saved by the unavailability of available phosphorus in the soil.

6. Actinorhiza : Bacteria belonging to the actinomycetes group that make nitrogen fixation by forming knots in the roots of the sapling tree are called actinorhiza. Frankia is a very good example of this. Frankia performs nitrogen fixation in more than 280 tree species of 8 different plant clans.

Method of use organic fertilizers

Organic fertilizers are used in farming in four different ways:

1. **Seed treatment method :** This is the best method of using bio fertilizers. Mix about 50 grams of jaggery or gum in ½ liter of water and boil it, after cooling it, mix the bio fertilizer (200 grams) and mix it well. Sprinkle this solution on 10 kg of seeds and mix it well, so that each seed can be coated with it. After this, seeds are dried in a shady place. Sowing of treated seeds should be done immediately after drying.
2. **Plant root treatment method :** In paddy and vegetable crops whose plants are planted such as tomato, cauliflower, cabbage, onion etc. the roots of the plants are treated by bio fertilizers. For this, in a wide and shallow vessel, make a solution by mixing one kilogram of Azotobacter and one Kg PSB with 250 grams of jaggery in 5-7 liters of water. After this, after uprooting the plants from the nursery and after clearing the soil at the roots, bind 50-100 in a bundle and immerse the bacteria in the fertilizer solution for 10 minutes.
3. **Tuber treatment :** Tubers are treated for the use of bio-fertilizers in crops such as sugarcane, potato, ginger, One kg of Azotobacter and one kg of PSB mix the bio fertilizers in 20-30 liters of solution. After this, soak the tubers for 10 minutes. Immediately after transplanting.
4. **Soil treatment method :** Prepare a mixture of 5-10 kg of bio-fertilizer and 70-100 kg of soil or compost and leave it overnight. After this, they mix it in the field at the final plowing.

Benefits of using bio fertilizers

- Using these increases the yield by about 10-15 percent.
- These chemical fertilizers especially fulfill nitrogen and phosphorus needs up to 20-25 percent.
- Use of these leads to quick germination and increase in the number of buds.
- Increases the fertility of the ground.
- Use of these increases the amount of sugar in sugarcane, starch in maize and potato and oil in oilseeds.

Precautions in the use of organic fertilizers

1) Keep bio fertilizer in a dry place under shade.
2) Choose bio fertilizer according to the crop.
3) Use appropriate amounts.

4) While purchasing bio fertilizer, carefully check the date of making the name of the fertilizer and the name of the crop, etc.
5) Do not use bio fertilizer after the expiry date.

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ZERO BUDGET NATURAL FARMING: NEED OF THE HOUR

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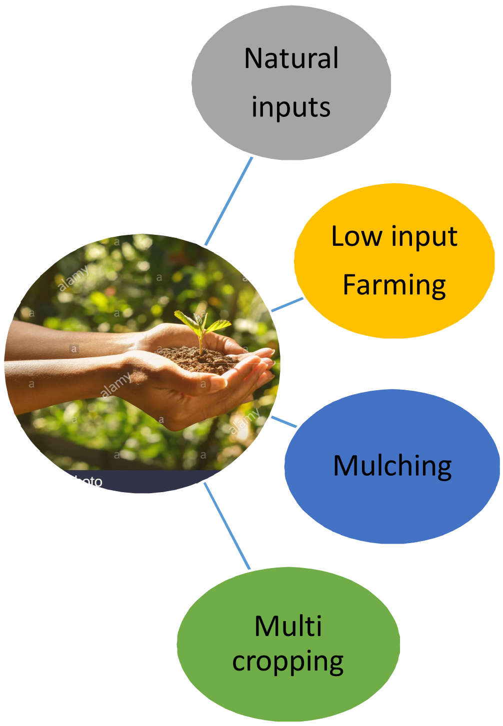
Introduction

Zero Budget Natural Farming (ZBNF) or holistic agriculture is a method of agriculture that counters the commercial expenditure and things required for the growth of plant are present around the root zone. Other hand is a method of chemical-free agriculture having its origin in India. This method is promoted by agriculturist and Padma Shri recipient **Subhash Palekar** during Green revolution's time to protect farmers from excessive investment in seeds, fertilizer and irrigation. In this method of farming the cost growing and harvesting crop is zero.

AIM

This model eliminates the cost of fertilizer, pesticide and seeds and greatly reduce the incentive to borrow, one of the chief causes for farmer suicides in the country.

Principles



Natural input

Natural farming does not require chemicals inputs or organic compost like vermi-culture (S. Palekar considers these external inputs as destructive as chemicals) but promotes a natural catalyst of biological activity in the soil and natural protection from diseases.

Low Input farming

The production cost for the farmer is zero as no input needs to be purchased. As **1.5 to** 2.0 *o/c* of the nutrients are taken from the soil by the plant, there is no need to add fertilizers. These nutrients provided by nature (as in the forest) are totally free of cost.

Soil mulching

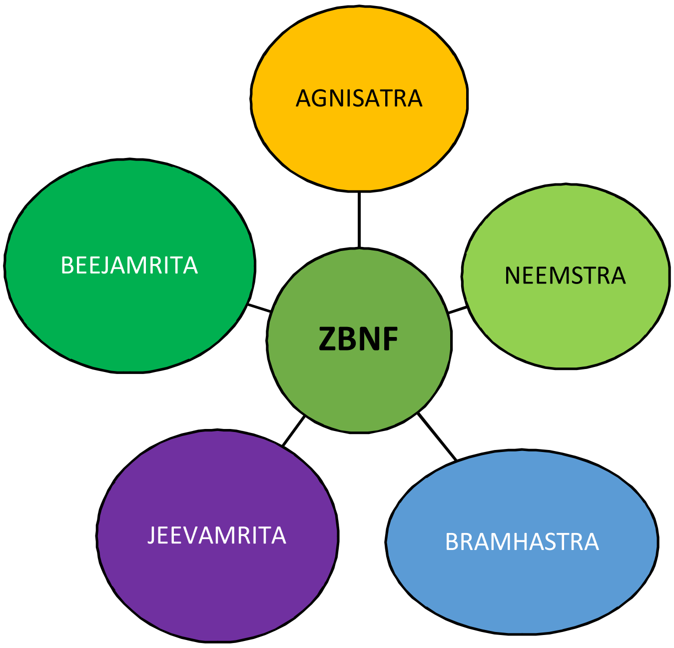
It is necessary to create the micro climate under which micro-organisms can well develop, that is 25 to 32 °C temperature, 65 to 72 % moisture. It creates darkness and warmth in the soil. Its conserves humidity of the soil, cools it promotes its micro-organisms. Mulching promotes humus formation, suppresses weeds and maintain the water requirement of crops.

Multicropping

Multicropping is a good way to minimize the risks for the farmer who is able to enjoy continuity of yield throughout the year. In case of crop`s failure he can also rely on the other crops. It has expanded farmers income sources.

Application

ZBNF promotes the application of **Jeevamrutha** - a mixture of fresh desi dung, aged desi cow urine, jaggery, pulse flour, water and soil on farmland. It adds nutrients to soil, and acts as a catalytic agent to promote activity of microorganisms and earthworms in the soil.



Bijamrita, is used for seeds. Water vapour condensation for better soil moisture. Concoctions using neem leaves and pulp, tobacco and green chillies are prepared for insect and pest management.

Needs

According to NSSO data, almost 70% of agricultural households spend more than they earn and half of all farmers are in debt. This method also promotes soil aeration, minimum watering, intercropping, bunds and topsoil mulching and discourages intensive irrigation.

Benefits

An approach towards sustainability. Expense-free farming up to 30 acres with one native cow. Farming with minimum electricity and water consumption. Producing quality, poison-free food. Agriculture without external input. Techniques of multi-crop cultivation for higher net income. Reducing external labor requirement. Farming in tune with nature. Saving the farmers from suiciding themselves and leaving behind their families as beggars.

Criticisms

There is no scientific proof that yields will not be affective. We don't have any idea regarding the long-term impact and viability of the method. Some experts from NITI Aayog pointed out that India needed the green revolution in order to become self-sufficient and ensure food security**.**

Government Initiatives in the Field

Rashtriya Krishi Vikas Yojana (RKVY) scheme the projects of organic farming decided by respective state level sanctioning committee (SLSC) according to their priority.

Paramparagat Krishi Vikas Yojana (PKVY)'s guidelines of 2018 promoting various organic farming models like Natural farming, Rishi farming, Vedic farming, Cow farming, Homa farming, Zero budget natural farming etc.

Conclusive Remark

Savings on cost of seeds, fertilizers and plant protection chemicals has been substantial. Because of continuous incorporation of organic residues and replenishment of soil fertility. Helps to maintain the soil health. The new system of farming has freed the farmers from the debt trap and it has instilled in them a renewed sense of confidence to make farming an economically viable venture. In order to realize central government's promise to **double the farmers income** by 2022, one aspect being focused is methods of natural farming which will reduce the dependence of farmers on the loan.

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CLIMATE-RESILIENT ADAPTATIONS OF FARMED FISH FOR CLIMATE-SMART AQUACULTURE

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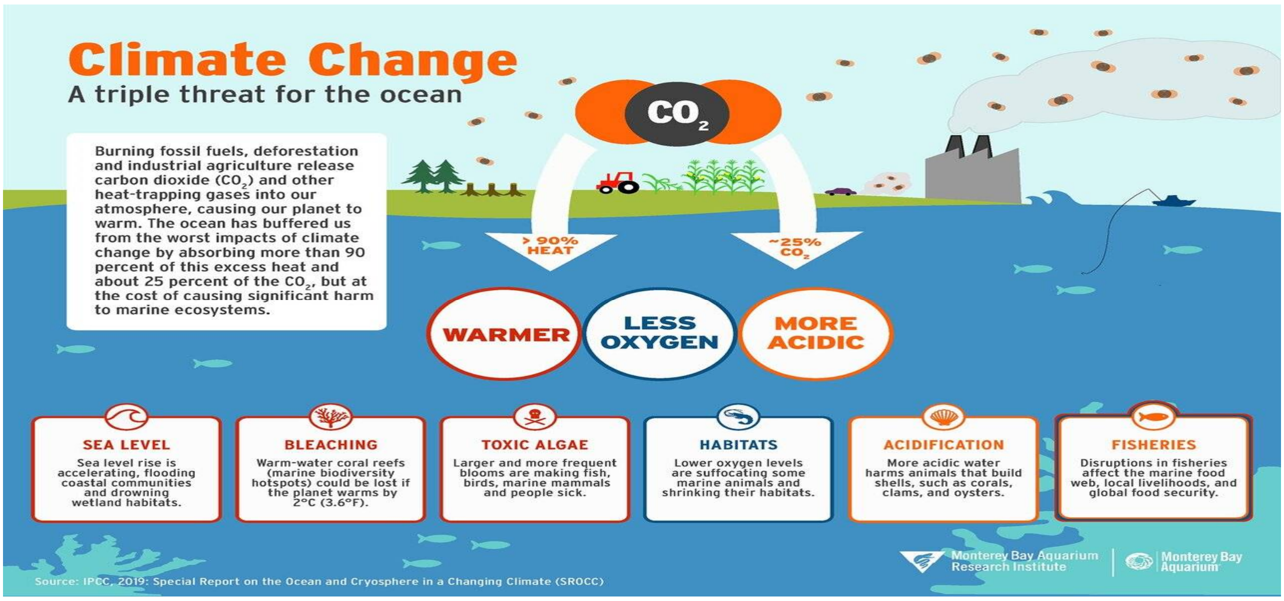
Introduction

The climate-resilient adaptations in farmed fish for climate-smart aquaculture are strategies which help to improve food security for the world's growing population under changing environmental conditions. People worldwide believe fish as a primary source of protein and income, supporting a rapidly growing aquaculture industry that gives roughly half the world-wide fish supply. In an era of world-wide global climate change and high demand for animal protein, increasing the assembly of fish through sustainable and environmentally sensitive practices is critical. The development of climate-smart aquaculture can provide responsible management strategies to the aquaculture industry. One aspect of this effort involves expanding the culture of climate resilient species with characteristics such as tolerance for hypo saline conditions, wide temperature ranges, and the ability to breathe air. Incorporating the culture of air-breathing species like the Pangasius catfish into climate-smart aquaculture not only provides the potential to grow local economics, it also can address a number of the concerns about environmental threats by taking advantage of the evolutionary ecology of those species in their natural environments. However, it is also necessary to fully understand the positive and negative tradeoffs associated with increasing fish production to ensure that practices remain environmentally and socially responsible.



Climate Changes effect on aquaculture

Aquaculture, like agriculture and other human activities, will face the consequences of long-term global climate change. Among the myriad challenges, global temperature increases ocean acidification, and water level rise will affect the world's coastal and inland aquaculture operations, much of which occur in poorer countries. Temperature changes will test the resiliency of domesticated varietals. The shifting distribution of global freshwater supplies and habitats will pose challenges as well as new opportunities for the aquaculture industry, small farmers, and the market place.

Strategies of aquaculture system

1. Physical modifications

- Planting shade plants, trees and around ponds to reduce thermal stress.
- Land shaping and construction of dykes with higher elevation
- Pond construction in fallow lands for fish farming and irrigation while the surrounding land can be raised with the excavated material and used for growing vegetables.
- Bamboo pens with trap doors can be built next to homes and stocked with some fish, and then when seasonal floods come the fish are not washed away and new fish also introduced via floodwater.

2. Species diversification

Climate resilient species and naturally tolerant varieties are good candidates for future aquaculture, species that are adaptive to the changes must be developed through research.

3. Selective breeding

4. Climate adaptive integrated aquaculture

5. Feed strategies

Research challenges and opportunities involve:

- In the aquaculture sector developing and refining cultivation techniques for new species, such as air-breathing fishes.
- Cultivation of indigenous species for contributing to the development of local communities and protecting ecosystems.
- Understanding the social, cultural, and economic impacts of climate change on the aquaculture industry and communities.

Climate Resilience in farmed fish

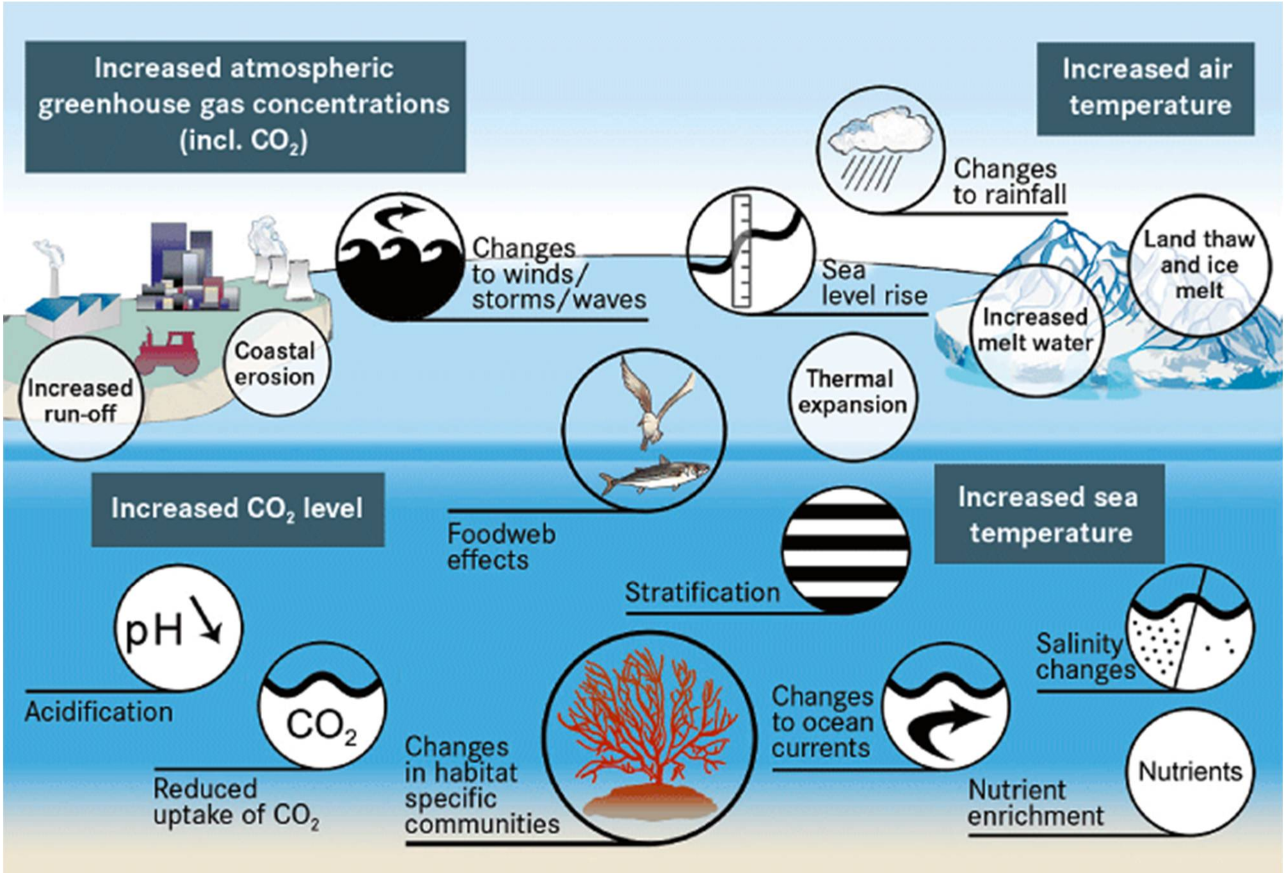
The step towards implementing climate-smart aquaculture includes diversification of the industry throughout climate resilient species and varietals that are also excellent candidates for aquaculture. Taking into consideration the dynamic tradeoffs, exploration of climate resilient fish for fisheries can embrace the optimization of previously cultured species, creating sustainable options for new species, and evaluating the socio-ecological impacts. Some of the climate resilient species under investigation by the aqua fish (showed below) incorporate a range of air-breathing fishes that are more able to resist most of the predictable impacts of climate change such as increased water temperature and poor water quality.

1. African Lungfish (*Protopterus aethiopicus*)
2. Giant Snakehead (*Channa striata*)
3. Pangasius Catfish (*Pangasius hypopthalamus*)

EAA to build climate change resilience

To build resilience to the effects of climate change and to derive sustainable benefits, fisheries and aquaculture managers, as a top priority, need to adopt and adhere to best practices such as those described in the FAO Code of Conduct for Responsible Fisheries and the EAA. Progress in this direction would be an important contribution towards maintaining biodiversity, preserving the resilience of human and aquatic systems to change, and improving our capacity to anticipate and adapt to inevitable climate induced changes in aquatic ecosystems and the related fisheries production systems. Some direct potential benefits of implementing the EAA include:

1. Creating resilient ecosystems, human, and governance communities through (i) Decreasing the exposure of the sector by increasing the aquatic systems resilience (ii) Decreasing the communities' sensitivities to change; as well as by (iii) Increasing the sector's adaptive capacity;
2. Supporting intersectoral collaboration e.g. integrating fisheries and aquaculture into national climate change adaptation and disaster risk management strategies and supporting integrated resource management, such as integrated coastal zone or watershed management, water planning.
3. Promoting integrated monitoring and information systems - incorporating scientific and local knowledge sources;
4. Improving general awareness of climate change within and outside the sector.
5. Promoting context specific and community-based adaptation strategies.
6. Avoiding "mal-adaptations" (e.g. overly rigid fishing access regimes that inhibit fisher migrations, adaptation actions that would increase fishing effort in an over-fished fishery).



Implications for aquatic systems

Occurrence of different effects due to climate changes in aquatic systems can be mitigated with the help of following implications-

1. Hydrological cycle and rainfall patterns
2. Water temperature
3. Oxygen content

4. Ice coverage
5. Sea level
6. Ocean circulation
7. Ocean acidification
8. Primary production

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AQUIFER OVEREXPLOITATION: CAUSE OF RIVER DRYING

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Abstract

Groundwater is the dominant source of freshwater. In a number of places water is being pumped from beneath the ground faster than it is being replenished through rainfall. The result is sinking water tables, empty wells, higher pumping costs and, in coastal areas, the intrusion of saltwater from the sea which degrades the groundwater. Most groundwater can no longer be used for domestic consumption or irrigation because of saline intrusion, and the country has resorted to desalination. Intrusion of saline water due to excessive extraction of water is also a problem in Asian countries. Sinking water tables can also make rivers less reliable, since many river flows are maintained in the dry season by springs that dry up when water tables fall.

Keywords

Groundwater, Aquifer, Overexploitation, Irrigation, Pumping

Introduction

Groundwater overexploitation and aquifer overexploitation are terms that are becoming common in water-resources management. Hydrologists, managers and journalists use them when talking about stressed aquifers or some groundwater conflict. Overexploitation may be defined as the situation in which, for some years, average aquifer abstraction rate is greater than, or close to the average recharge rate. But rate and extent of recharge areas are often very uncertain. Besides, they may be modified by human activities and aquifer development. In practice, however, an aquifer is often considered as overexploited when some persistent negative results of aquifer development are felt or perceived, such as a continuous water-level drawdown, progressive water-quality deterioration, increase of abstraction cost, or ecological damage. But negative results do not necessarily imply that abstraction is greater than recharge. They may be simply due to well interferences and the long transient period that follow changes in the aquifer water balance. Groundwater storage is depleted to some extent during the transient period after abstraction is increased. Its duration depends on aquifer size, specific storage and permeability. Which level of "aquifer overexploitation" is advisable or bearable, depends on the detailed and updated consideration of aquifer-development effects and the measures implemented for correction. This should not be the result of applying general rules based on some indirect data. Monitoring, sound aquifer knowledge, and calculation or modelling of behaviour are needed in the framework of a set of objectives and policies. They should be established by a management institution, with the involvement of groundwater stakeholders, and take into account the environmental and social constraints.

Overexploitation of groundwater resources - also named groundwater mining because a non-rechargeable portion of extracted groundwater is lost - causes mostly long-term transient hydrodynamic conditions and provokes hydraulic short cuts between different aquifer systems. This may lead to undesired water quality and quantity changes. Often overexploitation of groundwater resources exceeds the available groundwater recharge only slightly. It may even not result in an immediate draw down of the groundwater table because the aquifer is linked to adjacent aquifers substituting the missing ground waters.

Rivers are three dimensional dynamic systems dependent on longitudinal, lateral and vertical transfers of material energy and biota. They change over time in response to hydrological and biological processes and human intervention. Hydrology takes an overriding role here. Their ecological integrity lies with the totality of physical, chemical, biological and functional attributes. River flows are regulated not by humans but by the hydrological cycle. Irrigation is the main cause of groundwater overexploitation in agricultural areas. The global scenario of groundwater overdraft indicates that over-exploitation of groundwater from the shallow aquifers has deteriorated its quantity and quality.

Causes of Aquifer Depletion

- Aquifer depletion most commonly occurs because of the frequent pumping of water from the ground. We pump the water more quickly than it can renew itself, leading to a dangerous shortage in the groundwater supply. As a growing world with a population that continues to rise, the more we pump water from the ground at a rapid rate, the more difficult it is for the groundwater to provide us with the amount of water that we need.
- We continuously pump groundwater from aquifers and it does not have enough time to replenish itself. Water flows freely through the saturated rocks known as aquifers. There are large and small aquifers, and they are the underground water reserves that absorb water and hold it, enabling us to pump it for use. The amount of water that aquifers hold is beyond impressive and can provide us with billions of gallons of water per day. While this amount of water seems plentiful, groundwater is a major contributor to the Earth's freshwater supply and is responsible for providing up to 40% of freshwater in the world. Therefore, it doesn't have the ability to recollect quickly enough to be continually sourced for our use.
- Agricultural needs require a large amount of groundwater. It's frightening to think that there isn't very much groundwater left when you consider how much water we use on a daily basis to support our population of billions and our personal lifestyles. A large amount of groundwater goes to farming, but the availability of groundwater is steadily declining. Without it, it will be extremely difficult to provide drinking water and water for crops and animals that would help communities during times of drought. The less water that is available, the less food we have and we will be faced with the issue of great demand and very little supply.

Groundwater depletion is primarily caused by sustained groundwater pumping. Some of the negative effects of groundwater depletion:

- **Lowering of the Water Table**

Excessive pumping can lower the groundwater table, and cause wells to no longer be able to reach groundwater.

- **Increased Costs**

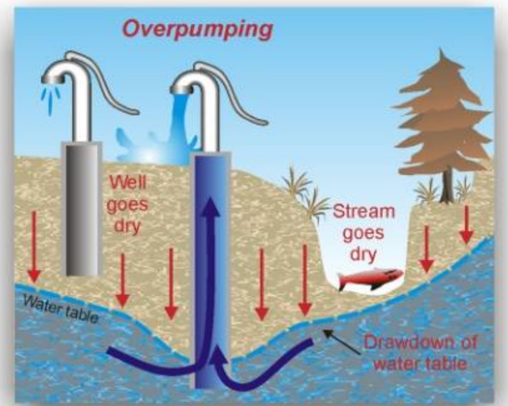

Fig 1 : Over pumping consequences

As the water table lowers, the water must be pumped farther to reach the surface, using more energy. In extreme cases, using such a well can be cost prohibitive.

- **Reduced Surface Water Supplies**

Groundwater and surface water are connected. When groundwater is overused, the lakes, streams, and rivers connected to groundwater can also have their supply diminished.

- **Land Subsidence**

Land subsidence occurs when there is a loss of support below ground. This is most often caused by human activities, mainly from the overuse of groundwater, when the soil collapses, compacts, and drops.

- **Water Quality Concerns**

Excessive pumping in coastal areas can cause saltwater to move inland and upward, resulting in saltwater contamination of the water supply.

Effects of Groundwater Depletion

1. Groundwater depletion will force us to pump water from deeper within the Earth.
2. Large bodies of water will become more shallow from groundwater depletion.
3. Saltwater contamination can occur.
4. As large aquifers are depleted, food supply and people will suffer.
5. A lack of groundwater limits biodiversity and dangerous sinkholes result from depleted aquifers.

The present study was carried out in one such over-exploited watershed 'Kanari watershed', which is located in the terrain of the Jabalpur district of Sihora region in Madhya Pradesh. The areal extent of the watershed incorporates such belt that requires a huge quantity of water for irrigation. Due to limited availability of surface water in this area, the groundwater is extensively utilised for irrigation, domestic, and industrial purposes. Use of groundwater particularly for irrigation of food grain production and other agricultural practices is quite rampant. This is increasing at an alarming proportion due to the recent increase in the agriculture land in this area, resulting in over-exploitation of groundwater and depletion of water level in the shallow aquifers.

Fig 2 : Groundwater Decline and Depletion

The availability of groundwater is extremely uneven, both spatially and temporally. The uneven distribution of groundwater can be attributed to heterogeneous lithology of the aquifers and uneven distribution of rainfall. The shallow groundwater, tapped by large diameter shallow dug wells, is the most important source of water, especially in the large rural tracts of the study area. The groundwater movement in the study area is mainly controlled by topography, drainage pattern, and structural controls over the area.

In view of the above, it is very essential to take urgent steps to arrest the over-exploitation of groundwater. It is observed that the entire study area of watershed is experiencing the vicious cycle of groundwater over-exploitation. This cycle is mainly based on the wrong agriculture practices, irregular monsoon rainfall pattern, typical basaltic aquifers, and irregular electric supply, etc. To break this cycle, it is recommended to change the cropping pattern in the entire watershed area. Presently, almost all area is irrigated by groundwater through irrigation wells. This over water consumption crops can be supplemented with other crops such as cotton, oil seeds, pulses, vegetables, etc., which will reduce the water requirement considerably leading to break this vicious cycle.

Conclusion

It is recommended that participatory groundwater management practices and modern irrigation techniques like drip or sprinkler method should be adopted for irrigation in this area. This will possibly reduce groundwater draft and save 30% of groundwater. Further, the use of some advanced agriculture techniques like Aquaferti seed drill, Raised bed technology, Laser leveling, Biogas slurry, System of Rice Intensification (SRI), and combination of all techniques in water management can improve the crop yields by 20–50%, which in turn will save 10–40% of irrigation cost, groundwater, irrigation time, and electrical energy. Another management strategy to improve efficiency of water use is to utilise Pipe Distribution Network (PDN) instead of Canal Distribution Network (CDN). By virtue of PDN the water use effi- ciency can be improved up to 70–80% from existing efficiency of 40% in the study area of watershed.

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DETECTION OF ADULTERATION IN FERTILIZERS (RAPID TEST)

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In Indian agricultural fertilizer and manure play very important role for production food and fiber. India is the second biggest consumer of fertilizer in the world succeeding to China. Fertilizer consumption was less than 1 million tonnes before the mid-1960s. With the introduction of high-yielding variety (HYV) seeds, there was acceleration in the growth of fertilizer consumption. Steadily its use has been increased from 7 million tonnes in year 1950-51 to 27.22 million tonnes during 2018-19 in India. The fertilizers are comprised of Urea, DAP, MOP, NPK complexes, SSP, zinc sulphate, copper sulphate. With the increase in consumption and its sale price, the problems of quality control have also increased. The Governments whether state or central are making efforts to control the quality of fertilizers. The demand and the sale price attract the dealers to get quick money by way of adulteration, misbranding, production and sale of nonstandard fertilizers to the farmers. Ensuing the farmers are not receiving the standard fertilizers. Mixing of harmful chemical substances degrades fertility of the land and causes serious health issues for humans. Moreover, by applying such contaminated fertilizers, farmers are cheated and production suffers. Though the department of agriculture extension along with other agencies regularly test fertilizers available in the market.

Table 1 : Production and consumption of fertilizers (ooo tonnes)

Fertilizer	Item	Year							
		1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2010-11	2017-18
N	Production	28.9	112	832.5	2163.9	6993.1	10942.8	12178.6	13423
	Consumption	55.0	211.7	1479.3	3678.1	7997.2	10920.2	16558.2	16653
P	Production	9.8	53.7	228.1	841.5	2051.1	3734.2	4371.2	4724
	Consumption	8.8	53.1	541.0	1213.6	3221.0	4214.6	8049.7	6854
K	Consumption	6.0	29.0	236.3	623.9	1328.0	1567.5	3514.3	2780

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Harmful Effects of Adulterated Fertilizer Use

1. The use of adulterated fertilizers with nutrient lacks over the year affected soil fertility and caused sufferers to farmers.
2. Fertilizer adulteration disturbs economic of farmers as fertilizers with low nutrient contents force farmers to buy extra fertilizers to get adequate crop nutrients.
3. Adulterated fertilizers also decrease crop productions, affect the food quality.
4. Effects on soil health like use of adulterated fertilizers would cause soil poisoning.

Need of Fertilizer Control Order (FCO)

The government of India passed The FCO on 28^{th} of April, 1957 in exercise of the power conferred by the section III of the essential commodities act of 1955. This order is intended to regulate the manufacture, distribution and supply of the fertilizers in India at a control cost. This has been effective from May 18^{th} 1957. It is revised in 1985 with effect from 25-9-1985. The Government of India has delegated to powers to state Governments to implement the order. The Government of India (GOI) also passed the Fertilizer Movement Order (FMO) on 31^{st} December, 1960 in order to regulate the interstate movement of fertilizers and the export of fertilizers which came into force with effect from 1961.

Fertilizer Control Order [FCO] Regulations:

1. All the fertilizer manufacturer should obtain licence from the Commissioner of Agriculture state Government concerned for the manufacture of fertilizer and mixed fertilizers
2. The fertilizer dealers should on renewable basis, register their dealership with the Assistant Director of the Agriculture (ADA) Regular of the division concerned in a state.
3. The terms and conditions of manufacture, distribution and sales imposed by the government should be followed.
4. Duties of inspecting officers and the dealers are specified.
5. Fertilizer specifications and kind of package are stated.
6. Method of drawing fertilizer samples for analysis in the fertilizer testing laboratories is stated.
7. Powers are vested with the FCO enforcing officials to book the cases against the fraudulent manufacturers, distributors and dealers of fertilizers.

Table 2 : Specifications and standards for important fertilizers [As per FCO, 1957]

Urea	• **Moisture per cent by weight 1.0 Maximum** • **Total nitrogen per cent by weight 44.0 minimum** • **Biuret per cent by weight 1.50 maximum** • **Particle size :In the form of granule the material shall pass through 2.8mm and not less than 80% by weight shall be retained on 1mm**
SSP	• Moisture per cent by weight, maximum 12 • Free phosphates as (P_2O_5) percent by weight 4.0 • Water soluble phosphates by weight maximum 16.0
MOP	• Moisture per cent by weight maximum 12.00 • Water soluble potassium per cent by weight minimum 60
DAP	• Moisture per cent by weight 1.0 • Total nitrogen per cent by weight minimum 18 • Total phosphates per cent by weight minimum 46.0 • Water soluble phosphates per cent by weight 41.6

Table 3 : Material used for fertilizer adulteration

No.	Name of fertilizers	Adulterants
1.	Urea	Common salt, silica, sands
2.	Diammonium phosphate (DAP)	Granular single super phosphate
3.	Single super phosphate (SSP)	Sand, ash, granular gypsum.
4.	Calcium ammonium nitrate (CAN)	Clay gypsum
5.	Muriate of potash (MOP)	Sand common salt

No.	Name of fertilizers	Adulterants
6.	NPK	Single super phosphate (granular)
7.	Zinc sulphate	Magnesium sulphate
8.	Copper sulphate	Sand, common salt
9.	Ferrous sulphate	Sand, common salt

Table 4 : Chemical required for fertilizer adulteration test

1.	NaOH (Conc.)	:	40 % in water, NaOH dilute – 1 %.
2.	Acetic acid	:	glacial
3.	$AgNO_3$	:	Dissolve 1 gm in 100 ml distilled water
4.	Cobalt nitrate	:	Dissolve 5 gm cobalt nitrate in 5 ml distilled water. Add 25 gm $NaNO_2$ and 2.5 ml glacial acetic acid. Mix and dilute to 100 ml with distill water
5.	$FeCl_3$solution	:	Dissolve 7 gm $FeCl_2$ and 12 gm ammonium acetate in 1 litres of distill water.
6.	Formaldehyde (37-40 %)	:	Add 1 ml method red indicator in 100 ml formaldehyde.
7.	Conc. and diluted acids (5 N)	:	H_2SO_4, HNO_3, HCl
8.	K_3 [Fe $(CN)_6$]	:	Dissolve 5 gm potassium fero cyanide in 100 ml water
9.	Ammonium acetate	:	
10.	Calcium oxide (CaO)	:	

Test for detection of adulterants in fertilizers

1) Urea :

a) Dissolve 1 gm sample in 5 ml water in a test tube. Add 5-6 drops of $AgNO_3$. If white ppt does not appear, the sample is not adulterated with salt.

b) Filter the solution, if no residue on filter paper. It is not adulterated with sand / silica.

c) Heat dry urea in a test tube, if melts completely the sample is pure, if not and solid residue remains it contains adulterated with sand / silica.

2) Diammonium phosphate (DAP) :

a) Dissolve 1 gm powdered sample in 5 ml distilled water. Add 1 ml conc. HNO_3 and mix. It dissolve completely, it is pure DAP. If it contains undissolved material, it is adulterated.

b) To 1 gm sample add 2-3 drops of NaOH or 1 gmCaO, smell of ammonia indicates the presence of nitrogen. If not, the sample is not DAP.

c) Dissolve 1 gm of sample in warm water and filter. To the filtrate add 1 ml $AgNO_3$. If yellow ppt. It contains phosphate. If not, it is not DAP but SSP.

3) Muriate of potash (MoP) : Take about 1 gm sample and dissolve in 10 ml dist. Water. If sample does not dissolve completely and undissolved material settles, it is adulterated. Place powder in blue flame, which burns with yellow flame, if adulterated.

4) NPK fertilizers :

a) Dissolve 1 gm of sample in 5 ml distilled water in a test tube. Add 1 ml conc. NaOH and heat place the moist (water) red litmus paper to the mouth of test tube. Paper turns blue indicates the presence of nitrogen. If paper remains unchanged, the sample does not contain nitrogen and highly adulterated.

b) Dissolve 1 gm sample in 5 ml of water and filter. Add 0.5 ml of $FeCl_3$, if yellow ppt. Forms which is soluble in conc. HNO_3 it indicates the presence of phosphorus.

c) To the 5 ml solution of sample add 2 ml formaldehyde. The colour of solution turns red. Add NaOH drop wise till yellow colour. Add 1 ml cobalt nitrate reagent. Yellow ppt indicates the presence of potassium (Potash).

5) Potassium (potash) : Dissolve 1 gm of sample in 5 ml of water. Add 1 ml dilute NaOH and 1 ml of $AgNO_3$. Yellow colour ppt indicates phosphate. If yellow ppt is not formed it is not phosphatic fertilizer.

6) Zinc sulphate : Dissolve 1 gm sample in 5 ml water and filter. Add 8-10 drops of NaOH to the filtrate, if white ppt appears and dissolve in 10-12 drops of conc. NaOH the sample is pure. If ppt does not dissolve in conc. NaOH, it is adultered.

7) $CuSO_4$: Dissolve 1 gm of sample in 5 ml water. The solution must be transparent blue colour. Add KSCN to the solution, if brown ppt copper is present.

8) $FeSO_4$: To the aqueous solution add 1 ml $K_3[Fe(CN)_6]$, appearance of blue coloured ppt confirms iron.

Conclusion

Adulteration reduces the quality of the food by adding unnatural substances and most of the chemicals used in adulteration are poisonous and hazardous to health. So, examination of fertilizers before application is necessary for the maintain soil fertility. The authorities to take necessary steps to stop this harmful practice by consolidation, monitoring and meting out exemplary punishment to those involved in fertilizer adulteration. Which also helpful for farmer those using the fertilizer and saving money by using good quality and pure fertilizers.

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ZERO TILLAGE; BOOST AGRICULTURE PRODUCTIVITY

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Introduction

Zero tillage farming is an extreme form of minimum tillage and also known as **"No Till Farming"** or as **"Direct Drilling".** Zero-tillage is a conservation technology that has the potential of saving time, energy and inputs for small farmers. But it did not spread as fast as expected during initial years due to perseverance of the farmers towards tilling and ignorance about some technical aspects critical to its apt implementation. An effective strategy in knowledge management formed the pivotal force behind large scale adoption of zero-tillage technology among farmers.

Tilling of soil is used to remove weeds, shape the soil into rows for crop plants and Furrows for irrigation. This leads to unfavourable effects like soil compaction; loss of organic matter; degradation of soil aggregates; depths of destruction of soil microbes and other organisms and soil erosion where top soils washed or blown away. Zero tillage avoid these effects by excluding the use of tillage. With this way of farming, crop residues or other organic amenities are retained on the soil surface and sowing or fertilizing is done with minimal soil disturbance. Continuous zero till needs to be managed very differently in order to keep or increase yield on the field.

What is Zero Tillage

It is an extreme form of minimum tillage practise in which the crop is sown directly into soil not tilled since the harvest of previous crop. Primary tillage is completely avoided and secondary tillage is restricted to seedbed preparation in the **Root Zone Only**. Zero tillage is the process where the crop seed will be sown through drillers without prior land preparation and disturbing the soil where previous crop stubbles are present. Zero Tillage (ZT) also called **No Tillage** or **Nil Tillage**.

- Placement of seed in to soil without soil preparation.
- It is the direct sowing of seed in the field without any disturbance to the soil.
- There are different forms of tillage systems which are practiced by the farmers and their levels of crop residues formations are different for each tillage practices

History

No till farming practices have been in use for thousands of years, with primitive farmers using a stick to make a hole in the ground, putting seeds in the soil, and then covering the seeds. The term No-tillage or minimum-tillage have been used since ancient times. Therefore, it called **"primitive cultures"** for the production of crops, simply because man has not the muscle force to till any significant area of land to a significant depth by hand. The concept of zero tillage was started in early 1940s by ***Edward Faulkner***. In 1973 Jim McCutcheon and University of Manitoba Professor **Dr. Earl Stobbe** began work to further the concept of zero tillage, and by 1976 the Carman area farmer had converted his entire acreage.

Status in India

No Till approach started from 1960s by farmers in India. The zero-tillage system is being followed in the Indo-Gangetic plains where rice-wheat cropping is present. Wheat will be planted after rice harvest without any operation. Hundreds of farmers are following the same system and getting more yields and profits by reducing the cost of cultivation. The green revolution paved the way for the rice-wheat production system in the north-western parts of India. But in due course of time, the yields of rice and wheat become stagnant due to inappropriate soil and water management system and late planting of wheat, as in the hot season rice is being grown and in the winter wheat follows the rice. In 1990's the zero tillage came to mitigate the problem, by planting the wheat by drilling without any land preparation and tillage.

The success of zero tillage depends on the machinery to drill seed in the uncultivated land. In late 1980's, CIMMYT introduced a prototype for drilling the seed. In India, the first localized seed drill was manufactured by GB Pant University with a motor to reduce the cost and make it available and affordable. The drills are tractor drawn and used in rice-wheat cropping system. Zero tillage proves better for direct-seeded rice, maize, soybean, cotton, pigeon pea, mungbean, clusterbean, pearl millet during kharif season and wheat, barley, chickpea, mustard and lentil during Rabi season. Wheat sowing after rice can be advanced by 10-12 days by adopting this technique compared to conventionally tilled wheat, and wheat yield reduction caused by late sowing can be avoided.

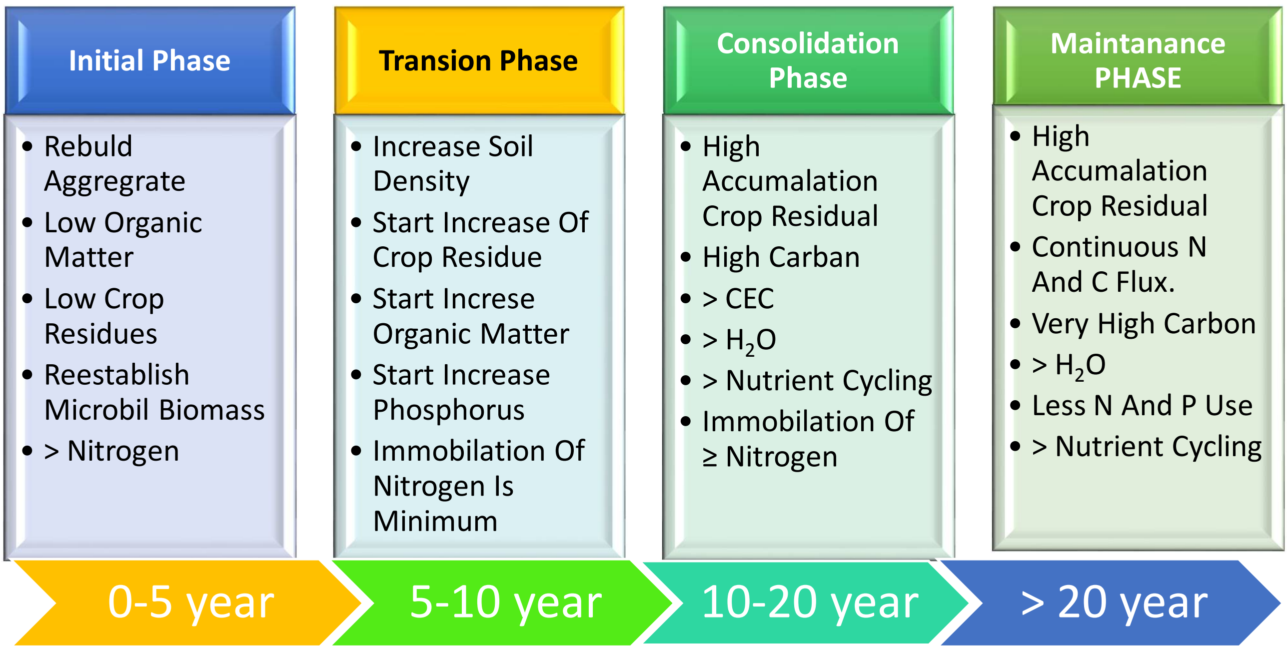
Advantages

- Reduction in the crop duration and thereby early cropping can be obtained to get higher yields.
- Permanent soil cover protects from the soil from the rain drops' energy, increases water infiltration, and hence drastically reduces water runoff and soil erosion risks.
- Reduction in the cost of inputs for land preparation and therefore a saving of around 80%.

- Increased population of earthworms, insects and greater root development contribute to better soil aeration.
- Residual moisture can be effectively utilized and number of irrigations can be reduced.
- Dry matter and organic matter get added to the soil.
- Environmentally safe - Greenhouse effect will get reduced due to carbon sequestration.
- No tillage reduces the compaction of the soil and reduces the water loss by runoff and prevent soil erosion.
- As the soil is intact and no disturbance is done, No Till lands have more useful flora and fauna.

Disadvantages

- It takes time to see the benefits of no-till. One can't take a farm that has been tilled for 50 years or more and hope to see big gains in yield after one season. Patience is important. Soil needs time to regain structure, and that doesn't happen overnight.
- With no-till a farmer has lost the ability to mechanically control weeds through tillage.
- There is a risk of carrying over plant diseases when crop residue is not incorporated into the soil after harvest. This can act as a host for disease and can infect the following crop. However, farmers can combat this situation by rotating crops that are not susceptible to the same diseases.



To adopt no-tillage practices successfully, recommends that farmers consider the following before starting with the no-tillage system.

- Improve the knowledge about all aspects of the system but especially in weed control
- Analyse the soil and if necessary incorporate lime and correct nutrient deficiencies.
- Avoid soils with bad drainage.
- Level the soil surface if this is rough for any reason.
- Eliminate soil compaction using chisel ploughs or sub soilers.
- Produce the highest amount possible of mulch cover.
- Buy a no-tillage machine.
- Start on only 10% of the farm to gain experience
- Use crop rotations and green manure cover crop to reap the full benefits of the system
- Be prepared to continuously learn and be up to date with new developments

Implements and Tools for Zero Tillage

1. No Till Planter
2. A Roller/Crimper
3. A Broad Fork
4. A Subsoiler
5. A No-Till Seed Drill
6. Zero Till Seed/Grain Drill Cum Fertilizer
7. Metal Cutting Blade Mould Board Plough
8. Rotary Weeder

Conclusion

The natural resources are precious and therefore demand an effective and sustainable use. Zero tillage is a potential technology in this scenario. Although the drawback of use of non-selective herbicide is more, it still causes less effect than the conventional method of farming. In zero tillage, more returns can be achieved and timely crop can be grown with higher yields.

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SOIL CONTAMINATION AND ITS MANAGEMENT THROUGH BIOREMEDIATION-AN OVERVIEW

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Introduction

Human evolution has led to immense scientific and technological progress at the cost of environment. Global development raises new challenges, especially in the field of environmental protection and conservation. The release of contaminants into the environment by human activities has increased tremendously over the past several years. Earlier focus was speeding up the industrialization process while, today attempts is to find ways to deal with the growing industrialization and the associated problems. Pollutants such as heavy metals, oil hydrocarbons and pesticides are environmentally harmful, causing serious impacts on the health of ecosystems. Mostly in humans, there is an incidence of carcinogenesis and mutagenesis as well as other toxic effects (Kuppusamy *et al.*, 2020). The large scale production of a variety of chemical compounds, such as organic solvents, fuels and fuel additives, pesticides, plasticizers, pigments, dyes, plastics and chemical feed stocks, has caused global deterioration of environmental quality. The soil has been traditionally the site for disposal for most of the heavy metal wastes which needs to be treated. Heavy metals bioaccumulation in the food chain especially can be highly dangerous to human health. The most common route of human exposure to heavy metals is through ingestion from both food and water sources.

In the last few years, public are aware about contamination and now strongly demanding cleanup measures. In this context, Government has put legislative restrictions on uncontrolled discharges of wastes and actions mandating environmental restoration of hazardous waste sites. This recent environmental awareness has highlighted the need for new technologies for the treatment of these wastes. Conventional remediation methods of heavy metal contaminated soils are expensive and environmentally destructive. Therefore, we have to think for different methods of bioremediation which is less expensive as well as environment friendly.

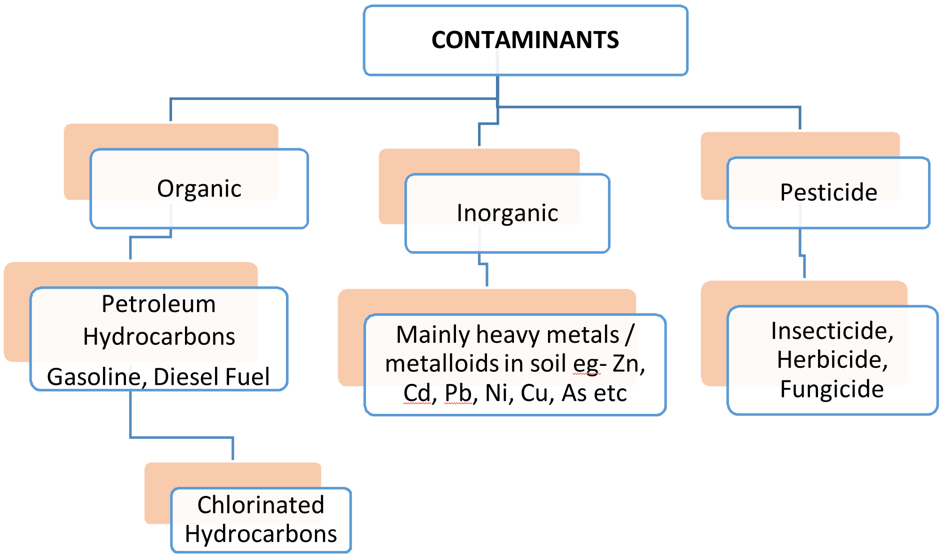
What is soil contamination?

Any addition to soil of substance that may exert adverse effect on its functioning is defined as soil contamination (ISSS, 2009). It is referred to as the accumulation in the soil of persistent harmful substances, chemical compounds, salts, radioactive wastes, or pathogens that have a negative impact on biological systems (Mareddy, 2017).

Status of soil contamination in India

- >125 major contaminated sites across the country.
- 175 million hectare degraded soil (out 329 million ha)
- >40% of chemical fertilizers pollute ground water.
- 14 States affected by Fluoride contamination.
- >65% of Indian villages exposed to residual pesticide risk.
- Heavy metals affecting GW of 40 districts from 13 states (Hasan, 2011)

Contaminates are three types-



- Organic pollutants are biodegradable, can be mitigated through bioremediation
- Inorganic pollutants are not bio-degradable, can be mitigated through Phytoremediation (Das, 2008).

Contaminants and contamination

Oil	• Hampers soil fertility • Disrupts seed germination (Yoshida *et al.*, 2006 and Gong *et al.*, 2001)
Pesticide residues	• 2-3% of applied pesticide is utilized • Rest pollutes soil-water-crop-food (EPA., 2005; CFTRI, 2003)
Heavy metals	• Replace essential elements from exchange sites (Taiz and Zeiger, 2002) • Adversely affects crop growth, human through food chain (Schmidt, 2003)

Agrochemicals : There are three types- a. Insecticides, b. Herbicides and c. Fungicides

Effect of agrochemicals

- Low biodegradability
- Not restricted within target, harms others
- 99% micro-arthropods killed by fumigant
- At least 2 years to recover
- Mites are sensitive
- Fortunately, Earthworms are not
- Fungicides, especially fumigants are more dangerous and specific adverse effect on fungi and actinomycetes
- Activities of microorganisms responsible for N-fixation, nitrification – affected

(Source: Aktar *et al.,* 2009)

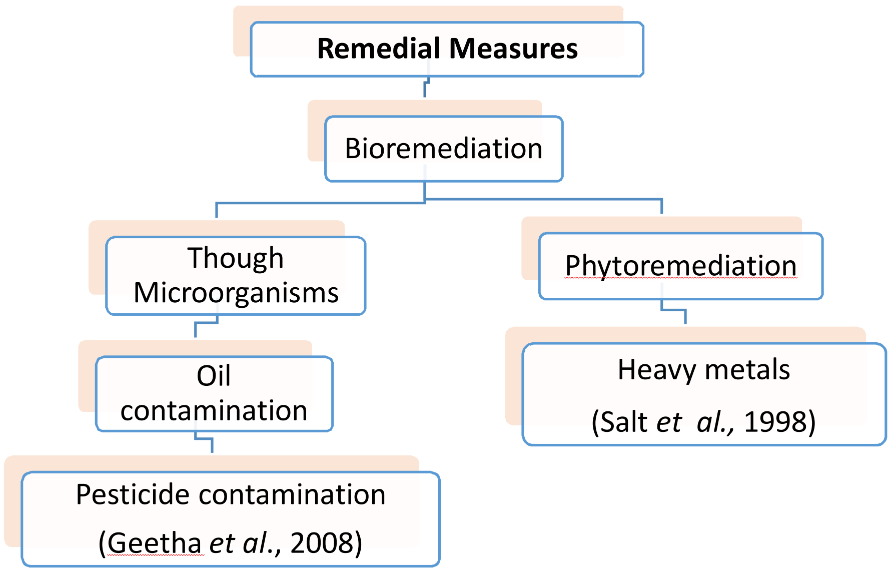
Source of heavy metal contaminants in soils

Although heavy metals are ubiquitous in soil parent materials, the major anthropogenic source of metals to soils and the environment are:

a) Metalliferous mining and smelting
b) Sewage sludges
c) Fossil fuel combustion
d) Metallurgical industries – manufacture, use and disposal of metal commodities
e) Electronics – manufacturing, use and disposal of metal commodities
f) Chemical and other manufacturing industries
g) Waste disposal
h) Warfare and military training (Heavy Metals in Soil. Ed. B. J. Alloway, 1996)

Heavy metal toxicity in plants

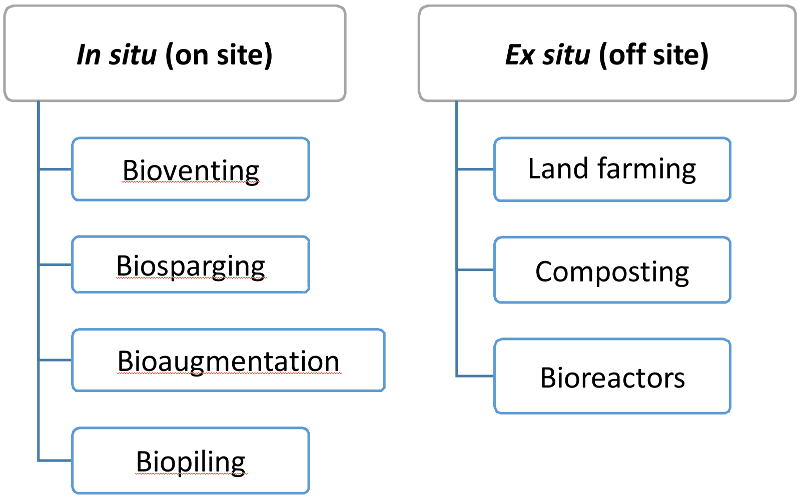
i) Changes in the permeability of the cell membrane: Ag, Br, Cd, Cu, F, Hg, I, Pb.
ii) Reactions of sulphhydryl (-SH) groups with cations: Ag, Hg, Pb.
iii) Competition for sites with essential metabolites: As, Se, Te, F.
iv) Replacement of essential ions (mainly major cations): Cs, Li, Rb, Se, Sr.
v) Occupation of sites for essential groups such as phosphate and nitrate: Arsenate, fluorate, borate, bromate, selenate, tellurate and tungstate (Sanz *et al.,* 2009).



What is Bioremediation?

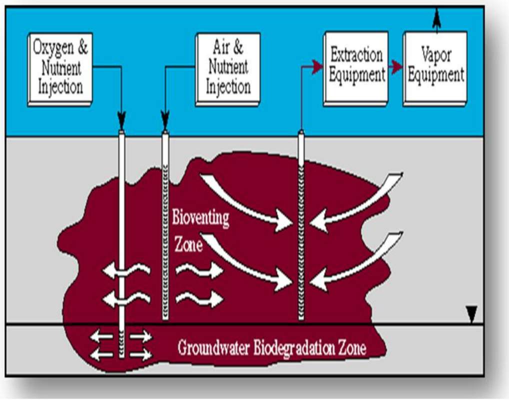
Bioremediation is the process by which living beings such as plants, algae and microorganisms are used to remediate, remove or reduce contamination from the environment (Saxena and Bharagava, 2020) or uses biological agents, mainly microorganisms, e.g. yeast, fungi or bacteria to clean up contaminated soil and water (Strong *et al.*, 2008).

Bioremediation Strategies

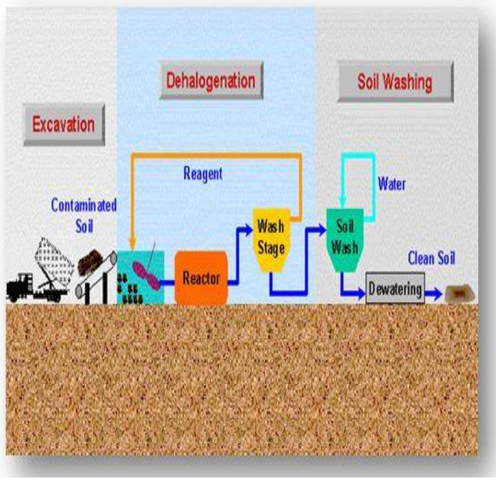


(Source : Sharma *et al*., 2012)

Bioventing stimulates the natural in-situ biodegradation of any aerobically degradable compounds by providing oxygen through low air-flow rates to existing soil microorganisms. Biosparging involves injection of air under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of contaminants by naturally occurring bacteria.

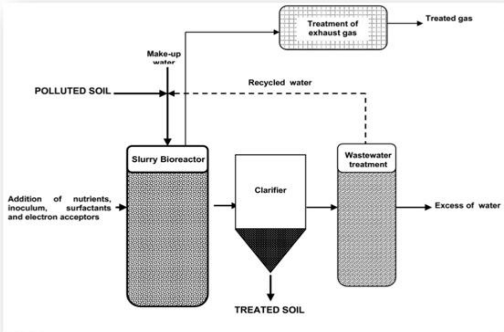


Bioaugmentation is the introduction of a group of natural microbial strains or a genetically engineered variant to treat contaminated soil or water. It is commonly used in municipal wastewater treatment. Biopiling is a full-scale technology in which excavated soils are mixed with soil amendments, placed on a treatment area, and bioremediated using forced aeration where the contaminants are reduced to carbon dioxide and water (Sharma *et al.*, 2012).



Bioreactors are slurry phase treatment plants. A slurry bioreactor is a containment vessel and apparatus used to create a three-phase (solid, liquid, and gas) mixing condition to increase the bioremediation rate of soil bound and water-soluble pollutants as a water slurry of the contaminated soil and biomass (usually indigenous microorganisms) capable of degrading target contaminants.

Land farming is a simple technique in which contaminated soil is excavated and spread over a prepared bed and periodically turned over until pollutants are degraded.



Composting is a process by which organic wastes are degraded by microorganisms, typically at elevated temperatures. Typical compost temperatures are in the range of 55° to 65° C (Sharma *et al.*, 2012).

Bioremediation prerequisites

Factors	Conditions required
Microorganisms	Aerobic or Anaerobic
Natural Biological processes	Catabolism and Anabolism
Environmental Factors	Temperature, pH, oxygen, electron acceptor /donor
Nutrients	Carbon, Nitrogen ,Oxygen etc.
Soil Moisture	25-28% of water holding capacity
Type of soil	Low clay or silt content

(Source: Sharma et al., 2012)

Optimum situations for an oil degradation programme

Parameters	Condition required for microbial activity	Optimum value for an oil degradation
Soil moisture	25–28% of WHC	30–90%
Soil pH	5.5–8.8	6.5–8.0
Oxygen content	Aerobic, 10% air-filled pore space	10–40%
Nutrient content	N and P for microbial growth	C:N:P ::100:10:1
Temperature (°C)	15–45	20–30
Contaminants	Not too toxic	Hydrocarbon 5–10% dry weight of soil
Heavy metals	Total content 2000 ppm	700 ppm
Type of soil	Low clay or silt content	-

(*Source: Vidali, 2001)*

Few case studies

The petroleum industry effluents, oily sludge and oil spills cause a serious threat to the environment as their constituents are toxic, mutagenic and carcinogenic. Safe disposal of these wastes is serious problem. None of the available conventional disposal methods are environment friendly. Biological methods have been well reviewed and acknowledged for remediation of petroleum hydrocarbon contaminated waste (oily waste). An indigenous microbial consortium was developed by assemble of four species of bacteria, isolated from various oil contaminated sites of India, which could biodegrade different fractions of total petroleum hydrocarbon (TPH) of the oily waste to environment friendly end products. The said consortium was applied on field scale at different oil refineries in India and successfully bioremediated 48,914 tons of different types of oily waste. In 44 field case studies of different batch size of *ex situ* bioremediation process, the initial TPH content varying from 83.50 to 531.30 g kg^{-1} of oily waste, has been biodegraded to < 10 g kg^{-1} of oily waste in major cases in 2-12 months. In one refinery due to coastal climate, the bioremediation time was > 20 months. The bioremediated soil was non toxic and natural vegetation was found to be grown on the same. Bioremediation technology has helped various oil industries for the management of their hazardous oily wastes in environment friendly manner.

Biodegradation of Total Petroleum Hydrocarbon (TPH) of oily waste undertaken for bioremediation at various oil refineries in India:

Particulars of oil refinery	TPH (g/kg oil waste) Before bioremediation	TPH (g/kg oil waste) After bioremediation	% of bioremediation	Time taken (month)	Biodigredation rate (kg TPH/day/ m^2 area)
CPCL, Chennai	129.50 - 437.10	8.80 - 14.30	93.20 - 97.80	3 - 13	0.21 ± 0.07
IOCL, Barauni	162.00 - 212.20	3.70 - 50.70	70.18 - 98.14	5 - 5.5	0.43 ± 0.17
IOCL,Digboi	170.40 - 531.30	8.70 – 48.70	86.93 - 97.74	2.5 - 15	0.84 ± 0.64
IOCL, Gujarat	132.00 - 270.00	3.90 - 34.50	82.54 - 98.13	2 - 12	0.41 ± 0.36
IOCL, Haldia	193.00 - 269.00	5.60 - 12.50	94.47 - 97.44	6 - 10	0.19 ± 0.05
IOCL, Mathura	152.50 - 223.10	3.50 - 8.50	96.19 - 97.70	4 - 12	0.37 ± 0.20
IOCL, MRPL,	206.50 - 238.00	2.60 - 8.00	96.51 - 98.86	3 - 10	0.38 ± 0.09
Mangalore Panipat	83.50 - 198.60	8.40 - 9.10	89.94 - 95.12	21 - 24	0.07 ± 0.03
Total / Range	**83.50 - 531.30**	**2.60 – 50.70**	**70.18 - 98.86**	**2 - 24**	**0.07 - 0.84**

(Source: Mandal et al., 2012)

Bioremediation of pesticide contaminated soils

Through surface soil treatment using a microbial consortia of *S. aureus, Flavobacterium sp., Alcaligen sp., Bacillus sp., Serratia sp., Mucor sp., Phizopus stolonifer, Aspergillus sp.* and *Penicillium sp.*

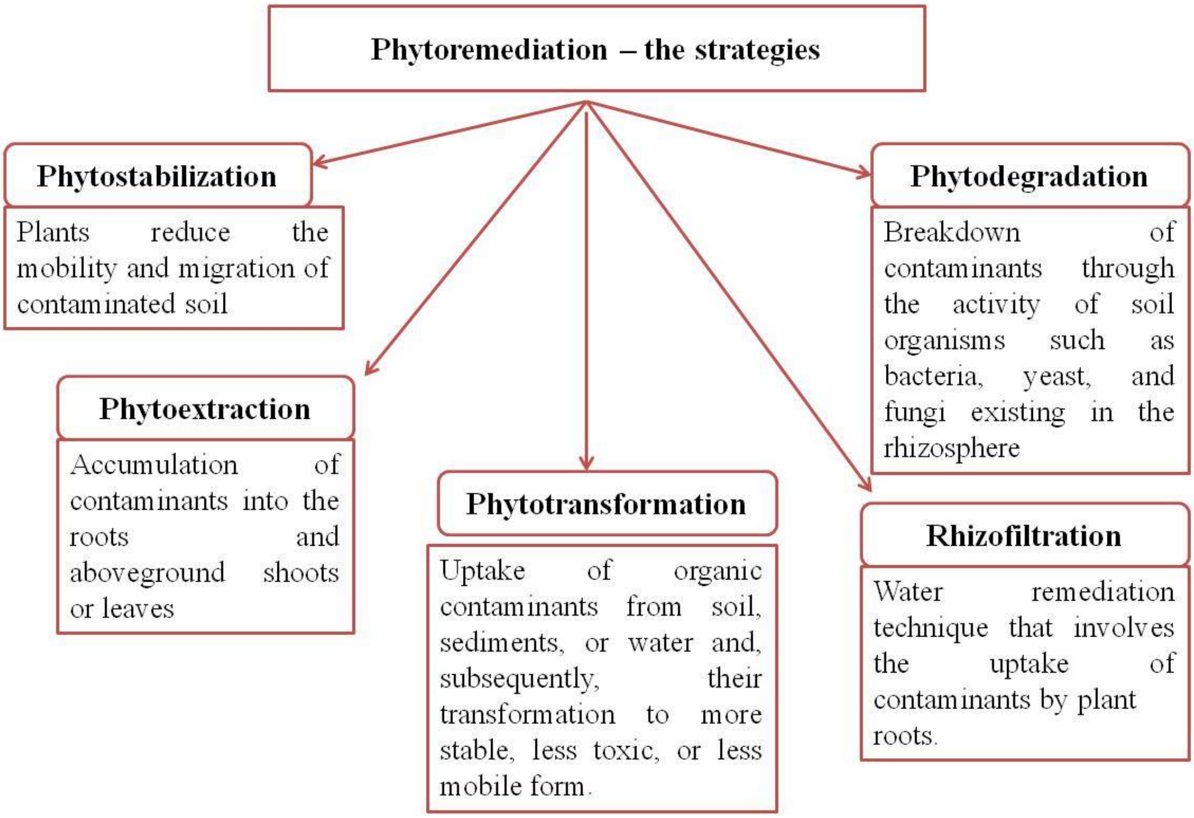
Per cent changes in chemical and biological oxygen demand (COD and BOD) during bioremediation of soils amended with pesticides:

Concentration Pesticide	25 mg kg^{-1}		50 mg kg^{-1}		100 mg kg^{-1}		Control	
	COD	BOD	COD	BOD	COD	BOD	COD	BOD
Chlorpyrifos	-63.4	+22.8	-56.2	+19.8	-48.7	+17.6	-68.0	+35.2
Cypermethrin	-61.5	+16.2	-56.0	+15.4	-49.5%	+7.60	-63.7	+29.9

Chemical Oxygen Demand (COD) monitored during bioremediation showed that the reduction in COD concentration was directly proportional to the degradation of the parent compound. The Biological Oxygen Demand (BOD) measured during the bioremediation showed an increase due to the growth and proliferation of prominent micro-organisms in the presence of high nutrient availability of cow-dung slurry and soil under simulated conditions. (Geetha *et al.*, 2008).

Phytoremediation refers to the use of plants in polluted sites to promote physical, biological, biochemical, microbiological and chemical interactions to attenuate the toxicity of contaminants (Godheja *et al.*, 2019).

- Naturally occurring "Metal Hyperaccumulating" plants can accumulate 10-500 times higher levels of metal than other crops (Chaney *et al*., 1997).
- The degree of accumulation of metals such as Ni, Zn and possibly Cu, observed in hyper accumulators, often reaches 1-5% of their dry weight (Raskin *et al*., 1997).



(Source: Vidali, 2001)

Common Hyperaccumulators

At least 45 families (*Brassicaceae, Fabaceae, Euphorbiaceae, Asteraceae, Lamiaceae, Scrophula-riaceae* etc.) have been identified to hyper accumulate heavy metals (USEPA, 2000).

Thlaspi caerulescens, commonly known as alpine pennycress, is among the best known hyper-accumulators (Kochian, 1996). It accumulated up to 26,000 mg kg^{-1} Zn; and up to 22% of soil exchangeable Cd from contaminated site without showing injury (Gerard *et al.*, 2000)

Hordeum vulgare

Brassica juncea

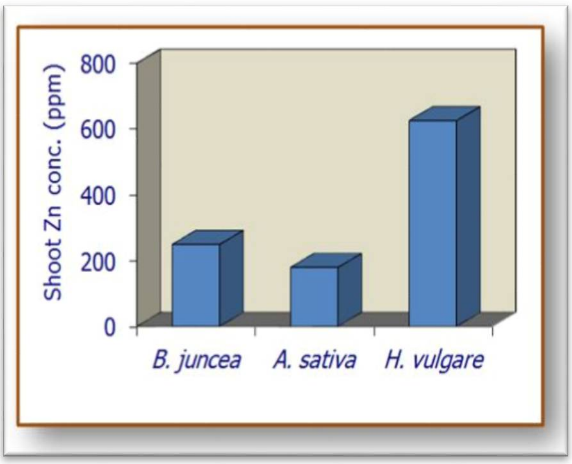
Avena sativa

Common Hyperaccumulators

Plant Name	Common name	Metal
Azolla fililiculioides	Water fern	Cr, Ni, Zn, Fe, Cu, Pb
Bacopa monnieri	Water hyssop	Hg, Cr, Cu, Cd
Eichhornia crassipes	Water hyacinth	As, Cd, Co, Cr Cu, Al, Ni, Pb, Zn, Hg, P, Pt, Pd, Os, Ru, Ir, Rh
Lemna minor	Duck weed	Mn, Pb, Ba, B, Cd, Cu, Cr, Ni, Se, Zn, Fe
Pistia stratoites	Water lettuce	Cu, Al, Cr, P, Hg
Salvinia molesta	Kariba weed	Hg
Spirodela oligorrhiza	Giant duckweed	Cr
Vallisneria spiralis	Eel grass	Hg

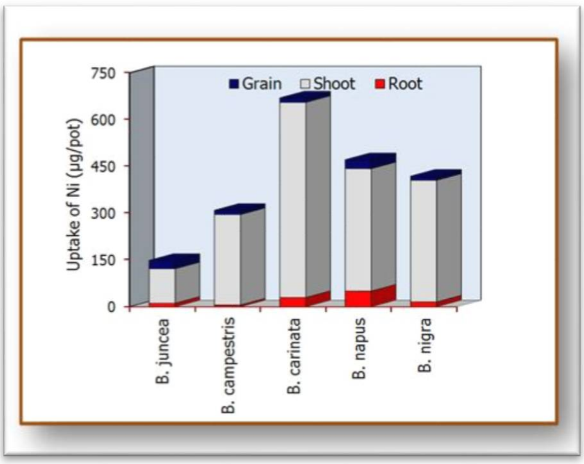
(Source: Prasad et al., 2006)

Zinc phytoextraction- a case study



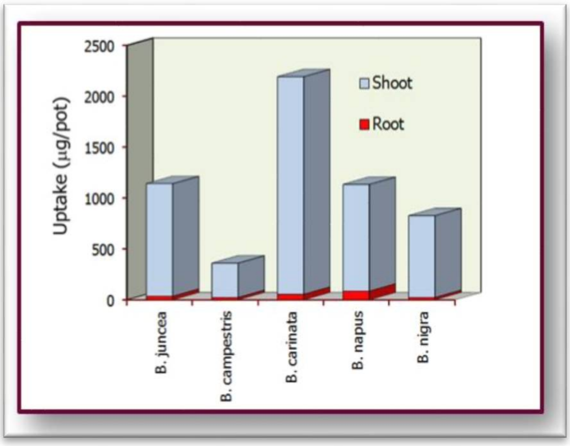
(Source : Ebbs and Kochian, 1998)

Nickel phytoextraction- a case study

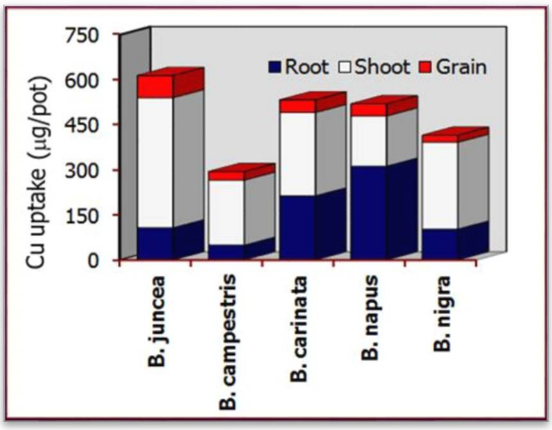


(Source: Purakayastha et al., 2008)

Lead phytoextraction- a case study



Copper phytoextraction- a case study



(Source : Purakayastha et al., 2008)

Arsenic contamination in West Bengal

Build up of arsenic in soil due to use of arsenic contaminated irrigation water has led to number of environmental problems in South Asia particularly in West Bengal, India and Bangladesh (Uddin *et al.*, 2005).

Exposure : 12 district; 111 blocks; 0.173 million sq km; 42.7 million people (http://www.soesju.org/arsenic/wb.htm).

The disorder is progressive

Years of irrigation	Arsenic in irrigation water (ppb)				
	50	100	250	500	1000
	Arsenic added to soil (mg/kg)				
1	0.28	0.56	1.4	2.8	5.6
5	1.4	2.8	7	14	28
10	2.4	5.6	14	28	56
20	5.6	11	28	56	110
30	8.4	17	42	84	170
50	14	28	70	140	280

Green shading <25, orange 25 – 50 and red >50 mg As kg^{-1} soil (Brammer and Ravenscroft, 2009)

Arsenic (As) phyto-extraction through hyperaccumulators

The brake fern (*Pteris vittata*), is an efficient As hyper-accumulator (Ma *et al.*, 2001). It takes up large amounts of As (up to 2.3% dry plant weight) from soil and translocates to aboveground biomass (up to 90% of the total As uptake) (Cao *et al*, 2004). Four other fern species, *Pityrogramma calomelanos* (Visoottiviseth *et al.*, 2002), *Pteris cretica*, *P. longifolia* and *P. umbrosa* are also been identified as potential As accumulators. (Francesconi *et al.*, 2002; Zhao *et al.*, 2002). *Pteris biaurita* L., *P. quadriaurita* Retz *and P. ryukyuensis* Tagawa were also identified as new hyperaccumulators of As (Sivastava *et al.*, 2006).

Arabidopsis thaliana

Concluding remarks

Bioremediation is a less expensive, natural process and is therefore an acceptable waste treatment process for soil. Bioremediation can often be carried out on site, often without causing a major disruption of normal activities. It eliminates the chance of future liability associated with treatment and disposal of contaminated material. Phytoremediation, precisely, is well suited for use at very large field sites where other methods of remediation are not cost effective or practicable.

Although

- Bioremediation/ Phytoremediation often takes longer time than other options
- Bioremediation is limited to those compounds that are biodegradable
- Phytoextraction poses risk of contamination of the vegetation and food chain

Therefore, research is needed to develop and engineer bioremediation technologies that are appropriate for sites with complex mixtures of contaminants.

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FARMING OF FRESHWATER PRAWNS (*Macrobrachium rosenbergii*)

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Introduction

One of the first species to become scientifically known was the giant river prawn, *Macrobrachium rosenbergii*, with the first recognisable illustration appearing in 1705. Species of the freshwater prawn genus *Macrobrachium* are distributed throughout the tropical and subtropical zones of the world. They are mostly located in marine freshwater regions, including streams, reservoirs, swamps, drainage ditches, canals and wetlands, as well as in estuarine regions. In the initial phases of their life cycle, most species need brackish water (and therefore they are found in water directly or indirectly related to the sea), while some complete their cycle in inland saline and freshwater lakes. Some species prefer clear water-containing rivers, while others are found under extremely turbid conditions. The introduction of *M. rosenbergii* and related species into reservoirs and the improvement of existing catch fisheries, particularly in Brazil, India and Thailand, have been some of their current successes. For stocking purposes, further developments will require hatchery-reared post larvae (PL) and juveniles.

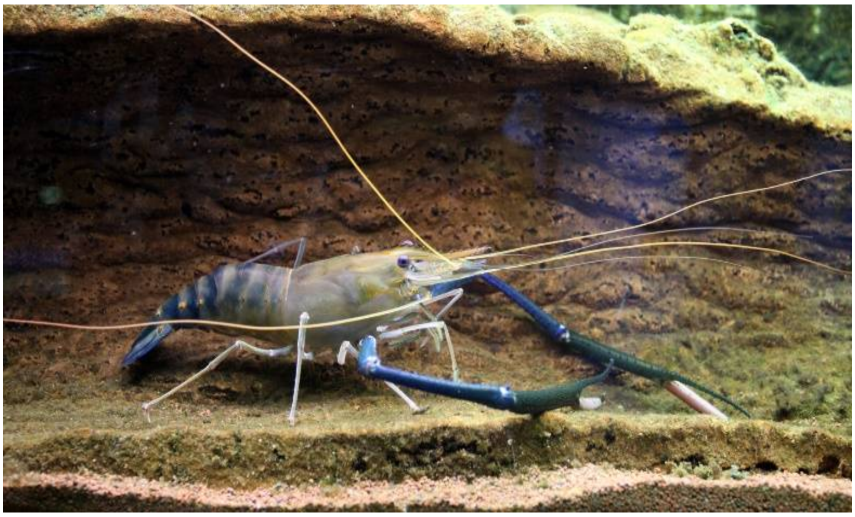

Fig : *Freshwater prawn* (*Macrobrachium rosenbergii*)

Production system

Seed supply

Female broodstock are typically obtained from grow-out ponds as needed for hatchery use, but also often from catching fisheries. "Berried" (egg-carrying) females are usually used only once. Commercial farms usually do not hold captive broodstock for breeding purposes in tropical regions, but adults are over-wintered indoors in temperate regions to store PL ponds as early as possible in the brief grow-out season. In broodstock keeping systems, the average male to female ratio is 1-2 BC males or 2-3 OC males per 20 females, at a gross stocking density of 1 prawn per 40 litres. Fertilization begins externally within a few hours of copulation, when the eggs are moved under the abdomen to the brood chamber. During embryonic development, which lasts about 3 weeks, the eggs remain attached to the female. Free-swimming Zoeae are formed at hatching. Between 5 000 and 100 000 eggs are carried, depending on the size of the berried female. Eggs are orange until 2-3 days before hatching, when they become grey-black.

Table 1 : Characteristics of water suitable for freshwater prawn hatcheries

Variables	Freshwater (ppm)	Seawater (ppm)	Brackish water (ppm)
Total hardness (as $CaCO_3$)	<120	-	2325-2715
Calcium (Ca)	12-24	390-450	175-195
Sodium (Na)	28-100	5950-10500	3500-4000
Potassium (K)	2-42	400-525	175-220
Magnesium (Mg)	10-27	1250-1345	460-540
Silicon (SiO_2)	41-53	3-14	5-30
Iron (Fe)	<0.02	0.05-0.15	<0.03
Copper (Cu)	<0.02	<0.03	<0.06
Manganese (Mn)	<0.02	<0.4	<0.03
Zinc (Zn)	0.2-4.0	0.03-4.6	<3
Chromium (Cr)	<0.01	<0.005	<0.01
Lead (Pb)	<0.02	<0.03	<0.03
Chloride (Cl)	40-225	19000-19600	6600-7900
Chlorine (Cl_2)	Nil	-	Nil
Sulphate (SO_4)	3-8	-	-
Phosphate (PO_4)	<0.02	-	-
Hydrogen sulphide (H_2S)	Nil	Nil	Nil
Total dissolved solids (TDS)	217	-	-
Turbidity (JTU)	Nil	Nil	Nil
Dissolved oxygen (DO_2)	>4	>5	>5
Free carbon dioxide (CO_2)	Nil	-	Nil
Ammonia (NH_3-N)	-	-	<0.1
Nitrite (NO_2-N)	-	-	<0.1
Nitrate (NO_3-N)	-	-	<20
pH	6.5-8.5 units	7.0-8.5 units	7.0-8.5 units
Temperature	-	-	28-31 (^{0}C)

Nursery

Although some farmers stock grow-out ponds with young PL, before switching to grow-out ponds, many either buy larger juveniles or rear PL in their own nursery ponds. Ecologically managed indoor nurseries are used in temperate areas with a short grow-out season to maximise animal size before stocking outside as soon as temperatures become high enough. Depending on whether substrates are used or not, indoor nurseries are stored at 1,000-2,000 PL/m^3. Outdoor nurseries may be stocked with PL freshly metamorphosed or with indoor nursery juveniles. Stocking rates are usually 1 000/m^2 PL, 200/m^2 small juveniles (0.02 g) or 75/m^2 of 0.3-0.4 g juveniles, but increased densities are possible if substrates are used.

Ongrowing techniques

In tropical monoculture, pond stocking densities differ greatly. PL or young juveniles are reared at 1-4/m^2 in extensive rearing systems (typically producing <500 kg/ha/yr); semi-intensive systems (producing 500-5 000 kg/ha/yr) stock at 4-20 PL or young juveniles/m². Pond stocking densities in tropical monoculture vary widely. In (typically producing <500 kg/ha/yr), PL or young juveniles are stocked at 1-4/m²; semi-intensive systems (producing 500-5 000 kg/ha/yr) are stocked at 4-20 PL or young juveniles/m². Some small intensive systems which stock >20/m² to reach >5 000 kg/ha/yr often rarely exist. Approximately 5-10 PL/m² or 4 juveniles/m² are stored in temperate areas with a restricted rearing window of opportunity; levels can be raised in the presence of substrates.

Harvesting techniques

Harvesting is either complete (in "batch" rearing) or selective (in "continuous" or "combined" rearing). Complete harvesting is accomplished by pumping by gravity drain-down or water removal, while seine nets are used to routinely kill larger animals. Stretched knot mesh sizes of 1.8 cm are used to harvest small prawns and from 3.8-5.0 cm for large prawns. The harvest time and frequency depend solely on the amount and characteristics (the size of the animal) of the consumer demand.

Handling and Processing

From harvesting onwards, careful handling is essential to ensure high quality goods. First, during processing, it is important to avoid prawns from being crushed. Secondly, if they are not going to be sold live, they should be killed at 0 °C instantly (at the pond bank) in a combination of water and ice and washed in chlorinated tap water. Prawns can be shipped in aerated water at 20-22 °C for live selling. Prawns sold fresh must not be kept on ice for more than 3 days. Prawns for sale frozen must be quick-frozen at -10 °C (not simply placed in a "domestic" freezer) and stored at -20 °C or below.

Disease and control measures

Due to inadequate water intake care, poor husbandry, overcrowding, poor sanitation, and non-existent or incomplete quarantine procedures, the major disease issues involving *Macrobrachium rosenbergii* usually arise.

Table 2 : Some of the most important diseases, the steps to combat these problems are referred to as improved husbandry (IH)

Disease	Agent	Type	Syndrome	Measures
MMV (*Macrobrachium* Muscle Virus)	Parvo-like virus	Virus	Infected tissue becomes opaque, with progressive necrosis; affects juveniles	IH
WSBV (White spot Syndrome BaculoVirus)	Baculovirus	Virus	White spots; affects juveniles	IH
Unnamed viral disease	Nodavirus	Virus	Whitish tail; affects larvae	IH
Black spot; brown spot; shell disease	*Vibrio*; *Pseudomonas*; *Aeromonas*	Bacteria	Melanised lesions; affects all life stages, but more frequently observed in juveniles & adults	IH; oxolinic acid; nifurpurino
Bacterial necrosis	*Pseudomonas*; *Leucothrix*	Bacteria	Similar to black spot but only	IH; nifurpurinol; erythromycin;

Disease	Agent	Type	Syndrome	Measures
			affects larvae, especially stages IV & V	penicillin-streptomycin; chloramphenicol
Unnamed fungal infection	*Lagenidium*	Fungus	Extensive mythelial network visible through exoskeleton of larvae	IH; trifluralin; merthiolate

Status and Trends

Output from farms is expanding rapidly in Asia. The expansion rate in China, the largest producer, has declined, partly due to the production of an alternative indigenous species *Macrobrachium nipponense* and partly because marine shrimp are now grown in freshwater (and are sometimes referred to erroneously as freshwater prawns). Overall, the yield of *M. rosenbergii* from aquaculture grew from 17 000 tonnes to 195 000 tonnes during 1993-2002. It is difficult to forecast more global growth, as it primarily depends on the volume of market demand. It is also projected to extend the farming of other species of *Macrobrachium,* especially *M. nipponense* (already very considerable in China), *M. malcolmsonii* and *M. amazonicum.*

Main issues

In the past, the production of freshwater prawn agriculture was hampered by its longer hatchery period and lower productivity growth relative to marine shrimp. These constraints are now balanced by a number of positive factors concerning its sustainability and the development of a distinct and expanding market niche for freshwater prawns. Furthermore, fewer poor-quality products enter the international markets now that the technique for avoiding "mushiness" has become well-known.

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GENE PYRAMIDING THROUGH MARKER-ASSISTED SELECTION FOR THE BIOTIC STRESS RESISTANCE IN FRUIT CROPS

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Introduction

Yield and quality are central to sustainable crop production. Biotic stresses (Bacteria, viruses, fungi, nematodes, insect pests and weeds) remain the greatest constraint to crop production accounting for 52% of the global yield loss (Suresh and Malathi, 2013). Nowadays, interest in the use of chemicals against biotic stress is decreasing because of its various limitations such as the requirement for more than one chemical application, an investment that is not affordable by most small-scale farmers. Besides, using chemical spray may have adverse effects on human health and the environment, including beneficial organisms and may lead to the development of chemical-resistant pathogen races, insects, and weeds (Vincelli *et al*., 2016). On the other hand, the use of resistant cultivars is currently seen as the best strategy, durable, economical, and environmentally friendly means of biotic stress control. Broad-spectrum and durable resistance across diverse ecosystems is essential to manage biotic stresses, particularly to protect crops from multiple infections, which are common in agriculture settings. Developing crop varieties that can withstand incidence of multiple stresses is one of the major breeding objectives nowadays, wherein series of target genes identified in different parents are accumulated into a single genotype is known as gene pyramiding.

Techniques of Gene Pyramiding

1. Conventional breeding
2. Biotechnological approaches

Conventionally, genetic engineering means genetic transformation of the crop with a single gene associated with the trait of interest. As disease resistance is a highly complex multigenic trait, generally single gene transformations result in insufficient and/or narrow spectrum disease resistance (Anand *et al*., 2003). However, conventional method of crop improvement has been complained to be slow, less precise, less flexible, labour-intensive and expensive (Choudhary *et al*. 2008). Hence, a technological intervention that can reduce the time and costs necessary to develop and release new cultivars with durable resistance are always welcome. Recently, biotechnological tools like molecular markers and genetic engineering are widely used in crop improvement program for rapid and efficient accumulation of desirable genes from various sources into a single background to produce broad spectrum/durable resistance (Campbell *et al*. 2003).

Gene Pyramiding Through Multiple Parents Crossing

In this breeding strategy, the goal is to accumulate genes/QTLs identified in multiple parents into a single genotype. In general, the gene pyramiding aims at the derivation of an ideal genotype that is homozygous for the favorable alleles at all loci. The gene pyramiding scheme can be distinguished into two parts (**Figure 1**). The first part is called a pedigree, which aims at cumulating of all target genes in a single genotype called the root genotype. The second part is called the fixation step which aims at fixing the target genes into a homozygous state i.e. to derive the ideal genotype from the one single genotype. The use of DNA markers, which permits complete gene identification of the progeny at each generation, increases the speed of pyramiding process.

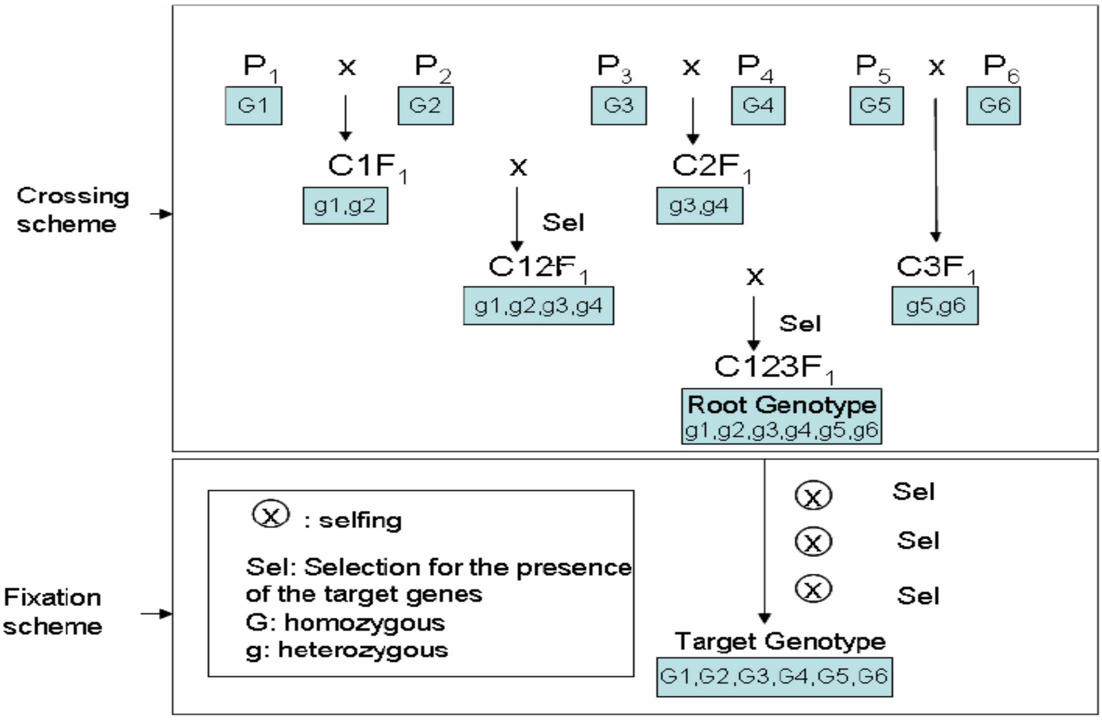

Fig. 1 The gene pyramiding scheme

Marker-assisted Gene pyramiding

A marker is usually a DNA sequence located close to the gene of interest. The advent and application of molecular marker technology made it easier to identify, map and efficiently pyramid resistant genes/QTLs into crop plants. DNA markers tightly linked (<5 cM) to the desired gene serve as chromosomal landmark, 'signs' or 'flags' to track the introgression of the desired gene in progenies in a cross (Asad *et al*., 2012). Hence, identification of resistant genes/QTLs with closely linked DNA-markers is useful for successful transfer of the gene/QTLs into improved cultivars via marker-assisted selection (MAS) (Collard *et al*., 2005). Molecular markers are especially advantageous for agronomic traits that are otherwise difficult to tag such as resistance to pathogens, insects and nematodes, tolerance to abiotic stresses, quality parameters and quantitative traits.

Why Marker-Assisted Selection (MAS) in Gene pyramiding?

Marker-assisted selection (MAS) can increase the efficiency of incorporating desirable traits present in wild germplasm into domesticated, or elite, cultivars. The primary benefit of MAS is the ability to select individuals possessing a trait of interest at the seed or seedling stage using genetic markers. MAS allows the breeder to eliminate plants that do not possess the desired trait and may otherwise require a decade of cultivation to assess phenotypically. Instead, resources and space can be dedicated only to individuals with the desired characteristic. In addition to facilitating introgression of a single source of disease resistance, MAS is a valuable tool for introgression of several sources of resistance to the same disease, or even resistance to multiple diseases, through a process called pyramiding.

Application of MAS in improving disease resistance in Fruit crops

One approach proposed to achieve durable resistance is the pyramiding of functionally different resistance genes against the same pathogen. Currently, molecular markers linked to several resistance genes and quantitative trait loci (QTLs) are available. Several grapevine and apple powdery mildew resistance loci have been identified and described to date.

Table 1. Major resistance loci in grapevine and apple species conferring resistance to *Plasmopara. viticola*, *Elsinoe necator*, and *Erwinia amylovora*

R-locus	Source of resistance	Resistance Mechanism	Chromosome	Reference
RUN1	*M. rotundifolia* Thomas Cabernet Sauvignon x VRH3082-1-42	PM, DM, PCD of penetrated cell	LG12 Linkage with Rpv1	Feechan *et al*. (2015)
RUN2 alleles	*M. rotundifolia* x Magnolia Chenin Blanc x JB81–107-11 Trayshed x *M. rotundifolia*	PM, PCD of penetrated cell	LG18 loci Overlap with rpv3 marker VMC7F2	Feechan *et al*. (2015)
Sen1	*V. rupestris* x Chardonnay	PM Susceptibility	LG09	Howard *et al*. (2018)
REN1	*V. vinifera* Kishmish vatkana, Karadzhandal	PM, PCD of penetrated cell	LG13 SC8–0071-014	Feechan *et al*. (2015)
REN2	*V. cinerea* Illinois 547–1	PM, PCD of penetrated cell	LG14	Feechan *et al*. (2015)
Pl-2	A679–2 (apple)	PM, PCD of penetrated cell	LG11	Jansch *et al*. (2015)
Pl-bj	*M. baccata* 'Jackii'	PM	LG10	Jansch *et al*. (2015)
Rvi19	Wildung		LG1	Howard *et al*. (2018)
Rvi11	*M. baccata* 'Jackii'		LG2	Jansch *et al*. (2015)

Conclusion

Biotic factors such as viruses, bacteria, fungi, nematodes, insect pests cause significant yield loss across the world. The use of resistant cultivars is seen as the best strategy, economical, durable and environmentally friendly to control these biotic stresses. As single gene-based resistance breakdown within a short period, current breeding programs targeted at stacking multiple resistance genes/QTLs into a single genotype to develop durable biotic stress resistant cultivars. Durable disease resistance and elite fruit quality could be simultaneously achieved efficiently and accurately in breeding for superior new cultivars under three conditions. First, locus specific DNA tests are developed and used to pyramid multiple sources of resistance for a single plant disease and/or combine disease resistance alleles for multiple plant diseases and to monitor inheritance of alleles directly influencing fruit quality. Use of MAS can enable breeders to unlock the potential of wild germplasm by facilitating selection at an early stage of development or even as a seed allowing for less time and money to be spent growing plants which will inevitably be discarded. However, when crossing wild relatives and elite cultivars there are certain limitations and difficulties. Often many generations of backcrossing are required to decrease linkage drag and other wild characteristics. Use of MAS technology can help reduce the amount of time required for breeding, but decades may still be required for consumer and regulatory acceptance.

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