Modern biotechnologies of an aquaculture – a key element of the innovative development of economy of the Southern Federal District of Russia

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Abstract. Development of aquaculture is the important socio-economic factor defining modern development of the fishery industry in corresponding federal districts, including the Southern Federal District. The analysis of the current state of aquaculture of the Southern Federal District is provided and it is shown that development is possible only in case of industrialization of aquaculture and integration into it of relevant scientific and technology solutions (biotechnologies). Cultivation using biotechnology is carried out in the territory of the Southern Federal District by the Southern scientific center RAS at NEB (scientific expedition base) "Kagalnik". The developed technology meets priorities and perspectives of scientific and technology development of the Russian Federation, allows one to create production being basis of the innovative development of domestic market of products and also steady position of Russia in foreign market. Biotechnology is based on technology of intensive cultivation of fishes and agricultural products in single complex using the biological product stimulating growth of plants. The implementation of technology will allow to achieve the maximum growth of useful products from unit of area. To achieve a transition to highly productive and environmentally friendly agro- and aquaculture in the southern regions of Russia, it is necessary to develop integrated biotechnologies.

1. Introduction
Experts of FAO consider that it is impossible to increase volumes of production (catch) in the future as it will lead to serious biological and economic effects for fishery in general [1]. In the conditions which developed biological resources of freshwater and sea reservoirs of Russia, the aquaculture as the main direction ensuring food security [4] is recognized as the only right way of development of the fishery complex.

In our country state policy on priority development of fishery in internal reservoirs is carried out, the special place at the same time is allocated to aquaculture [2]. At the present stage the Russian products of aquaculture make about 4% in a total amount of catch, and in the world the aquaculture makes 46.8% of the industry market.

At the present stage the commercial fish farming of Russia is placed in 6 geographical areas having different climatic conditions. The most part of the territory of Russia belongs to the first three zones of fish breeding. In borders of these zones the Central, Volga and Siberian federal districts are located. Optimum climatic conditions for development of aquaculture have 4, 5 and 6 zones of commercial fish
farming within which there is Southern federal the district which following the results of 2018 takes the leading positions (68,8 thousand tons) (figure 1).

In the territory of the Southern Federal District all directions of production of aquaculture can develop: pond; industrial fish breeding on warm waters of power plants; trout farming in the areas located near mountains; pasture fish farming in lakes, estuaries and water reservoirs.

The main objects of commercial fish farming of the district are: the carp, herbivorous species of fishes, trout, paddlefish, sturgeon and even is rare species, such as buffalo, clarias catfishes and tilapia. In the Southern Federal District growth of volume of commodity cultivation of objects of aquaculture in 2018 in relation to 2014 was 26.5%, or 14.5 thousand tons, in comparison with 2016 the output of commodity cultivation increased by 8.3%, or 5.2 thousand tons [3].

![Figure 1](image1.png)

**Figure 1.** Production of marketable fish on territorial subjects of the Russian Federation for 2018, tons

Increase in production of commercial fish farming in all fish-breeding zones has to go on the basis of intensification and increase in fish of productivity of reservoirs [2].

Production of marketable fish in the Southern Federal District is provided in figure 2 [3].

The intensive development of commercial fish farming is possible only in case of industrialization and integration into it of relevant scientific and technology solutions, both in terms of reproduction, feeding and keeping, and in terms of processing. This approach will give the chance to leave from nonprofessional farms and to create the modern high-technology fish industry.

![Figure 2](image2.png)

**Figure 2.** Production of marketable fish in the Southern Federal District of Russia

Biotechnology of complex cultivation of objects of aquaculture and agricultural products in the Southern Federal District began to be applied more than 5 years ago. Cultivation using biotechnology is carried out in the Rostov region by the Southern Scientific Center of the Russian Academy of Sciences at the NEB (scientific expedition base) «Kagalnik». The developed technology meets the priorities and prospects of the scientific and technological development of the Russian Federation, allows to create production which is the basis for the innovative development of the domestic market for products, as well as Russia’s stable position in the foreign market. A distinctive feature is the increase in the specific productivity of the area of the aquatic complex. Further development of complex biotechnology in the south of Russia will provide transition to highly productive and environmentally friendly agro- and aquaculture.
The biotechnology of co-production was tested and implemented at the enterprise of the Astrakhan region in the OOO «Global Catering Service». The production is based on the actual technology of intensive fish and agricultural production in a uniform complex using a biological product that stimulates plant growth. This technology has allowed to achieve the maximum increase in useful products per unit of area, using modernized technical means that increase production efficiency. Production is based on actually technology of intensive cultivation of fishes and agricultural products in complex using the biological product stimulating growth of plants. This technology allowed one to achieve the maximum gain of useful products from unit of area, when using the upgraded technical means increasing production efficiency.

2. The purpose of the study
The purpose of the study is to present an analysis of the current state of aquaculture in the Southern Federal District and to identify opportunities for further effective development based on industrialization and the integration of relevant scientific and technological solutions (biotechnologies) into it. Our research justifies the need for the development of integrated biotechnology and the transition to highly productive and environmentally friendly agro- and aquaculture.

3. The object of the study
The object of the study was a biotechnology based on technology of intensive cultivation of fishes and agricultural products in single complex using the biological product stimulating growth of plants. The implementation of technology will allow one to achieve the maximum growth of useful products per unit of area.

4. Materials and methods
In a single agro-biotechnological complex, the cultivation of young tilapia was carried out, including the salad crop. The aquabiocomplex is a closed system of pools, a settler, filters (mechanical and biological), a lighting system, an automated system of monitoring of parameters of the environment. Pools where floating platforms the raft system for cultivation on mineral substrate are located.

During the research, fish-breeding and biological research methods were used, hydrochemical, biotechnical methods of research according to the standard techniques and the interstate standard using the modern laboratory equipment were applied.

Complex cultivation of agrobioproducts was carried out on the basis of NEB (scientific expedition base) "Kagalnik" of Southern Scientific Center of the Russian Academy of Sciences and also in OOO «Global Catering Service». In the complex system for joint cultivation of fish and plants optimal conditions of the water environment were supported, constant control over the following parameters was carried out: temperature, oxygen, active reaction of the environment and also content of ammonium nitrogen, nitrates and nitrites.

The content of nutrients was determined in an analytical cross-disciplinary laboratory; rapid tests were used to monitor and measure some parameters of the water environment quickly. For control over the environment and effective cultivation of plants used a nitrate meter (for measuring the concentration of nitrate ions in vegetables), a luxometer (for measuring the illumination of a room) and a hygrometer (measuring temperature and humidity in a room).

In a single complex as objects, there were: young tilapia, and vegetable crops (lettuce,). Lettuce (Lactuca sativa L.), mid-season varieties. The biological product on the basis of strain of bacteria of Serratia ficaria having ability easily to colonize the root system of plants was applied to stimulation of vegetation of plants. With its development, the release of biologically active substances stimulating plant growth occurs. The strain of Serratia ficaria not only inhibits the development of pathogenic diseases in crops, but also increases the content of vitamin C in fruits, it also has a phytostimulating effect, significantly reduces the level of nitrates and nitrites in the final product, has a cumulative effect and is easily propagated on plants [5].
The indicators of the environment for growing fish and keeping plants using aquaponics were constant:

- Water temperature - from 26.9 °C; air temperature - from 24-26 °C;
- Oxygen - 6.1-9.12 mg / l; pH 7.4-8.4 mg / l, the active reaction of the environment units;
- Humidity - from 40-90%.
- Lighting - from 1000 - 9000 lux.
- Distance from the lighting fixture to plant - 20-50 cm.
- The distance from the lighting device to the plant is from 20-50 cm.

The fish were fed with Coppens Supreme -15 feed.

As a substrate for plants we used: expanded clay, mineral wool. An LED construction consisting of blue and red diodes in a 2: 1 ratio acted as a light source. Plants are grown on floating platforms. Plant seeds were pre-soaked in culture fluid with a cell titration of 109 CFU / ml. Seeds were placed in Petri dishes with pre-laid filter paper. The experiment was carried out in two versions - treated seeds with bacterial suspension and water. In each experiment, there were 20 plants. After germination in Petri dishes, germination and seed germination energy were evaluated according to GOST 12038-84 [6].

Weighing and measuring were carried out according to the recommendations of I. F Pravdin [6]. The analysis results were processed using generally accepted methods of biological statistics (Lakin, 1990) using computer programs [7].

5. Discussion of the results

For a full cycle of growing tilapia, the experimental setup was 180 days. The average mass of tilapia at the end of the cycle was 434.4 ± 9.74 with an average initial mass of 3.3 ± 0.6. The absolute increase in mass was 431.1 g, the average daily increase was 2.4 g / day, the average daily growth rate was 2.75%, and the accumulation mass coefficient was 0.1 units.

| Indicators                      | Value          |
|--------------------------------|----------------|
| Initial weight, g              | 3.32±0.3       |
| Final weight, g                | 434.45±11.27   |
| Absolute increase, g           | 431.1          |
| The average daily gain, g / day | 2.4            |
| The average daily growth rate, %| 2.75           |
| Mass accumulation coefficient, units | 0.1          |
| Duration, days                 | 180            |

In an integrated co-growing unit, tilapia grew faster than that in classical closed water installations, the data are shown in figure 3.

Figure 3. Analysis of growth of tilapia
Lettuce plants grow well in complex cultivation with aquatic production, the average rate of lettuce ripening (from sowing to harvesting) is 38 days (higher than in open ground), the nitrate content in the leaves is normal, the weight of lettuce leaves from 1 m$^2$ is an average of 1400 –1600 gr; weight of green part - 3600 g / m$^2$

Table 2 shows the data on the development of lettuce in the test and control. In the control, treatment with a suspension of a biological product was not performed. It can be concluded that in the process of development of lettuce in the integrated installation, its significant growth occurs, compared with the control. So the length of the stem increases by 60% at the end of the experiment.

| Lettuce | Test | Control |
|---------|------|---------|
| Root Length (mm) | 8,5 | 7 | 10,25 |
| Stem Length (mm) | 18,63 | 7 | 61,8 |
| Stem Length (mm) | 42 | 62 | 250 |
| | 23 | 61,8 | 150 |

The productivity of lettuce from 1 m$^2$ varied at different stages of cultivation. So the maximum productivity of lettuce in a floor installation was 6.1 kg / m$^2$.

![Figure 4](image-url)  Productivity of lettuce in floor installation, kg/sq.m

At the final stage of the experiment, the level of nitrates and grown lettuce was controlled both in the experiment and in the control. From the data shown in Figure 5, we can conclude that the culture fluid significantly reduced the level of nitrates, which allows us to grow safe ecological products. On day 40, nitrate levels in the grown plants were monitored.

![Figure 5](image-url)  Level of nitrates in lettuce

From the data obtained, we can conclude that the culture fluid significantly reduces the level of nitrates in lettuce compared to that of the control.
6. Conclusion

Growing aquaculture objects and green plants in a single complex in the south of Russia is environmentally friendly production, this is a very important criterion in the current environmental conditions. As a result of the research, biotechnological principles for the production of ecologically clean aqua and agricultural products in combination with closed water supply have been formulated.

The proposed combined method of cultivation allows maximum use of the area of water recycling plants, reduces the discharge of waste water, and yields safe and environmentally friendly products in the shortest possible time. The possibility of regulation of conditions of keeping in complex cultivation with plants allows one to carry out year-round cultivation of any kinds of fishes. Cultivation of fish is carried out at repeated use of the same volume of water subjected to cleaning and again returned in fish-breeding tanks.

Agricultural fish farming technologies of the Southern Federal District of Russia allow not only to quantitatively increase the production of live fish in a short time, but also to reduce its cost. The introduction of new biotechnologies into the agricultural sector of southern Russia will expand the range of aquaculture products.

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