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THE ROLE OF PROBIOTICS IN AQUACULTURE: ENHANCING HEALTH, GROWTH, AND SUSTAINABILITY

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Probiotics have emerged as an important tool in modern aquaculture, offering a sustainable and effective way to improve the health and productivity of farmed aquatic species. As aquaculture continues to expand to meet the global demand for seafood, the sector faces mounting challenges, including disease outbreaks, poor water quality, and the environmental impacts of intensive farming. Traditional approaches, particularly the use of antibiotics and chemicals, have led to concerns about antibiotic resistance and ecological harm. In this context, probiotics provide a natural alternative to enhance the overall resilience and performance of aquaculture systems.

What Are Probiotics in Aquaculture?

Probiotics are live beneficial microorganisms that, when administered in appropriate amounts, confer health advantages to the host. In aquaculture, they can be introduced through feed, directly into the water, or via bioencapsulation in live feed organisms. Once established, these microbes help improve the internal and external microbial balance in fish and shellfish, supporting healthier and more robust populations. Common probiotic genera used in aquaculture include *Bacillus*, *Lactobacillus*, *Pseudomonas*, *Enterococcus*, and *Saccharomyces*, each chosen for specific benefits based on the target species and farming environment.

Enhancement of Digestion and Feed Utilization

One of the primary ways probiotics benefit aquatic animals is by enhancing their digestive efficiency. Certain probiotic strains produce enzymes such as proteases, amylases, and lipases, which assist in breaking down proteins, carbohydrates, and fats in the feed. This enzymatic support allows for better nutrient absorption and improved feed conversion ratios, leading to faster growth and reduced feed costs. Especially in commercial operations where feed accounts for a significant portion of expenses, probiotics can significantly boost economic efficiency.

Immune System Stimulation and Disease Resistance

Another critical role of probiotics is their ability to strengthen the immune system of aquatic organisms. They help activate both innate and adaptive immune responses, increasing the production of antibodies, immune cells, and enzymes that ward off infections. This immune modulation results in reduced incidence and severity of diseases caused by harmful bacteria such as *Vibrio*, *Aeromonas*, and *Edwardsiella*. Probiotics may also help prevent viral and fungal infections by maintaining a balanced microbial environment that limits the opportunity for pathogens to take hold.

Competitive Exclusion and Antimicrobial Effects

Apart from their direct effects on the host, probiotics contribute to disease control by competing with pathogens for space and nutrients in the gut and surrounding environment. This process, known as competitive exclusion, limits the ability of harmful microbes to colonize and proliferate. Additionally, some probiotic strains secrete substances like bacteriocins, hydrogen peroxide, and organic acids that inhibit or kill harmful bacteria. This antimicrobial action further reduces the need for antibiotics and helps maintain a healthier microbial ecosystem in aquaculture systems.

Improvement of Water Quality

Probiotics also play a key role in maintaining and improving water quality, a crucial factor in the success of aquaculture. In high-density farming systems, uneaten feed and waste products can accumulate and degrade water quality by increasing ammonia, nitrite, and organic matter levels. Certain probiotic bacteria have the ability to break down organic waste, convert harmful nitrogen compounds into less toxic forms, and stabilize pH and oxygen levels. This not only improves the living conditions for aquatic organisms but also minimizes environmental pollution and the risk of disease outbreaks caused by poor water conditions.

Enhancement of Stress Tolerance

The resilience of aquatic animals to environmental stress can also be improved with probiotic use. Stress caused by fluctuations in temperature, salinity, oxygen levels, or handling can suppress immune function and make organisms more vulnerable to disease. Probiotics help reduce oxidative stress and stabilize metabolic functions, making the animals more adaptable and less susceptible to stress-related mortality. This is particularly valuable in hatcheries and during transportation, where stress is a common challenge.

Limitations and Challenges

Despite the clear benefits, the use of probiotics in aquaculture is not without challenges. The effectiveness of probiotics can vary depending on the species of the aquatic animal, environmental conditions, and the specific strains used. Not all probiotic products are created equal, and maintaining the viability of probiotic organisms during storage and application is crucial. Moreover, the regulatory oversight of probiotics in aquaculture is still developing in many regions, which can lead to inconsistent quality and performance of commercial products. Therefore, careful selection, testing, and monitoring are necessary to ensure optimal results.

Future Perspectives

Looking ahead, the role of probiotics in aquaculture is likely to expand further as research continues to uncover new strains and applications. Advances in microbiome research are allowing scientists to better understand the microbial communities within aquatic animals and their environments, enabling more targeted and effective probiotic strategies. The development of synbiotics—combinations of probiotics and prebiotics—and genetically enhanced probiotic strains may also unlock new possibilities for disease prevention, growth promotion, and environmental management in aquaculture.

Conclusion

In conclusion, probiotics represent a powerful and sustainable approach to enhancing the health, productivity, and environmental sustainability of aquaculture systems. By improving digestion, boosting immunity, reducing pathogen load, enhancing water quality, and increasing stress tolerance, probiotics offer a comprehensive solution to many of the challenges faced by the industry. As the world increasingly turns to aquaculture to meet its nutritional needs, probiotics will play an essential role in shaping a healthier and more resilient aquatic food production system.

Reference

Bantguzar, V. S., Satkar, S. G., Kumar, R., & Anjana, A. (2024). *Comprehensive review of prebiotics and probiotics in aquaculture: Mechanisms and applications*. *International Journal of Veterinary Sciences and Animal Husbandry*, *9*(1S), 777–780.

Madhulika, et al. (2025). *Multifaceted role of probiotics in enhancing health and growth of aquatic animals: Mechanisms, benefits, and applications in sustainable aquaculture – A review and bibliometric analysis. Aquaculture Nutrition*.

Mamun, M. A. A., Nasren, S., & Bari, S. M. (2018). Role of probiotics in aquaculture: Importance and future guidelines. *Journal of Bangladesh Academy of Sciences*, *42*(1), 105–109

Sarmah, P., & Sarma, S. (2023). Probiotics for sustainable development in aquaculture: A review. *Uttar Pradesh Journal of Zoology*, *44*(12), 34–46.

Studies from PubMed:

- Review: *Functionality of probiotics in aquaculture: An overview*. (2021). *Elsevier*. arxiv.org+2pubmed.ncbi.nlm.nih.gov+2arxiv.org+2
- FAO & WHO definition and multi-species efficacy information. (Madhulika et al., 2025).

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GENOTYPIC ENHANCEMENT OF RICE VARIETIES FOR SUPERIOR PERFORMANCE UNDER DIRECT SEEDING CONDITIONS

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Rice is staple food for over half of the population and forms the basis of food and financial stability in many developing and agricultural-dependent countries (FAOSTAT, 2021). Traditionally, growing rice involves transplanting seedlings into puddled fields, which is labor-intensive, water-demanding, and increasingly less sustainable due to climate change and growing labor shortages. Now a days Direct-seeded rice (DSR) is gaining prominence as a sustainable alternative to traditional puddled transplanted rice, offering significant savings in water, labor, and time. However, DSR adoption remains limited due to challenges such as poor seedling establishment, heavy weed infestation, lodging, and increased vulnerability to abiotic stresses like drought and temporary flooding. To address these issues, breeding programs are focusing on developing rice varieties with traits such as early seedling vigor, anaerobic germination tolerance, weed competitiveness, and lodging resistance. Advanced tools like marker-assisted selection, genomic selection, and gene editing are being utilized to incorporate key stress-resilient genes and quantitative trait loci (QTLs), including *SUB1*, *qDTY*, and *AG1*.

Desired Traits for Direct Seeding

DSR-adapted rice varieties include early seedling vigor, uniform germination, strong root development, weed competitiveness, lodging resistance, and tolerance to abiotic stresses such as drought, and low soil fertility. Traditional varieties bred for puddled transplanting often underperform in direct-seeded systems due to poor early establishment, vulnerability to weed competition, and susceptibility to stress during the critical early growth stages.

Hence, breeding efforts are now focused on developing varieties specifically tailored to the unique conditions of DSR ecosystems.

Rapid Germination and Seedling Vigor ensures rapid establishment and enhances the plant's ability to compete with weeds. This trait is influenced by seed size, coleoptile length, mesocotyl elongation, and seedling dry weight.

Lodging resistance is another critical requirement, as plants grown in non-puddled, aerobic soils often have weaker anchorage and are more prone to lodging due to shallow rooting and plant height. Traits such as stronger culm strength, shorter stature, and deeper rooting systems are therefore targeted in DSR breeding pipelines.

Weed competitiveness is a major challenge in direct seeding due to the absence of water cover that naturally suppresses weeds in transplanted systems. Breeding for traits like early canopy closure, rapid leaf area development, and allelopathy can reduce the need for herbicide inputs and support integrated weed management strategies.

Drought Tolerance ensures consistent performance under soil water deficits

Breeding strategies

- **Conventional breeding** Crosses between elite lines with desired traits are commonly used. Combine desirable traits from different varieties
- **Marker-Assisted Selection (MAS)** MAS helps pyramid multiple trait QTLs efficiently. Examples include lines combining AG, blast resistance, and drought tolerance (Islam et al., 2017; Laha et al., 2019).
- **Genomic Selection and GWAS** Genome-wide marker profiles enable breeding for complex traits. GS models are identifying multiple small-effect loci for early vigor and root traits (Sandhu et al., 2016). GS is speeding up selection processes.
- **Gene editing** Precise alteration of genes related to desirable traits. CRISPR/Cas9 holds potential for customizing root/development traits, e.g., editing DRO1 for root angle (Uga et al., 2013).

Future Directions

- Development of DSR-specific ideotypes
- Exploiting wild germplasm and landraces for novel traits
- High-throughput phenotyping and precision breeding
- Climate-resilient breeding for variable environments

Conclusion

Breeding rice for enhanced performance under direct seeding conditions requires a multi-disciplinary approach that combines conventional breeding, molecular genetics, stress physiology, and agronomy. By aligning breeding objectives with the agronomic realities of DSR, researchers can develop climate-smart, high-yielding, and resource efficient rice varieties that contribute to sustainable intensification and food security in rice-producing regions.

References

Islam, M. S., Majumder, R. R., Collard, B. C. Y., Singh, R. K., Hasan, M. M., Rahman, M. M. (2017). Marker-assisted introgression of anaerobic germination and submergence tolerance into rice. Theoretical and Applied Genetics. 130(5), 1085–1097.

Laha, S., Bose, S., Barman, S. C., Bhattacharya, S., Mandal, N. P., & Pramanik, S. (2019). Pyramiding of blast and bacterial blight resistance genes for flowering direct-seeded rice: MAS approaches. Euphytica. *215*(7), 117.

Sandhu, N., Kumar, A., Yadaw, R. B., & Vives, A. (2016). QTL mapping for early root architectural traits in direct-seeded rice. Scientific Reports *6*, 34066.

Uga, K., Sugimoto, K., Ogawa, S., Rane, A. B., Ishitani, M., & Al-Shami, M. (2013). Rice root system architecture is modified by the DRO1 gene for deep rooting. Nature Genetics. 45(9), 1097–1102.

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OIL POLLUTION IN MARINE ENVIRONMENTS: A COMPREHENSIVE OVERVIEW

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Oil pollution is one of the most visible and damaging threats to marine ecosystems. While the public generally associates oil spills with catastrophic tanker accidents or offshore drilling disasters, such as the 2010 Deepwater Horizon explosion in the Gulf of Mexico, the majority of oil pollution originates from less obvious, diffuse sources. Routine shipping operations, illegal discharges, and oil carried by rivers into the sea all contribute significantly to marine contamination. Alarmingly, these everyday sources account for about 90% of marine oil pollution, while large-scale disasters constitute only about 10%.Oil spills are regrettably common around the world: the Amoco Cadiz in France in 1978; the Exxon Valdez in Alaska in 1989; the 'Gulf War' in Kuwait in 1991; the Erica in France in 1999; the Aegean Sea in Galicia, Spain, in 1992; and the Prestige in Spain and France in 2002, which are some of the most well-known oil spills. Oil spills originate in oil platforms, refineries, or oil tankers that have an accident or that 'clean' their tanks in the ocean.

Globally, oil enters the marine environment through multiple pathways: 5% from natural seeps, 35% from shipping activities, 45% from atmospheric fallout and industrial discharge, and 5% from unidentified sources. The oil Itself, composed primarily of hydrocarbons, contains up to 10,000 different compounds, including toxic substances such as heavy metals and nitrogen compounds. Despite an increasing share of vegetable oils like palm oil in the global economy, fossil fuels remain the dominant pollutant.

Fate and Breakdown of Oil in Marine Waters

When oil is released into the ocean, it undergoes a series of physical, chemical, and biological transformations. Immediately, large slicks form and float on the surface. Volatile components evaporate, and the oil begins to spread, forming emulsions and dispersions in the water. Sunlight can cause photooxidation, altering the molecular structure of the oil, while some fractions dissolve in the water.

Over time, biological breakdown—primarily by bacteria—becomes the dominant degradation process. This rate depends on environmental factors such as temperature, wave action, oxygen levels, and nutrient availability. Warmer temperatures and higher oxygen and nutrient levels promote faster breakdown. The use of chemical dispersants can increase surface

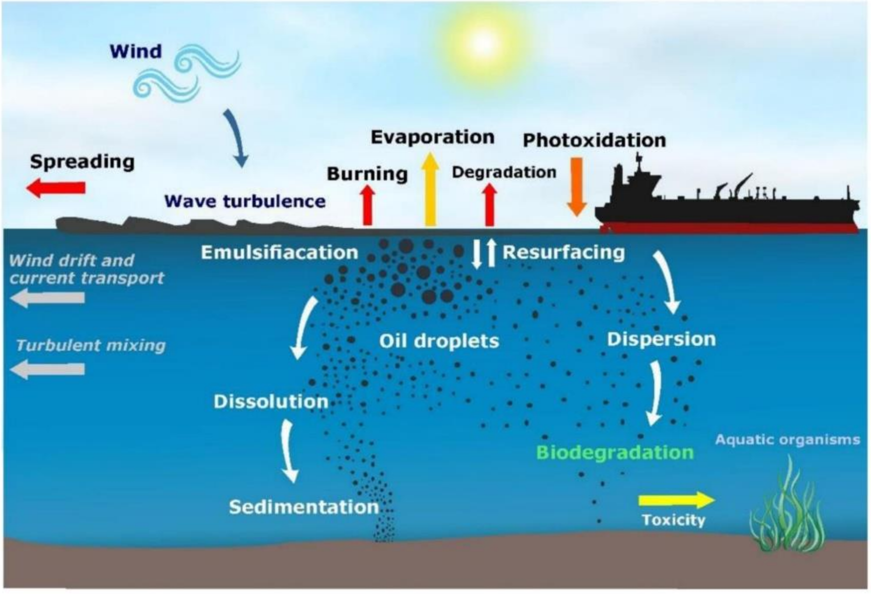

Fig 1: Transportation, weathering and fate of spilled oil in the marine environment. Adapted from Keramea et al.

area and speed up microbial degradation, although this approach comes with trade-offs, particularly in sensitive environments.

Some oil, especially heavier fractions, sinks or forms tarballs that are more resistant to breakdown. Emulsions like "chocolate mousse"—water-in-oil mixtures—can quadruple the volume of oil and severely hamper cleanup operations.

Impacts on Marine Habitats and Species

Oil spills affect marine habitats differently, depending on shoreline structure, exposure to wave action, and ecological sensitivity. Authorities use sensitivity rankings to prioritize clean-up efforts, often focusing on conservation areas and critical habitats.

- **Exposed Rocky and Sandy Shores** are considered low sensitivity areas due to natural cleansing by waves, but can still experience long-term shifts in species composition.
- **Sandy Beaches are more vulnerable**, especially those with coarse sediments and branching channels, which allow deeper oil penetration.

- **Coral Reefs are highly sensitive.** Oil can kill corals and disrupt complex symbiotic relationships, often resulting in long-term ecological shifts.
- **Mangroves, with their dense root systems and anoxic soils, suffer severely.** Oil kills flora and fauna, and hydrocarbon removal is extremely slow.
- **Soft Substrates and Sandbanks** such as those in the Wadden Sea host diverse benthic organisms. While bioturbation helps degrade oil, its absence due to mortality leads to prolonged contamination.
- **Salt Marshes** can suffer vegetation loss, which in turn affects breeding birds and other species. Recovery can take decades.
- **Regeneration periods vary widely**—from a few months for exposed shores to over 20 years for protected soft substrates and mangroves.

Response Mechanisms and Strategies

The effectiveness of oil spill response depends on rapid action, environmental conditions, and the scale of the spill. Mechanical containment methods include skimmers and floating booms, while chemical dispersants can be dropped from aircraft. However, dispersants are only effective in the early stages post-spill and may pose ecological risks of their own. In nutrient-poor waters, bioremediation—stimulating bacterial growth through nutrient addition—offers another option.

In the Deepwater Horizon disaster, oil was released at great depth, resulting in large underwater plumes. Dispersants were used extensively, raising concerns about long-term ecological effects. The need for well-coordinated national response plans has become evident. Countries like the US and Germany have established robust emergency frameworks, significantly improving response times and effectiveness.

Policy also plays a crucial role. The MARPOL 73/78 convention, the US Oil Pollution Act of 1990, and the ISM Code by the IMO have led to the mandatory use of double hull tankers and reduced operational discharges. These measures contributed to a significant drop in tanker-related pollution incidents since the 1980s.

Looking Ahead – Cautious Optimism and Continued Vigilance

Despite the increase in global oil transportation, marine oil pollution has declined significantly in recent decades. This positive trend results from international regulations, technological improvements, and stricter enforcement. However, major incidents like Deepwater Horizon are reminders that the threat remains.

Illegal discharges during tank-cleaning still contribute one-third of marine oil pollution. More rigorous monitoring and harsher penalties are required to address this ongoing issue. Shallow-water habitats, like the Wadden Sea, remain difficult to protect due to limitations in cleanup equipment.

The path forward requires integrated global and regional cooperation. Designating marine protected areas, enforcing international conventions, and developing new technologies for spill prevention and response are essential. Education and public awareness can also play a role in reducing pollution from land-based sources.

Conclusion

While significant progress has been made in reducing marine oil pollution, vigilance, innovation, and international collaboration remain key to protecting our oceans for future generations.

Reference

Keramea, P., Spanoudaki, K., Zodiatis, G., Gikas, G., & Sylaios, G. (2021). Oil spill modeling: A critical review on current trends, perspectives, and challenges. Journal of Marine Science and Engineering, 9(2), 181.

De la Huz, R., & López, J. (2011). Oil spills. In J. Nriagu (Ed.), Encyclopedia of Environmental Health (pp. 295–305). Elsevier.

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PROBIOTICS USED IN SHRIMP AQUACULTURE

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The term, probiotic, simply means "for life", originating from the Greek words "pro" and "bios". Probioticis defined as "a live microbial feed supplement which beneficially affects the host animal by improving its intestinal balance". Probiotics, the natural, beneficial bacteria are now well accepted and widely used in shrimp aquaculture. Potentially, they may have one or more beneficial functions for aquaculture producers:

- Water and pond bottom sediment quality are improved, leading to less stress on shrimp and thus improved health.
- Effluent water is cleaner, thus environmental impact is low.
- Pathogenic bacteria and their virulence can be controlled, and the overall microbial ecosystem can be managed.
- Antibiotics are not used. This stops the increase in virulence and pathogenicity in aquatic bacterial pathogens due to antibiotics. It will also minimize the risk of multiple antibiotic resistances.
- Stimulation of the shrimp immune system.
- Improved gut flora and hence lower disease incidence and increased food assimilation.

Concepts in Probiotic Bacteria

The term probiotic has been defined as "a mono- or mixed culture of live microorganisms that when applied to animals or man, affect beneficially the host by improving the properties of the indigenous microflora". Moriarty (1996a, 1998) extended the definition for aquaculture to include the addition of natural bacteria to tanks and ponds in which the animals live.

Probiotic bacteria improve the health of shrimp or fish by controlling pathogens and improving water quality by modifying the microbial community composition of the water and sediment. Probiotic bacteria enter the gut or attach to external surfaces of the animals either directly from the water or via attachment first to food or other ingested particles. Thus, they are used in aquaculture both as water and sediment quality conditioners and as feed supplements.

When we started work with probiotics in commercial shrimp farms, the products that were available had a low number of the important genus: bacteria Bacillus. Before use they had to be brewed by the farmer with a nutrient medium to produce a high enough number to be added to a pond to be beneficial. Now, we can produce pure strains of Bacillus at low cost and market these as powdered mixtures of spores with a long shelf life. The powders are simple for the farmer to use.

Many shrimp and fish farmers often think of probiotics as medicines like antibiotics. They expect a quick and decisive effect. They are then discouraged from using probiotics when the results are not immediate or dramatic. The changing of a bacterial community takes time. It is an ongoing process that requires addition of the beneficial strains of bacteria throughout the culture period. The bacteria that are added must be selected for specific functions, added at a high enough population density and under the right environmental conditions to be effective.

Bacillus – The True Probiotics for Shrimp Aquaculture

Gram positive Bacillus species are spore formers and produce a wide range of antagonistic compounds. They are suitable as commercial probiotics in aquaculture. Species such as *B. subtilis* and *B. licheniformis* occur naturally in fresh and sea water environments and are found naturally in the intestinal tracts of prawns. They are considered true probiotics for shrimp aquaculture.

Ineffective products that are sold as probiotics have caused farmers to question the probiotic concept, rather than the nature or mode of action or number of the bacteria in the product. Some contain inappropriate species of bacteria, or population densities that are too low to be effective for aquaculture.

The microflora of the sediment and water in which the cultured shrimp or fish live is influenced by the microbes released from faeces of all the animals in their environment. If a pathogen is present, its population density can be magnified through interactions in the intestinal tracts of the animals and in the faeces. When food for aquatic animals is added to the water, it adsorbs or absorbs bacteria from the water before it is eaten. However, when probiotic bacteria are added to ponds or tank water and are adsorbed to feed, they enter the intestinal tract and compete with pathogens. Thus the farmer can manipulate the species composition by seeding large numbers of desirable strains of bacteria or algae; in other words, by giving chance a helping hand.

When selected Bacillus strains are added to ponds frequently and at high density, they degrade organic matter faster than in situations where only the natural populations are available. Denitrifying Bacillus, which breakdown organic waste and use nitrate when oxygen is depleted, are especially effective on the pond bottom. A product is now available on the market from INVE that contains specially selected bacteria to speed up degradation processes

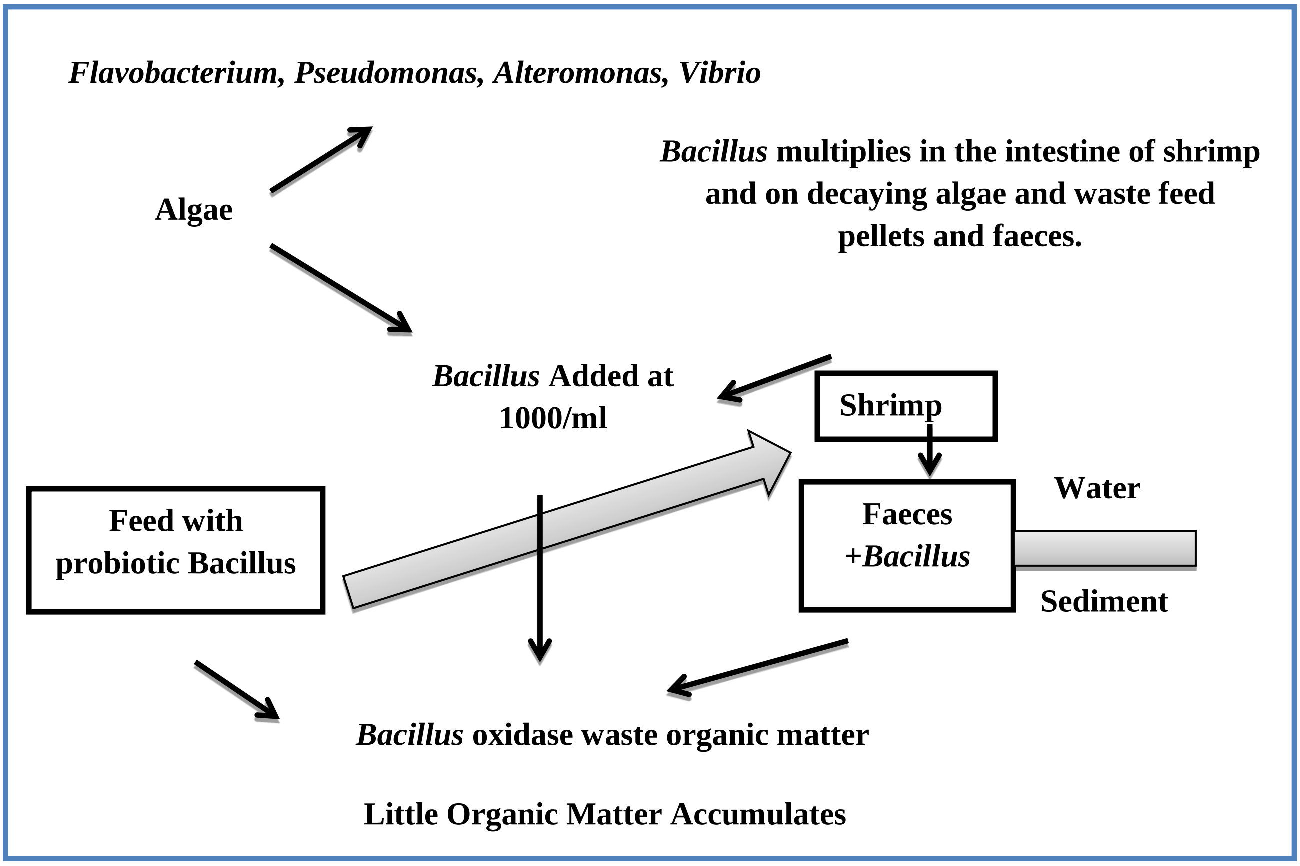

Fig 1: Effect of Bacillus at high population density in ponds. Bacillus competes with other bacteria in the pond for organic matter from algae, feed and animals. Specially selected Bacillus displaces pathogenic Vibrio.

Probiotics in Shrimp Aquaculture

1. Criteria for Selection of Probiotics for Shrimp Aquaculture.

It has been widely published that a probiotic must possess certain properties. The properties include:

1. The probiotic should not be harmful to the host it is desired for,

2. It should be accepted by the host, e.g. through ingestion and potential colonization and replication within the host,

3. It should reach the location where the effect is required to take place,

4. It should actually work in vivo as opposed to in vitro findings,

5. It should preferably not contain virulence resistance genes or AB resistance genes.

2. Evaluation of Probiotic Potential of Microbial Strains Other Than Animal Origin

Some of the probiotic strains are isolated from fermented foods, pond sediments, soil, water, and so forth. The procedure for evaluation of probiotic potential of microbial strains other than animal origin. The experimental conditions of the probiotic potential tests vary according to the target host and the further application of probiotics. After the above evaluation process, the strain is further tested for economic evaluation.

3. Application of Probiotics in Shrimp Aquaculture

Probiotic activity is mediated by a variety of effects that are dependent on the probiotic itself, the dosage employed, treatment duration and route, and frequency of delivery. Some probiotics exert their beneficial effects by elaborating antibacterial molecules such as bacteriocins that directly inhibit other bacteria or viruses, actively participating in the fight against infections, whereas others inhibit bacterial movement across the gut wall (translocation), enhance the mucosal barrier function by increasing the production of innate immune molecules, or modulate the inflammatory/ immune response. Several studies have demonstrated that pattern recognition receptors (PRPs), such as toll-like receptors

(TLRs) signaling pathways, immune responses, and the secretion of antimicrobial peptides such as defense's and chemokine's by the epithelium play important roles in these mechanisms.

Probiotics in Activation of Shrimp Immune Defences

Probiotics were successfully reported for their beneficial effects in warm-blooded animals. Experiments indicate that probiotic bacteria administered orally may induce increased resistance to enteric infections. As mentioned earlier, shrimp has a poorly developed immune system and probiotics were known to play an important role in the enhancement of immune response in shrimp.

The probiotic bacteria *Lactobacillus plantarum* was reported to enhance the immune responses and gene expression in white shrimp, *Litopenaeus vannamei*,when given in diet. The bacteria influenced both the cellular and humoral immune defences in the shrimp. *L. plantarum* was known to enhance the phenoloxidase (PO) activity, prophenoloxidase (ProPO) activity, respiratory bursts, superoxide dismutase (SOD) activity and clearance efficiency of *Vibrio alginolyticus*, peroxinectin mRNA transcription, and survival rate after challenge with *V. alginolyticus*.

These effects the immune defenses also maintain the defence levels in the shrimp offering a prolonged protection. Probiotics strains *Vibrio* P62, *Vibrio* P63, and *Bacillus* P64 were isolated from hepatopancreas of healthy wild shrimp *Penaeus vannamei*, and their immunostimulatory effect was studied.

Among the three, P64 showed a significantly higher immunity index and showed immune response similar to that of *V. alginolyticus* whereas the other two only showed good probiotic properties. Here, the P64 gave the immune alert with a significant increase in the hyaline cell population.

Table 1: Benefits of Probiotics in aquaculture

Probiotic strain	Used on	Effect of probiotic strain
Bacillus S11	*Penaeu smonodon*	Protection against *Vibrio harveyi* by stimulation of cellular and humoral immune defenses
Bacillus subtilis UTM 126	*Litopenaeus vannamei*	Control vibriosis by producing bacitracin, gramicidin, polymyxin, tyrotricidin, and competitive exclusion
Streptomyces	*Penaeus monodon*	Better water quality parameters, increased length and weight of the animal
Bacillus subtilis E20	*Litopenaeus vannamei*	Enhance humoral immune response

Conclusions

The probiotics in aquatic environment is still a controversial concept due to lack of authentic evidence or real environment demonstrations on the successful use of probiotics and their mechanisms of action. Probiotics is an alternative to antibiotics and chemicals in aquaculture which provide better health benefits, higher growth rate, increased survival rates and produce safe organic fish products to meet the protein requirements of future generations.

References

Farzanfar, A. 2006. The use of probiotics in shrimp aquaculture. *FEMS Immunology & Medical Microbiology*. 48(2), 149-158.

Gatesoupe, F.J. (1999). The use of probiotics in aquaculture: Review. *Aquaculture*. 180, 147-165.

Riquelme, C., Araya, R., Vergora, N., Rojas, A., Guaita, M., Condia, M. (1997). Potential probiotic strains in the culture of Chilean scallop Argopecten purpuratus (Lamarck, 1819). *Aquaculture*. 154, 17-26.

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SEEING THE UNSEEN: HIGH-THROUGHPUT PHENOTYPING FOR EARLY PLANT DISEASE DETECTION

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Plant diseases one of the most tenacious and unforeseen enemies to ensure global food security. Due to the climate change diseases cause tremendous declines in crop yield and quality because they are frequently brought on by complicated interactions between pathogens, hosts, and environments. In addition, traditional illness detection techniques during early symptoms are ambiguous or mild —which are mostly dependent on visual examination—are also subject to human prejudice and inconsistency.

The High-Throughput Phenotyping (HTP) technologies is revolutionizing how we perceive and evaluate plant health. Unlike traditional phenotyping, which relies heavily on visual scoring, HTP enables the rapid and non-destructive of plant traits across large populations and time points. Most importantly, it excels at qualitative disease detection—capturing complex symptom patterns such as leaf discoloration, necrosis, wilting, and chlorosis—long before irreversible damage occurs.

HTP platforms using imaging, robotics, and AI are changing plant disease detection. We examine symptom recognition research, current advances, and their implications for plant pathology, crop breeding, and sustainable agriculture, focussing on their qualitative skills.

The Evolution of Phenotyping in Plant Disease Research

Detection of plant disease intertwined with human observation has time consuming. From the decades scientist and farmers depend on visual symptoms- such as spots, blights or wilting to identify the disease. While this approach provided foundational knowledge, it inherently suffered from subjectivity, delayed detection, and limited scalability.

The rise of contemporary breeding programs, as well as global initiatives to improve disease resistance, highlighted the need for more precise, repeatable, and scalable phenotyping procedures. Early attempts at digitization introduced tools like handheld sensors and digital imaging, offering incremental improvements. However, these methods remained largely semi-automated, constrained by throughput and human involvement.

Plant phenomics is an emerging breakthrough. Penological study aimed to capture the full spectrum data from genomics and system biology under the diverse environmental conditions. From this context, High-throughput phenotyping emerge as a cornerstone, by using automation, sensor technology, robotics, and data analytics. This technique can applied to study large number of plants within minimal time.

The evolution of this technology has very impactful to study the plant diseases it can detect diseases with minimal symptoms progression, it can also detect slight frown of stress, and easily differentiate environmental and genetical effects on plants health.

Principles of High-Throughput Phenotyping

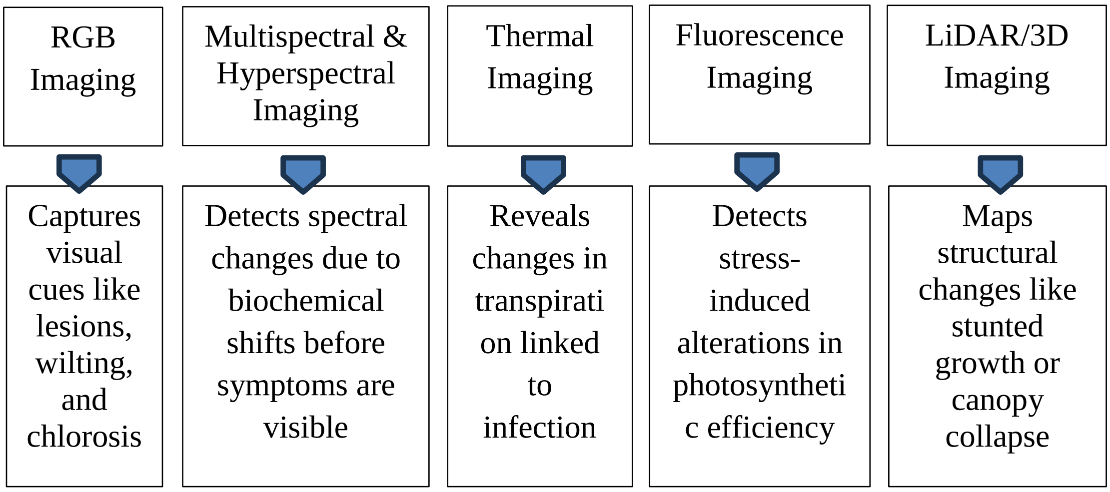
High Throughput Phenotyping (HTP) is a systematic and automated technology which can measure the large number of plants traits with in the certain periods of time by using automated sensor technology and advance computational tools. On the other hand, Low throughput phenotyping is an manual method. HTP are very crucial to understand the complex traits like disease resistant which may be due to for the influence of environment and genotype.

HTP platforms can be broadly categorized into three types based on deployment environments:

- Controlled Environment Platforms – Used in greenhouses or growth chambers, these systems use conveyor belts or robotic arms to position plants under fixed cameras, enabling precise, controlled early-stage screening.
- Aerial based Platform (UVAs/Drones)- For rapid field wide assessment, UAV and Drone has equipped with multispectral or thermal cameras.
- Ground based platform – For field phenotyping camera is mounted on tractor.

A variety of sensor modalities are employed

High-throughput phenotyping emphasizes reorganization of symptoms patterns, spatial spread and progression over the time - providing a rich, multidimensional picture of plant-pathogen interactions, In qualitative disease detection.



How HTP Detects Plant Diseases Qualitatively

Qualitative disease detection relies on spotting subtle visual and physiological signs of biotic stress, which HTP platforms capture early and accurately.

1. Symptom Recognition through Imaging

RGB imaging remains a fundamental tool in qualitative detection. It can identify visible symptoms such as:

- Necrotic lesions
- Mosaic patterns
- Leaf curling or deformation
- Chlorosis and wilting

By automating image capture and analysis, HTP eliminates subjective bias and allows for consistent scoring across time and environments.

2. Spectral Signatures of Stress

Hyperspectral and multispectral sensors detect unique spectral fingerprints associated with plant health. Diseased plants often exhibit reflectance shifts in the visible (VIS), near-infrared (NIR), and shortwave infrared (SWIR) regions due to:

- Chlorophyll degradation
- Disruption in cell structure
- Accumulation of secondary metabolites

These signatures can indicate infection before any visual symptoms emerge, enabling proactive management.

3. Thermal Infrared Imaging

Pathogen attack often affects stomatal regulation, altering transpiration and surface temperature. Thermal cameras detect localized warming in infected areas, especially during early pathogen colonization.

4. Chlorophyll Fluorescence

Chlorophyll fluorescence sensors measure photosystem II efficiency, which declines under stress. This metric provides a rapid, non-invasive proxy for disease impact on photosynthesis.

5. AI and Machine Learning for Qualitative Diagnosis

Advanced image analysis—powered by convolutional neural networks (CNNs), support vector machines (SVMs), and decision trees—enables automated classification of disease types and severity. AI models can be trained to recognize patterns in:

- Lesion morphology
- Color gradients
- Tissue texture

Case Applications

- Wheat rust detection via hyperspectral imaging with >90% accuracy.
- Rice bacterial blight detected through UAV-based RGB and multispectral integration.
- Potato late blight classified using deep learning on visible symptoms.
- HTP's qualitative strength lies in this rich synergy between sensor fidelity and pattern recognition, providing a robust tool for early, scalable, and accurate disease diagnosis.

Challenges and Limitations in Qualitative HTP for Disease Detection

While High-Throughput Phenotyping (HTP) holds immense promise, several scientific and logistical challenges limit its widespread adoption, especially for qualitative disease detection.

1. Biological and Environmental Complexity

Plant disease symptoms are often variable and context-dependent. A single pathogen may present differently across:

- Genotypes
- Growth stages
- Environmental conditions

Distinguishing between biotic (disease) and abiotic (drought, nutrient deficiency) stress remains particularly challenging, as both can produce similar visual cues like wilting or chlorosis.

2. Sensor and Resolution Limitations

Not all sensors capture the fine-scale details necessary for early or low-severity symptoms:

- RGB imaging lacks physiological depth.
- Hyperspectral sensors are often expensive and require complex calibration.
- Low spatial resolution from UAVs may miss individual plant-level variations in dense canopies.

3. Standardization and Validation Gaps

There's currently a lack of standardized scoring systems across HTP platforms. Variability in image acquisition protocols (lighting, angle, distance) can affect repeatability and cross-study comparability. This hinders model generalization across crops and environments.

4. Data Overload and Interpretation Bottlenecks

HTP generates massive datasets—from gigabytes of image stacks to multiband spectral cubes. Without streamlined pipelines for annotation, feature extraction, and visualization, meaningful interpretation becomes a bottleneck.

5. Infrastructure and Accessibility Constraints

Many HTP systems require significant investment in hardware, computational power, and technical expertise. This limits adoption in resource-limited regions, where disease outbreaks may be most prevalent and damaging.

Addressing these challenges calls for interdisciplinary collaboration—combining plant science, engineering, and data science—to create cost-effective, scalable, and adaptable HTP solutions tailored for real-world agriculture.

Recent Advancements and Innovations

In the past decade, advances in HTP—like miniaturized hardware, sensor fusion, AI, and cloud computing—have made disease detection more accurate, efficient, and field-ready.

1. AI-Driven Symptom Recognition

Deep learning algorithms, particularly convolutional neural networks (CNNs), have significantly improved pattern recognition capabilities. Trained on large annotated datasets, these models can now differentiate between diseases with high accuracy, even in complex field backgrounds. Models are also being developed to learn symptom progression over time, enabling early-stage intervention.

2. Edge and Real-Time Computing

Edge devices are now embedded within field platforms, allowing real-time processing of images and sensor data. This reduces latency and enables immediate alerts for disease outbreaks in the field, with minimal dependence on cloud infrastructure.

3. Low-Cost and Smartphone-Based HTP

Efforts to democratize HTP have led to the development of smartphone-based image acquisition tools, often integrated with open-source image analysis apps. These tools empower field pathologists, extension agents, and even farmers to identify diseases using AI-driven symptom libraries.

4. Sensor Fusion Systems

Multimodal platforms that combine RGB, thermal, and hyperspectral data offer synergistic insights, improving detection specificity. These hybrid systems are particularly powerful for complex disease syndromes and co-infections.

5. Cloud-Based Data Integration

Web platforms now support storage, annotation, and model training, enabling collaborative disease monitoring and crowdsourced labelling, creating global-scale disease surveillance networks.

Applications in Research, Breeding, and Precision Agriculture

High-Throughput Phenotyping (HTP) for qualitative disease detection is transforming the way we approach plant research, breeding, and field management. By enabling rapid, accurate, and non-invasive assessment of disease symptoms, HTP is bridging the long-standing gap between laboratory discovery and real-world agricultural application.

1. Accelerated Disease-Resistance Breeding

Traditionally, breeding for disease resistance has relied on manual scoring of symptoms—an inherently slow and error-prone process. With HTP, breeders can screen thousands of genotypes simultaneously, capturing subtle phenotypic differences such as lesion pattern, symptom spread, and severity dynamics. This allows for:

- Early-stage selection of resistant lines
- High-accuracy phenotypic data for genomic selection and QTL mapping

2. Field Disease Surveillance and Outbreak Management

In precision agriculture, drone-based and ground-mounted HTP systems enable real-time disease scouting across large farm areas. By detecting symptoms early and geo-referencing hotspots, HTP facilitates:

- Site-specific pesticide application
- Reduced chemical use
- Early containment of infectious outbreaks

3. Fundamental Research in Plant-Pathogen Interactions

HTP provides time-series data that helps researchers understand symptom progression, host response, and pathogen behavior under variable environments. This dynamic insight is critical for building robust pathosystem models and testing biocontrol strategies.

Ultimately, HTP's integration into these domains enhances efficiency, sustainability, and resilience in crop health management, especially as agriculture confronts emerging disease threats and climate variability.

Conclusion

High-Throughput Phenotyping (HTP) is redefining how plant diseases are detected, monitored, and understood. By capturing nuanced, qualitative symptom expressions through advanced imaging and AI-powered analysis, HTP offers a powerful, non-invasive alternative to traditional methods. Its ability to detect early-stage infections, accelerate resistance breeding, and enable real-time surveillance makes it indispensable for modern agriculture. As the technology continues to evolve and become more accessible, HTP will be central to building resilient, disease-aware cropping systems, especially in the face of climate change and emerging pathogen threats. The future of plant disease diagnostics is not only high-throughput—but also smarter, faster, and more inclusive.

References

Araus, J. L., & Cairns, J. E. (2014). Field high-throughput phenotyping: the new crop breeding frontier. Trends in Plant Science, 19(1), 52–61. https://doi.org/10.1016/j.tplants.2013.09.008

Mahlein, A. K. (2016). Plant disease detection by imaging sensors–parallels and specific demands for precision agriculture and plant phenotyping. Plant Disease, 100(2), 241–251. https://doi.org/10.1094/PDIS-03-15-0340-FE

Furbank, R. T., & Tester, M. (2011). Phenomics–technologies to relieve the phenotyping bottleneck. Trends in Plant Science, 16(12), 635–644. https://doi.org/10.1016/j.tplants.2011.09.005

Sankaran, S., Mishra, A., Ehsani, R., & Davis, C. (2010). A review of advanced techniques for detecting plant diseases. Computers and Electronics in Agriculture, 72(1), 1–13. https://doi.org/10.1016/j.compag.2010.02.007

Raza, S. E. A., Prince, G., Clarkson, J. P., & Rajpoot, N. M. (2015). Automatic detection of diseased tomato plants using hyperspectral and thermal imagery. Plant Methods, 11(1), 1–10. https://doi.org/10.1186/s13007-015-0051-6

Cruz, J. A., & Yang, W. (2019). High-throughput phenotyping and phenomics for plant breeding. Plant Science, 282, 1–2. https://doi.org/10.1016/j.plantsci.2018.12.010

Singh, A., Ganapathysubramanian, B., Singh, A. K., & Sarkar, S. (2016). Machine learning for high-throughput stress phenotyping in plants. Trends in Plant Science, 21(2), 110–124. https://doi.org/10.1016/j.tplants.2015.10.015