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Agricultural biotechnologies in developing countries: Options and opportunities in crops, forestry, livestock, fisheries and agro-industry to face the challenges of food insecurity and climate change (ABDC-10)

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Synthesis: Current status and options for biotechnologies in fisheries and aquaculture in developing countries

Introduction

In 2007, more than 113 million tonnes of food fish were consumed globally, providing an estimated per capita supply of 17.1 kg (live weight equivalent). Aquaculture contributed nearly half (44.3 percent) of this total, and is the fastest growing food-producing sector in the world. It is expected that in the near future aquaculture will produce more fish for direct human consumption than capture fisheries. Given the inability of the capture fisheries sector to make an increasing contribution to global food fish production, the aquaculture sector is now recognized as a strong contributor for alleviating global poverty and increasing food security. The rapid growth of aquaculture has significantly benefited both from conventional technologies and from biotechnologies, and it is expected that advanced biotechnologies will further help the sector in meeting the global demand for aquatic food in the coming decades.

Creating an enabling public sector environment is essential for better governance at all levels of aquaculture development. There have been many regulatory rebounds in the aquaculture sector in some countries. Uncontrolled and unregulated development of the sector has outstripped the carrying capacity in some locations, causing significant production losses mainly due to diseases. Addressing such problems is of paramount importance to the sector, globally.

This document synthesizes the key elements of document ABDC-10/6.1 that provides an analysis of the use of biotechnologies in fisheries and aquaculture in developing countries, consisting of a stocktaking part (learning from the past) and a 'looking forward' part (planning for the future).

Stocktaking - Learning from the Past

The main areas where biotechnologies have been used in aquaculture production and fisheries management, both in developing and in developed countries, include genetic improvements and control of reproduction; biosecurity and disease control; environmental management and bioremediation; and biodiversity conservation and fisheries management.

One of the main reasons for the success of aquaculture as a significant food-producing sector in the world is the diversity of species currently in culture and the genetic diversity that can be exploited through captive breeding and domestication. However, compared with other food

production sectors, aquaculture has not made full use of modern biotechnologies, particularly in the field of genetics, to increase production.

Although aquaculture involves the culture of many more species than in the livestock sector, the number of domesticated species is limited and the sector still relies on wild-caught seed for culture. *Penaeus monodon*, the black tiger prawn, arguably the most valuable species produced globally, has yet to be fully domesticated. In contrast, commercial production of specific pathogen free (SPF) broodstocks and post-larvae of the white shrimp *Penaeus vannamei* is now possible and global production of *P. vannamei* has increased steadily. Improvements that allow the wider application of appropriate genetic and reproduction biotechnologies will undoubtedly increase aquaculture production, thus contributing to global food production. These biotechnologies include polyploidy, gynogenesis and androgenesis, the development of monosex populations and cryopreservation. Gene sequencing and mapping is also being applied in high-value species, particularly towards developing tools for disease diagnosis, pathogen identification and health management.

Disease outbreaks are a serious constraint to aquaculture development. Disease control and health management in aquaculture is different from those of terrestrial livestock sector, particularly due to the fluid environment that they live in. Disease occurs in all systems, from extensive to intensive, and losses are possible in all types of production systems.

There is a need for better management of intensive systems, and biotechnological tools can help. The tools used in disease diagnostics and therapy have changed over the years, from traditional conventional methods to modern biotechnological procedures. These new techniques are well proven, but require a high level of expertise. The use of such technologies in the production of high-value species is now a common practice in global aquaculture.

The safety of aquaculture food products is a global concern, as for any other food commodity. One of the key concerns is the presence of antimicrobial residues in the final product. There are banned antimicrobials in aquaculture where no residues are allowed in the final product. Although difficult, the way to mitigate this situation is to develop effective vaccines. The use of vaccines provides good immunoprophylaxis for some of the most important infectious diseases of finfish. In developed countries, their use has proved very effective in decreasing the unsustainable use of antibiotics.

Reducing the environmental impacts of aquaculture is a significant task. Aquaculture has often been accused of being unsustainable and not environmentally friendly. Reducing the impacts of effluent discharge, improving water quality and responsible use of water are key areas to be considered in aquaculture development. Several biotechnologies are being used to address these areas, such as bioremediation for the degradation of hazardous wastes; use of vaccination and probiotics to reduce antimicrobial use in aquaculture; and use of DNA-based methodologies for the early detection of toxin-producing algae.

In the capture fisheries sector, the sustainable management and conservation of fisheries is a priority. Better understanding of the population structure of the fishery is therefore of paramount importance. Some biotechnologies have already been applied, but there is ample scope for the greater use of biotechnologies in fisheries management worldwide. The use of molecular markers and the principles of population genetics have proved very effective for assessing the actual levels of genetic variability within single populations and for measuring the extent of differentiation between populations.

Looking Forward - Preparing for the Future

Aquaculture is the fastest growing food-producing sector in the world. In the effort to maximize the contribution from aquaculture, many constraints and hurdles need to be overcome in the coming decades, the biggest of which is environmental sustainability. There is proven scope for the use of biotechnologies in environmental management in the aquaculture sector, but continued research and application are needed.

Conventional methods of controlling diseases, such as chemotherapeutants, are ineffective against many new pathogens (notably viruses). Molecular techniques for pathogen screening and identification have therefore received increasing attention. Biotechnologies can contribute to better animal health management in aquaculture in developing countries, in particular through the development of sensitive and accurate molecular diagnostic methods and tools, and through the development of vaccines for tropical diseases.

Although current knowledge is limited, there is consensus that climate change could become a significant constraint for aquaculture development and fisheries management in the coming decades. One of the practical responses to climate change for aquaculture could be to strengthen the adaptive capacity and resilience of the sector, with particular regard to small farmers and other users of aquatic resources. Certain biotechnologies, particularly those dealing with genetic improvement, health and environmental mitigation, should provide valuable help in developing adaptive technologies and interventions against the ever-threatening issue of climate change.

Future demand for aquatic food is expected to be high. Production needs to be increased considerably over the next 20 years in order to maintain the current level of per capita consumption. This is not an easy task, and the sector will face constraints in the fields of disease prevention and health management, genetic improvement and domestication, environmental management and food safety. Biotechnologies can help the sector in this direction and provide means of producing healthy and fast-growing aquatic animals, through environmentally friendly means.

Most aquaculture is small-scale. Few biotechnological advancements or tools are currently applied in small-scale aquaculture operations, which aim at rural development, poverty alleviation and food security in developing countries, and so it is necessary to identify those that are used and consider their socio-economic impact. Most aquaculture biotechnologies are still too technical and costly for small-scale farmers. Efforts should be made to develop low-cost simple technologies that are easy for less advanced small-scale aquaculture farmers to adopt. More research is required to develop vaccines for tropical species, particularly for the major species of global production.

Aquaculture, compared to livestock and crop production, is still a novel production system in many developing and developed countries. Most biotechnological interventions have so far been developed to address improved production and better management of aquaculture, and have been targeted towards high-value commercial aquaculture species produced mainly for international markets. This appears to be due to the cost of the technology and to the organized nature of industrial aquaculture. In order to make the best use of modern biotechnologies for developing countries and enhance poverty alleviation and food security, it is imperative that more attention is paid to developing low-cost and economically viable technologies that can be used by the small-scale aquaculture farming sector, which comprises over 80 percent of the sector and production.

There is a need to secure better funding for aquatic biotechnological research and applications, which should also be directed towards investment in capacity-building within the relevant fields in the aquaculture sector. National biotechnology programmes in developing countries should include a special committee to oversee the aquatic biotechnology programme and research.

The gathering and disseminating of information on aquatic biotechnologies should be encouraged within and between countries in a given region, and developing countries should consider setting up dedicated websites for this purpose. Another important issue to be addressed is the increasing competition that aquaculture products are facing in accessing international markets, where one of the key criteria is food safety and compliance with international food safety standards. The aquaculture industry should therefore consider the importance of biotechnological interventions for improving and maintaining safety in cultured aquatic food products. National governments in developing countries should also consider research and development interventions in food safety within the broader framework of biotechnology.

It should also be noted that the establishment of efficient institutional structures and enforceable legal frameworks by governments are important for the responsible use of biotechnologies in

aquaculture at the national level. Such institutional arrangements should also strengthen research and extension needs and enhance relevant human and infrastructural capacities.

The international community, including FAO and other UN organizations, as well as NGOs, donors and development agencies, can play a key role in supporting developing countries by providing a framework for international cooperation and funding support for the generation, adaptation and adoption of appropriate biotechnologies in aquaculture and fisheries. Some of the ways in which they can do this is by:

- Recognizing that biotechnological interventions can contribute to sustainable aquaculture development worldwide.

- Helping developing countries collect, collate and analyse information about the biotechnologies in use in fisheries and aquaculture, and their contributions to national food security, poverty alleviation and social development.

- Maintaining databases and information systems that help countries access information for national biotechnology development programmes relating to fisheries and aquaculture.

- Dedicating an appropriate share of assistance projects to promoting and strengthening aquatic biotechnology R&D in developing countries, with international research efforts focusing on interventions that are accessible to small-scale farmers.

- Ensuring that technical assistance in biotechnology R&D should not be at the expense of funding for other key research fields, and that the technical assistance should support effective and intimate links to strong breeding and extension programmes.

- Considering biotechnological advancement as an important area to be supported in the context of aquatic sustainability, and by assisting developing countries in strengthening capacities for biotechnology policy development and long-term planning.

- Assisting developing countries in developing the capacities of the national agricultural research systems, which include aquaculture, to involve relevant stakeholders in decision-making processes.

- Assisting developing countries in the development of adequate institutional capacities in the development and enforcement of regulations related to the use of biotechnologies in fisheries and aquaculture.