The importance of *Azolla* aquatic plants in creating a natural sustainable nutrient environment in the fisheries industry

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Abstract. The article analyzes data on the cultivation of Azolla in different nutrient media and economic efficiency in fisheries. Azolla has a high nutritional value compared to other aquatic plants because it is a source of protein with almost all the essential amino acids needed for animal nutrition. In the selected nutrient medium, the green mass of Azolla increased several times. Technical regulations have been developed for growing Azolla in different nutrient media in open conditions. The results of a chemical study of the green mass of Azolla showed that in the selected nutrient medium the proportion of protein increased several times. This study analyzes the efficiency of feeding nile tilapia with *Azolla* one of the aquatic plants.

1 Introduction

In recent years, Food Safety problems in the world will become global. These problems are clearly expressed in developing and underdeveloped countries in Asia, Africa and South America. The Central Asian states have limited natural resources such as water, forests, pastures and land for farming. The fish farming sector is developing at the expense of aquaculture. The area of natural reservoirs is shrinking year after year. Therefore, providing the population with fish and fish products is only through artificial fish farming, that is, through aquaculture. Statistical analyzes showed that all fish farms use artificial combined feed for feeding fish. This factor greatly influences the increase in the cost of fish products in this region. Therefore, finding alternative sources of food for fish is relevant.

In the practice of some Southwestern countries, fish farming widely uses aquatic plants such as azolla and duckweed. In the conditions of Uzbekistan, the bioecological characteristics of azolla were studied and its biomass was used in rice growing and wastewater treatment. Growing azolla in different nutritional environments, studying the useful composition of green biomass depending on different environmental conditions, palatability and economic efficiency have been almost not studied. This article presents the

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results of a study on the cultivation of azolla in different nutrient media, biomass productivity and the beneficial composition of azolla under different growing conditions.

According to the World Bank reports, aquaculture or fish farming will provide two-thirds of global food fish consumption by 2030, as wild-caught catches decline, significantly increasing the emerging global middle class. In 2030, 62 percent of food fish will come from aquaculture, and tilapia, carp and catfish are likely to grow the fastest. Global tilapia production is expected to nearly double between 2010 and 2030, from 4.3 million tons to 7.3 million tons per year [World Bank 2013]. The author suggests that, the given figures mean that the demand for environmentally friendly and cheap feed in the fishing industry will increase even more. Therefore the use of algae as fish feed can be an alternative solution for farmers and business owners as well as consumers. Azolla algae has for many years been one of the most useful and inexpensive ways to feed fish around the world. *Azolla pinnata* is a macro alga rich in protein, essential amino acids, vitamins and minerals. Hence it can be used in sustainable animal feed production.

2 Materials and methods

2.1 Morfology of *Azolla* water plant

Azolla algae has for many years been one of the most useful and inexpensive ways to feed fish around the world. Azolla (*Azolla* sp.) is an aquatic fern consisting of a short, branched, floating stem, bearing roots which hang down in the water. The leaves are alternately arranged, each consisting of a thick aerial dorsal lobe containing green chlorophyll and a slightly larger thin, colorless, floating ventral lobe. Under some conditions, an anthocyanin pigment gives the fern a reddish-brown color. Plant diameter ranges from 1-2.5 cm for small species such as *Azolla pinnata*, to 15 cm or more for *Azolla nilotica*. Azolla plants are triangular or polygonal in shape, and float on the surface of the water, individually or in mats. They give the appearance of a dark green to reddish carpet, except *Azolla nilotica* that does not produce the red anthocyanin pigment. The most remarkable characteristic of azolla is its symbiotic relationship with the nitrogen-fixing blue-green alga (cyanobacterium) *Anabaena azollae*. The fern provides nutrients and a protective cavity in each leaf to *Anabaena* colonies in exchange for fixed atmospheric nitrogen and possibly other growth-promoting substances [1].

Azolla is a good replacer of protein from costly sources such as fish oil and fish meal dependent on feeding behaviors of the fish species. They can be used in the form of raw and fresh, powdered, dried, fermented, cooked, concentrated etc. It can be used as direct feed, partial or supplementary replacement to fish meal in preparation of fish feed [2]. Author is hypothesized that the use of *Azolla* as an alternative feed may provide health benefits to the fish while significantly reducing the dependence on commercial feed.

In the natural conditions of Azolla, organic polluted water bodies of Samarkand and Bukhara regions (Republic of Uzbekistan) are found. [3-6].

2.2 Chemical composition

The chemical composition of *Azolla* species varies with ecotypes and with the ecological conditions and the phase of growth. The DM content is generally low, in the 5-7% range. The protein content is in the 19-30% DM range in optimum growth conditions. The amino acid profile of azolla depends on the species, but the lysine content is relatively high (4-6% of the protein). Unlike duckweeds, azolla is relatively rich in fibre: NDF can be higher than 50% DM, crude fibre is about 15% DM and the lignin content is in the 10-13% DM range.

Like most aquatic plants, azolla is rich in mineral matter (10-20% DM) and can be used as a source of macro and micro minerals. However, the high fibre and high mineral contents explain why azolla should be generally included in limited amounts in the diets of monogastrics, as high inclusion rates tend to decrease performance. The bulkiness of fresh azolla is another limitation to its use in livestock diets and it is often preferable to dry it [7].

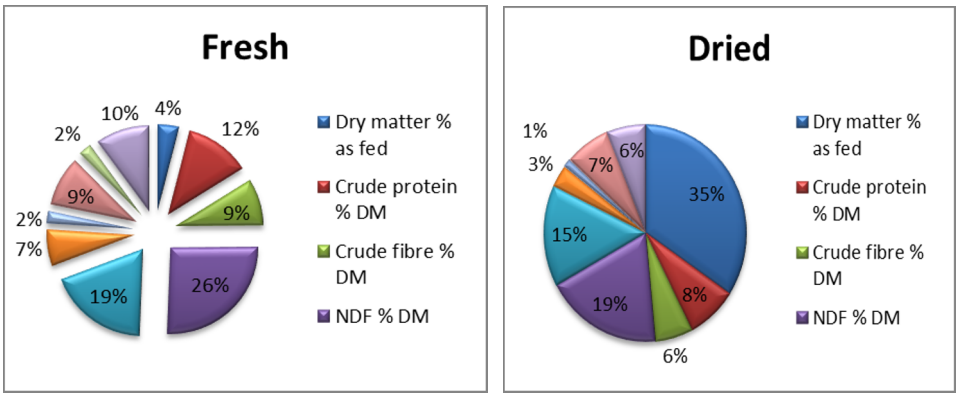

Fig. 1. Average or estimated composition value of fresh and dried Azolla [Feedipediya.org].

These pie charts show the average or approximate chemical composition of fresh and dried Azolla water plant.

2.3 Growth and cultivation

Growth and cultivation of Azolla involve specific conditions and practices to ensure optimal growth and development. Here is some information about the growth and cultivation of *Azolla*:

Growth Condition:

- *Azolla* prefers shade and requires 30-50% light for photosynthesis [4].
- It grows well in water with a depth of at least 5 inches and thrives in temperatures ranging from 20-35°C [8].
- The optimum pH for *Azolla* growth is between 4.5 and 7, and it requires a relative humidity of 80-90% [8].
- *Azolla* can survive in a water pH range of 3.5-10, but optimum growth occurs when the water is between pH 4.5 and 7 [7.]

Cultivation

- Size of the tank depends on the quantity of feed to be harvested [7].
- A fresh and pure culture of *Azolla* (0.5 – 1 kg) is placed in water, and it rapidly fills the cultivation area within 10 – 15 days [7].
- From then on, 500 – 600 g of *Azolla* can be harvested daily [7].
- Nutrient supplementation, such as the addition of cow dung, micronutrients, and super phosphate, is recommended to enhance the mineral content of *Azolla* [7], [6].
- *Azolla* is susceptible to attack by pests such as lepidopterous or dipterous insects or fungal, particularly during hot, humid periods, and snails are a common pest for *Azolla* [8]. (Figure 2)

Fig. 2. Growing Azolla in open conditions.

2.4 *Azolla* algae is an alternative food for various fish species

Azolla algae can be an alternative food for various fish species. Some of the fish species that have been fed with Azolla and showed positive results include:

- Pangasius catfish: A study found that Azolla raised from red tilapia aquaculture wastewater can replace fishmeal protein up to 10 g kg^{-1} in the diet of Pangasius catfish juveniles, resulting in significant improvements in weight gain, specific growth rate, protein efficiency ratio, and feed conversion ratio [9]
- Nile tilapia: Research has shown that Nile tilapia fry fed rations containing up to 42% of Azolla outperformed fish on a fish meal-based control diet, demonstrating the beneficial effects of feeding Azolla [10].
- Common carp, rohu, catla, mrigal carp, orange fin labeo, black tiger shrimp, patin fish, gift tilapia, and shabbout: These fish species were used for testing Azolla feed in an extensive review on the potential use of Azolla in the fish feed industry [2].
- Rohu, common carp, and catla: These fish species were fed with *Azolla* meals and showed positive growth effects [11].

These studies demonstrate the potential of *Azolla* algae as an alternative food for various fish species, offering a cost-effective and sustainable alternative to traditional fishmeal-based diets.

3 Results and Discussion

The author analyzes various experiments based on feeding tilapia fish with *Azolla* aquatic plants. Because some effective results have been achieved in feeding tilapia fish with *Azolla* aquatic plant, it has a significant place in the fishing industry as an environmentally friendly and economical feed. According to the study published in the Journal of the World Aquaculture Society (*JWAS*) discusses the cost-effectiveness, sustainability, and potential of *Azolla* as a replacer of protein from costly sources such as fish oil and fish meal in fish feed. The study includes various fish species, including Nile tilapia, in its experiments [12].

As noticed by the study published in the Journal of Mater. Environ. Sci. investigated the impact of feed supplemented with *Azolla* plant on the growth performance and survival rate of Tilapia in desert areas. The study found that using Azolla as a 25% replacement in fish feed resulted in positive effects on growth performance and survival rate [12]. According to research article on Research Gate discusses the effects of fish feed supplemented with *Azolla* meal on the growth performance, digestive enzyme activity, and health condition of genetically-improved farmed Tilapia (Oreochromis niloticus). The study showed the potential benefits of *Azolla* as a feed ingredient for Tilapia fishes [13]. One of the study

shown from the FAO demonstrates that *Azolla* niloticus, together with Nile perch silage as a supplement, can be used as a complete diet for cultured fish. The study found that Tilapia consumed *Azolla* and *Lemna* plants first when these plants were provided, and the decline in growth rate could be due to the low digestibility of plant proteins [14].

These findings suggest that *Azolla* water plant can be an effective and cost-effective feed for Tilapia fishes, offering a sustainable alternative to traditional commercial feeds.

3.1 Azolla uptake by Tilapia nilotica and digestive rate

As mentioned in one of the scientific books that, tilapia nilotica is an important fish in the rice- *Azolla*-fish system. It lives in the tropics and grows normally when water temperature is stable above 12 c; fastest the water temperature is 25-34 C. The trial showed that the amount of *Azolla* taken up by *T. nilotica* was about 50-80% of its body weight. they used the international indication method to determine the digestion rate of *Azolla* by *T.notice*. Digestative rate 59.7%.

Results of feeding ^{1}N -labeled *Azolla* to *T. nilotica* showed that ^{1}N was most abundant in the intestines and stomach. There are also considerable ^{1}N in the gills. That may be because gills are not only the exchange site of O_2 and CO_2 but are an excretory organ as well.

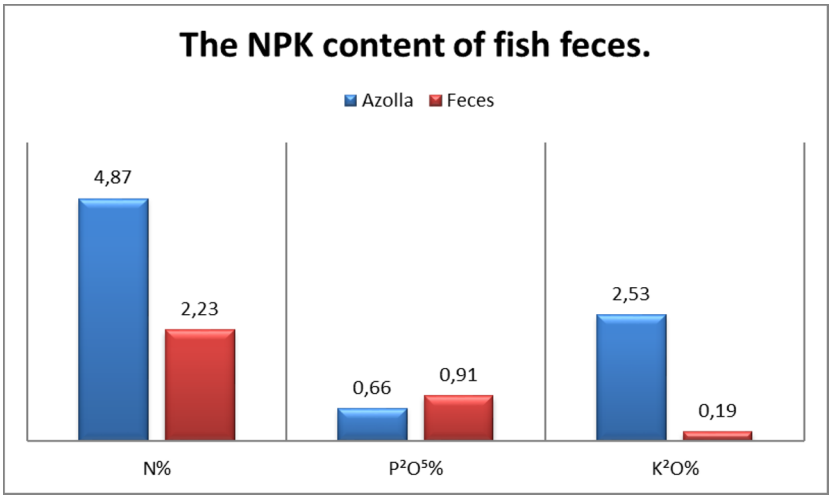

Fig. 3. The NPK content of fish feces.

The experiment showed that the ratio of N in fish feces was about 40% compared to that in *Azolla*. That means that about 60% of N fixed by Azolla from air was assimilated by fish and 40% of the N fixed was excreted in the feces. The phosphate content in *Azolla* was rather low and showed little change. However the K content decreased significantly. We need more information to understand whether the total amount of K was utilized by fish or part of it was dissolved in water.

3.2 Importance of Azolla algae in other sectors

Azolla, an aquatic plant, plays a crucial role in creating a natural and sustainable nutrient environment in the fisheries industry. Its significance is multifaceted:

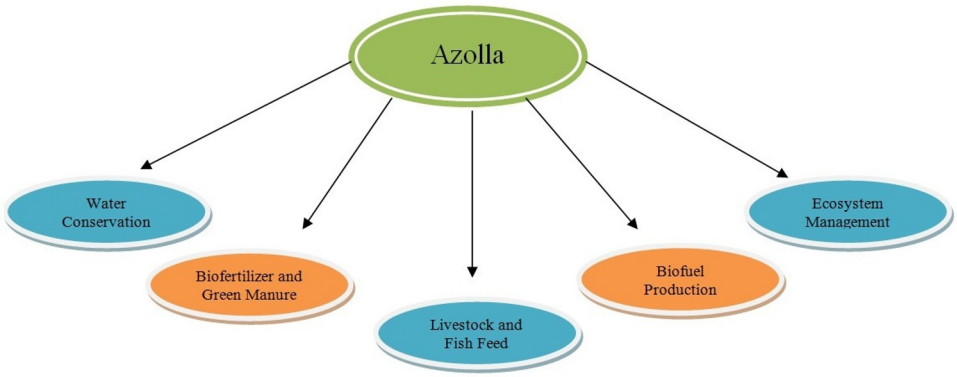

Fig. 4. Use of *Azolla* in fish feed and other ields.

Water Conservation: When grown along with rice, *Azolla* reduces water evaporation, a desirable phenomenon in tropical rice farms. It can also help in reducing salt concentration in soil and has been used in conjunction with fish farming, contributing to water conservation and sustainable agricultural practices [17].

Biofertilizer and Green Manure: *Azolla* has been utilized as a biofertilizer and green manure in rice production, releasing significant amounts of organic nitrogen and reducing the need for chemical fertilizers. This contributes to sustainable agriculture and cost savings in rice cultivation [13].

Livestock and Fish Feed: *Azolla* is a valuable feed for livestock, fish, swine, and poultry due to its high protein content, essential amino acids, vitamins, and minerals. Its use as a feed supplement has been recommended and tested, offering a sustainable and cost-effective alternative to traditional feeds [8].

Biofuel Production: *Azolla* has been identified as a universal feedstock for biofuel production, offering a renewable and cheap source of biofuels. Its rapid growth and substantial biomass production make it a promising candidate for sustainable biofuel production [18].

Ecosystem Management: Azolla's role in ecosystem management includes bioremediation of toxic substances and the potential to minimize greenhouse gas emissions from agriculture. It has been used for bioremediation of wastewaters and can efficiently assimilate nitrogen, contributing to environmental sustainability production [18].

4 Conclusion

In conclusion, *Azolla* seaweed is widely distributed in subtropical regions, and in recent years, it has been widely used not only in subtropical but also in tropical regions. Azolla's diverse applications in agriculture, aquaculture, and environmental management make it a valuable and sustainable source of natural nutrient media in the fisheries industry. It is one of the eco-friendly and affordable feed especially for Tilapia fish, and these plants have been used as fish feed for many years. Its role as biofertilizer, livestock and fish feed, biofuel raw material and water its contribution to conservation and ecosystem management highlights its importance in improving sustainability and efficiency in the fisheries and agricultural sectors.

Economic stability can be achieved by partially reducing the demand for fish feed, the price of which is increasing in the world market, by using this plant as an additional feed of *Azolla* algae in the fishing industry. Secondly, for the cultivation of this type of algae, no additional things are required, which means that *Azolla* can easily grow in lakes, sewage

and polluted water. At the same time, it has a significant positive impact on the environment, meaning that *Azolla* algae are also natural water-purifying bio-sanitizers.

Also, this aquatic plant can be widely used in other fields, for example, in medicine, agriculture, many different fields, it can be concluded that Azolla aquatic plant is used as a water purifier and an effective alternative to fish feed.

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