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SUSTAINABLE INTENSIFICATION IN FRESHWATER FISH FARMING IN HUNGARY

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УСТОЙЧИВОЕ ПОВЫШЕНИЕ ЭФФЕКТИВНОСТИ ПРЕСНОВОДНЫХ РЫБХОЗОВ ВЕНГРИИ

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Abstract. A great challenge in freshwater aquaculture, especially in pond aquaculture is, how to increase the production without additional impact on the environment and without losing the traditional values of the ponds such as ecological services, water- and landscape management. The application of combined intensive-extensive fish production systems (e.g. "pond in pond"; "fish pond water recycling") can contribute to the development of sustainable intensification. The paper presents the results of the practical application of new systems and technologies in two major pond fish farms ("Aranyponty" Zrt. and "Jászkiséri Halas" Kft.) and an intensive trout farm ("Hoitsy and Rieger" Kft.) in Hungary. The paper also shows how the Hungarian Aquaculture Association assists the development of sustainable intensification of the Hungarian fish production sector.

Key words: freshwater aquaculture; sustainability; intensification; combined intensive-extensive system.

Реферат. В пресноводной аквакультуре, в частности, в прудовой аквакультуре, важной задачей является увеличение производства, без усиления при этом воздействия на окружающую среду и без утраты традиционной ценности прудов как экологических объектов со своей водной системой и ландшафтами. Применение комбинированных интенсивно-экстенсивных систем производства рыбы (например, «пруд в пруду», рециркуляция воды в рыбоводном пруду) может внести свой вклад в развитие устойчивого повышение эффективности. В работе представлены результаты практического применения новых систем и технологий в двух главных рыбхозах ("Aranyponty" Zrt. and "Jászkiséri Halas" Kft.) и в рыбхозе по интенсивному выращиванию форели ("Hoitsy and Rieger" Kft.) в Венгрии. В работе также описано, каким

образом Венгерская ассоциация аквакультуры оказывает помощь в целях устойчивого повышения эффективности в секторе производства рыбы в Венгрии.

Ключевые слова: пресноводная аквакультура, устойчивость, повышение эффективности, комбинированная интенсивно-экстенсивная система.

Introduction

The world population will reach 9.4 billion by 2050 and it is a great challenge for the food industry including fisheries and aquaculture how to meet the demand of the increasing population with adequate amount, good quality and healthy food. The global aquaculture production should be increased by about 130% by 2050, however it should be done without the deterioration of the environment and overexploitation of resources. The term "sustainable intensification" is a relatively new and evolving concept emerged in agriculture. Sustainable intensification has been defined as a form of production wherein "yields are increased without adverse environmental impact and without the cultivation of more land". Although marine aquaculture has future potential to explore off shore areas for increasing production, freshwater aquaculture has similar constraints and challenges as agriculture where cultivable land areas are limited. In freshwater aquaculture semi-intensive production of fish in earthen ponds is still a dominant type of aquaculture in many regions of the world including Central and Eastern Europe. There are limitations in conventional intensification of pond fish farming by increasing stocking density and applying formulated feed due to various reasons such as environmental and animal welfare regulations, social concerns and the increasing competition for freshwater resources. Therefore the increase of freshwater aquaculture production requires innovative approaches and the use of new systems and technologies. The Strategic Research and Innovation Agenda (SRIA) of the European Aquaculture Technology and Innovation Platform (EATiP) identified research programs in order to assist sustainable European aquaculture and freshwater fish farms also put significant efforts in the development of systems and technologies to produce more fish without the deterioration of the natural environment and overuse of resources. Three member

farms of the Hungarian Aquaculture Association (MASZ), namely two pond fish farms the "Aranyponty" Zrt. and "Jászkiséri Halas" Kft. and an intensive trout farm, the "Hoitsy and Rieger" Kft. provide good example of the efforts how to increase the production without additional impact on the environment and without losing the traditional values of the ponds such as ecological services, water- and landscape management.

Principle and practical application Combined Intensive Extensive (CIE) production

The Combined Intensive Extensive (CIE) production system as the term indicates consists of an intensive and an extensive component. The intensive unit is used exclusively for the production of fish or other aquatic animals, while in the extensive unit the production function may not be the primary one since this unit has functions like the treatment of the effluent from the intensive unit or ecological services (e.g. habitat for wildlife), or even recreation. The intensive unit (e.g. small pond, tank) and the extensive unit (usually large pond) could be physically/spatially separated, but the intensive unit could also be placed in the water body of the extensive pond. It is important however to provide a continuous water flow from the intensive- to the extensive unit in order to remove the excess nutrients through biological processes in the extensive pond. Low head and high capacity pumps are used for water movement. The water that is treated in the extensive pond can either be recirculated to the intensive unit, or discharged into the natural environment without causing any negative impact.

Numerous experiments with CIE systems have been carried out in several countries, mainly in Germany, Hungary. Israel and USA (Diab et al, 1992; Varadi et al., 2001; Brune et al., 2004; Füllner et al., 2007) that clearly demonstrated the advantages of such systems, however their introduction to the practice is rather slow. The main reasons are that farmers are sticking to conventional technologies and trying to avoid risks in production, but also the lack of innovation capacities and financial resources. The spreading of new technologies is also caused by lack of

enabling economic environment, innovation promotions, competitive spirit, and farmers' cooperation. The potential in practical application of CIE systems however, is demonstrated by some innovative farmers in Hungary that may give a boost to the wider application of such systems in Central and Eastern Europe.

"Pond-in-pond" and "Fish pond RAS" at the Jaszkiseri "Halas" Kft.

The layout of the pilot system in the farm that includes the "pond-in-pond" and the "fish pond Recirculating Aquaculture System (RAS)" components is shown in Figure 1.

Figure 1 – "Pond-in-pond" and the "fish pond Recirculating Aquaculture System (RAS)" components in the fish farm of the "Jaszkiseri "Halas" Kft"

Experiences and results with the operation of the Pond-in-pond system

The "pond-in-pond" system consists of four fish rearing tanks (30 m^3 each) that are arranged in a floating unit with a total volume of 120 m^3. The scheme of the "pond-system" is shown in Figure 2.

The water circulation was ensured by a low head high capacity air lift pump. The air was provided by an air blower that was driven by an electric motor of 2 kW.

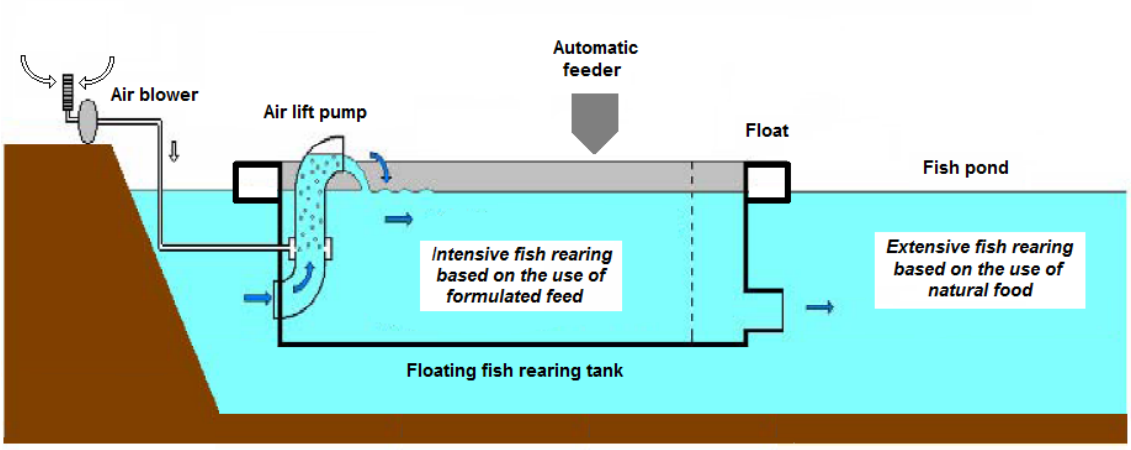

Figure 2 – Scheme of the "pond-in-pond" system

The formulated feed was distributed to the fish rearing tank by automatic feeder.

Common carp and hybrid striped bass were raised in the tanks intensively during the natural growing season, when the extensive pond served as a natural treatment unit to remove the nutrients from the effluent of the floating rearing tanks. The highest standing biomass for carp was 40 kg/m^3, however carp rearing was not that economically feasible if the carp price was 550 HUF/kg (ca. 1,8 €/kg). However, the operation of the system was profitable when hybrid striped bass (*Morone saxatilis x M. Chrysosps*) was produced intensively. The total yield in the system was 4800 kg (40 kg/m^3) and the total income was 28,800 € when the fish was sold on a price of 6 €/kg. The view of the system in operation is shown in Figure 3.

Experiences and results with the operation of the "fish pond RAS"

Experiments with "fish pond RAS" have also been started at the farm, when one of the wintering ponds (2000 m^2) beside a large (20 ha) extensive pond (shown in Figure 1.) was turned into an intensive pond for carp production. The view of the intensive pond equipped with automatic feeder and surface aerator is shown in Figure 4.

The results of the pilot-scale production are summarized in the followings (Borbely and Csorbai, 2012).

In the large (20 ha) extensive pond large size two summer old carp of 300 g

Figure 3 – "Pond-in-pond" system in operation in the fish farm of the "Jaszkiseri "Halas" Kft"

Figure 4– View of the intensive carp rearing pond as a component of a fish pond RAS in the "Jaszkiseri Halas" Kft.

was stocked with a stocking density of 1000 fish/ha. The production was based on the use of natural food and supplementary feeding by cereals. The overall Feed Conversion Ratio (F.R.C.) was 1:4. At the end of the growing season the gross yield was 1050 kg/ha (700 fish/ha with an average weight of 1.5 kg). The survival rate was only 70% due to the massive bird predation. The net result of the extensive fish rearing was 656 €/ha.

In the small (2000 m^2) intensive pod the same size (300 g) of two summer old carp was stocked with a stocking density of 7000 fish/ha that was 7 times higher than that of the extensive pond (7000 fish/ha).The fish was fed on pelleted feed with an F.R.C. of 1:1.6. The gross yield was 10,000 kg/ha (6600 fish/ha with an average weight of 1.5 kg). The survival rate was much higher in the intensive pond (94%) because the small pond could be protected more efficiently against bird predation than the large one. The net result of the intensive production was 4,293 €/ha.

Combined intensive-extensive system at "Aranyponty Zrt."

The Combined Intensive Extensive (CIE) system that was applied at "Aranyponty Zrt." is similar to the system described in Chapter "Experiences and results with the operation of the Pond-in-pond system", however in this case the intensive unit is a floating cage and a special polyculture is applied in the extensive pond. European catfish (*Silurus glanis*) as indigenous high market value species was produced in the cage intensively, while the main species of the polyculture in the extensive pond were common carp (*Cyprinus carpio*), silver carp (*Hypophthalmicthys molitrix*), grass carp (*Ctenopharyngodon idella*) and paddle fish (*Polyodon spatula*).

One summer old European catfish was stocked into the floating cages (5x5x2m) that were placed in a fish pond (Figure 5).

Formulated feed was applied that was distributed to the cages by automatic feeder driven by solar panels. The fish meal was substituted completely by soybean meal and meat meal. The F.C.R. was 1.95 kg. Since the digestibility of plant based nutrients is limited in carnivorous fish the feed was enriched with microbial protein.

Figure 5 – Floating cages in a fish pond at the "Aranyponty Zrt." for the intensive rearing of European catfish

When the dissolved oxygen level in the pond decreased to low level paddle wheel aerator supplied air to the water body. The catfish reached 1350 g individual weight by the end of the growing season. No any disease problem occurred during the intensive rearing of the catfish. One cage of 50 m^3 was put in a one hectare pond area, in which 500 kg European catfish was produced. The organic wastes from the cages (uneaten feed and excreta) was utilized and processed in the fish pond where common carp, grass carp, silver carp and paddle fish were produced. The organic wastes from one cage provided sufficient nutrients for one hectare where common carp and paddle fish were the main species. No fertilizer and supplementary feed were applied in the extensive pond, where the yield was 700 kg/ha (500 kg/ha common carp and 200 kg/ha paddle fish). The grass carp and silver carp as complementary species contributed to the improvement of the nutrient utilization in the system.

In order to improve the water quality, mainly to limit the growth of the blue green algae and also to prevent the accumulation of sediment in the fish pond a special bacterial product (effective microorganism) "Corenzim Aleurit" was applied. When the fish pond bottom was properly treated by lime, and regular N fertilization

was applied, we were able to maintain the preferable dominance of green algae for a long period. The most effective treatment was the combined use of the bacterial product (100 l/ha) and sodium percarbonate (45 kg/ha) together with continuous aeration. The bacterial product didn't have any adverse effect on the fish and macro benthic community in the sediment.

Partial water recycling to save water and protect environment at the trout farm of "Hoitsy and Rieger Kft."

The trout farm is producing Rainbow trout (Onchorhynchus mykiss Walbaum, 1792), brown trout (Salmo trutta m. fario Linné, 1758), and brook trout (Salvelinus fontinalis Mitchill 1815) in 18 raceways with a total area of 3700 m^2. The annual production of the farm is 36-38 tons of market size fish according to the availability of the supply water.

In order to produce trout intensively in a protected environment that is also a touristic area the farm built a special water treatment system and the effluent water from the raceways is circulated through the system. The open air RAS contributes to the protection of the natural environment but also to decrease the dependence on the natural water supply since the flow rate of the creek is varying greatly. The water treatment system comprises the following main units: (1) drum filter; (2) biological filter; (3) constructed wetland. The water is circulated by air lift pumps. In order to ensure safe operation there are two independent (but connectable) water circles in the RAS.

The effluent water from the raceways flows to the drum filters by gravity. The drum filter (Figure 6) has stainless steel mesh of 70 µ.

The sludge from the drum filter is collected in a pit where it is mixed with sawdust and removed once a year.

The biological filter of the outdoor RAS is a "floating bed" biofilter with a 800 m^2/m^3 effective filter area (Figure 7).

The plastic media in the biological filter is kept floating by air that is blown into the water through perforated pipes placed in the bottom of the filter tank. The air

Figure 6 – Drum filter in the open air RAS of the Hoits and Rieger intensive trout farm

Figure 7 – The view of the biological filter Hoitsy and Rieger intensive trout farm

also provide oxygen to the nitrifying bacteria and helps the removal of harmful gases first of all CO^2.

The water is circulated through the fish tanks, the drum filter and the biological filter by air lift pumps with low head (max 25 cm) and high capacity. The water recycling in the system is partial, therefore a part of the water is released regularly to the creek Garadna that is flowing along the farm area. However the effluent water from the farm is treated on a constructed wetland where various water plants remove the N and P from the water. The applied water plants are the followings: common bulrush (Typha latifolia); European water-plantain (Alisma plantago aquatica); Chlorocyperus glaber; sedges (Carex sp.), club rush (Scipus sylvaticus) common duckweed (Lemna minor) és broad-leaved pondweed (Potamogeton natans). The wetland efficiently removes the nutrients from the effluent water and the intensive trout farm doesn't have any negative impact on the water of the creek and the surrounding ecosystem.

The Hungarian Aquaculture Association to assist sustainable aquaculture development

The Hungarian Aquaculture Association (Hungarian acronym MASZ) was established on 13th of July 2010 by 11 innovative fish farms and 3 research and education institution. The main reason of the establishment of a new association in Hungary was to boost sustainable aquaculture development in Hungary through innovation. Thus the major objectives of MASZ – besides the representation of interest of members, and active participation in the decision making process – are organising workshops, conferences, publishing papers and documents, assisting R&D activities and pilot projects. Five years after the establishment of the Association MASZ has 49 members (44 Small and Medium Enterprises and 5 institutions) among them the most innovative farms and leading institutions in aquaculture research and innovation. The share of MASZ members in the total fish pond area in Hungary and that of total fish harvested is 40% and 43% respectively.

The transfer of information and knowledge and the assistance of technology

transfer are important activities of the Association. MASZ provides regularly news to members related to aquaculture development through its website, newsletter and occasional specific news by e-mail. The Association has also published various documents like the Hungarian version of the EATIP "Future of European Aquaculture" document (EATiP, 2012) and the "Biology and technology of commercial fish farming in Recirculating Aquaculture Systems (RAS) and the possibilities of the use of RAS in Central and Eastern Europe". MASZ is organising an annual aquaculture conference with the sub-title: "Farmers and scientists together to give momentum to aquaculture development". The Association organized the Workshop of European Pond Fish Farmers in 2013. The statement of the workshop later was complemented and accepted by the 2rd. International Carp Conference in Wroclaw and published as "Wroclaw Statement" (Wroclaw Statement, 2013). The Association is also involved in the implementation of an EU FP7 project “Diversify” disseminating the results of the research aiming at the intensive culture of pike perch in RAS, besides MASZ is involved in project preparatory works in the framework of Horizon 2020. International collaboration is an important activity of MASZ that is member of the Federation of European Aquaculture Producers (FEAP). MASZ is also active to strengthen collaboration among producers associations in Central and Eastern European countries where the challenges and opportunities of aquaculture development are similar. MASZ is also involved in the organisation of the 3rd International Carp Conference that will be organised in Vodnany, Czech Republic between 3-4 September 2015.

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