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Chapter 1

Aigamo farming: A Sustainable Integrated Rice - Duck System

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Abstract

Aigamo farming is an integrated rice-duck system that offers a sustainable alternative to conventional chemical-intensive rice cultivation. By introducing ducklings into paddy fields, this system utilizes their natural feeding and movement behaviour to control weeds and pests, improve soil aeration, and enhance nutrient cycling. Studies indicate that Aigamo farming can reduce weed density by up to 70% and pest incidence significantly, while increasing rice yield by 10 to 20% under well-managed conditions. Duck droppings contribute organic nutrients, improving soil fertility, although supplementary nutrient management may still be required. Additionally, the system helps mitigate methane emissions by increasing soil oxygen levels, contributing to climate-resilient agriculture. Economic benefits include reduced input costs and additional income from duck meat and eggs. Despite challenges such as labour requirements and management complexity, Aigamo farming represents an eco-friendly, economically viable, and sustainable approach for improving rice production and supporting smallholder livelihoods.

Keywords: Aigamo farming, Integrated farming, Rice-duck system, Sustainable agriculture.

Introduction

Rice (*Oryza sativa*) is one of the most important staple food crops in the world, providing the primary source of calories for more than half of the global population. It plays a vital role in ensuring food security, sustaining rural livelihoods, and supporting agricultural economies, particularly in Asian countries where it forms the backbone of daily diets and farming systems. Despite its significance, conventional rice farming systems are increasingly challenged by their heavy reliance on chemical herbicides, pesticides, and fertilizers to maintain crop productivity. One of the major constraints in modern rice cultivation is the dependence on chemical inputs for effective weed and pest control. Rice, being a slow growing crop during its early growth stages, is highly susceptible to competition from fast growing weeds and damage from insect pests. Traditional practices such as manual weeding are labour intensive and time consuming, often placing a burden on farmers, while chemical control methods, though effective in the short term, pose serious environmental and health risks. These include soil degradation, water contamination, loss of biodiversity and potential hazards to human health. These limitations in conventional rice production systems highlight the urgent need for sustainable and ecologically sound alternatives. In this context, Aigamo farming emerges as a promising solution that integrates rice cultivation with duck rearing in a mutually beneficial system. This approach minimizes dependence on external chemical inputs and promotes a natural, self-regulating agroecosystem. By incorporating livestock into crop production, it facilitates nutrient recycling and supports the development of a circular agricultural model in which farm resources are efficiently utilized. Over the past few decades, Aigamo farming has gained increasing attention not only in Japan, where it originated, but also in several other Asian countries such as China, Vietnam, Indonesia, and India. Its growing adoption is driven by the rising demand for organic and sustainably produced food, along with the need to reduce production costs and environmental impacts. Farmers practicing Aigamo farming often benefit from reduced expenditure on agrochemicals and gain additional income through the sale of duck meat and eggs. Moreover, this integrated system enhances farm resilience, improves soil health, and contributes to long-term sustainability. Thus, Aigamo farming, as an integral component of Integrated Farming Systems (IFS), represents a practical and sustainable approach to modern agriculture. By effectively combining crop and livestock components, it offers a balanced strategy that not only enhances productivity and profitability but also ensures environmental conservation and ecological stability.

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Concept and Principle of Aigamo Farming

Aigamo farming is an innovative and environmentally sustainable agricultural practice that integrates rice cultivation with duck rearing within the same paddy field. This system, which originated in Japan, was revitalized and popularized by Takao Furuno, who demonstrated its effectiveness as a low-input, ecologically balanced farming method. The term "Aigamo" refers to a crossbreed between wild ducks (*Kamo*) and domestic ducks, specifically developed for agricultural purposes. As a component of the broader rice duck farming system, Aigamo farming represents a form of polyculture that enhances biological interactions within the agroecosystem, thereby improving both productivity and sustainability.

In this system, ducklings are introduced into the rice field about 10 to 20 days after transplanting, once the seedlings are well established, at a stocking density of approximately 150 to 300 ducks ha^{-1}. The ducks remain in the field until just before the grain filling stage, during which they actively perform several ecological functions. They feed on weeds, insects, and small aquatic organisms, thereby reducing weed competition and pest incidence, while their constant movement helps in soil aeration and prevents weed establishment by disturbing the soil surface (Furuno, 2001). Additionally, their droppings enrich the soil with organic nutrients, contributing to improved fertility. Thus, the system operates on the principle of biological synergy, where ducks obtain food from the field, and rice plants benefit from natural pest control, weed management, and nutrient recycling, resulting in a sustainable and self-regulating agricultural system.

Components of the Aigamo System

Rice Crop

The rice crop is the primary component of the system, grown under flooded field conditions. During its early growth stages, rice is highly vulnerable to weed competition and pest attacks, making protection essential. The integration with ducks helps reduce these constraints naturally.

Aigamo Ducks

Aigamo ducks are crossbreed of wild and domestic ducks, especially suited for paddy field conditions. They are lightweight and do not harm rice plants, while their active feeding behaviour helps in consuming weeds, insects, and other small organisms, thereby supporting crop growth.

Water

Proper water management is crucial to maintain an optimal environment for both rice plants and ducks. Maintaining suitable water depth ensures smooth duck movement, supports rice growth, and enhances nutrient cycling within the system.

Additional Components

Additional components such as fish and Azolla can be integrated into the system to improve efficiency. Fish contribute to pest control and nutrient dynamics, while Azolla acts as a biofertilizer by fixing atmospheric nitrogen and enriching soil fertility.

Figure 1: Components of the Aigamo System

Working mechanism of Aigamo Farming

The functioning of Aigamo farming is based on natural ecological processes, where the behaviour and activities of ducks contribute directly to crop management and soil health. The study by Asano *et al.* (1999) revealed that Aigamo ducks exhibit an omnivorous feeding habit.

Analysis of the crop contents indicated that their diet includes weeds, insects, grains and non-food materials like soil and pebbles.

Weed control

Ducks actively feed on a variety of weeds present in the paddy field, particularly during the early stages of crop growth. Their feeding behaviour is complemented by their physical activity, as they stir the upper layer of soil with their webbed feet, uprooting young weeds and exposing them to water, which inhibits regrowth.

Pest management

Aigamo ducks consume insects, larvae, and other harmful pests found in the field. By feeding on these organisms, they act as natural pest control agents, reducing pest populations and lowering the dependence on chemical pesticides.

Soil fertility improvement

Duck droppings serve as a source of organic manure, adding essential nutrients such as nitrogen, phosphorus, and potassium to the soil. This natural fertilization improves soil fertility and supports healthy plant growth.

Soil aeration

The continuous movement of ducks in the field disturbs the soil and water, enhancing aeration. In terms of daily activity, aigamo ducks are most active during early morning and late evening hours, with reduced activity during midday. A single duck can cover approximately 3.8 km in a day within a paddy field, ensuring thorough coverage and repeated disturbance of the same areas. This process increases oxygen availability in the root zone and promotes better nutrient absorption by rice plants.

Effect of Aigamo farming on plant growth and yield

Aigamo farming influences rice plant growth and yield through a combination of ecological interactions within the paddy field. The presence of ducks helps reduce weed competition and pest pressure, allowing rice plants to utilize available nutrients, light, and space more efficiently. This often results in improved plant vigour, better tillering, and enhanced canopy development. The movement of ducks also promotes soil aeration and stimulates microbial activity, which can support nutrient availability and root growth. Aigamo farming has been shown to enhance overall crop performance, leading to an increase in rice yield by approximately 10 to 20% (Hossain *et al*., 2005). However, the direct contribution of duck faeces to plant nutrition is relatively limited and may not fully meet the crop's nutrient requirements. As a result, while improvements in plant growth parameters such as tiller number and chlorophyll content may be observed under well-managed conditions, these effects are not always significantly higher than those achieved with conventional fertilization. Additionally, the mild physical stimulation caused by ducks around the base of rice plants promotes lateral root development, which supports the formation of more tillers. Yield outcomes in Aigamo systems are therefore variable; in many cases, rice yields are comparable to or moderately higher than conventional systems, primarily due to reduced competition and improved field conditions rather than increased nutrient input alone. Overall, aigamo farming supports stable crop performance by creating a balanced growing environment, though optimal yields are best achieved when it is integrated with appropriate nutrient management practices.

Effect of Aigamo farming on crop protection

Weed management

Aigamo farming provides effective biological weed control, particularly in the surface soil layer (0 to 2 cm) where most weeds germinate. The continuous paddling, trampling and foraging activities of ducks disturb the soil and uproot young seedlings, thereby reducing weed establishment. The weed control period in Aigamo systems typically extends to 40 to 70 days, which is significantly longer than in herbicide-based systems. A study by Wei *et al*. 2019 reported that weed density can be reduced by about 50 to 70%, with control efficiency exceeding 80 to 95% for major paddy weeds such as *Monochoria vaginalis, Cyperus difformis* and *Sagittaria* spp. Ducks are particularly effective against soft, broad leaf aquatic weeds like *Monochoria vaginalis*, while some grasses such as *Echinochloa* spp. May persist due to lower preference or tolerance to disturbance. According to Du *et al*. 2025 study on a ratoon rice-duck system, this approach can reduce weed density by an incredible 99.1% and biomass by 94.4% using only a fraction of standard herbicides while maintaining normal yields.

Pest management

Pests globally reduce rice yields by 25 to 41%, with major threats being stem borers, brown plant hoppers, and leaf folders. Aigamo ducks contribute to natural pest control by actively feeding on insects, larvae, pupae and egg masses present in the paddy ecosystem. They mainly consume soft-bodied pests such as planthoppers, leafhoppers, small larvae and also snails like *Pomacea canaliculata*. Ducks forage by pecking at plant bases, water surfaces and soil, while their movement exposes hidden pests, making them easier to consume (Hossain *et al*., 2002; Li *et al*., 2019). This continuous feeding reduces pest populations and limits crop damage. A field study at Tamil Nadu Agricultural University evaluated duck release (2 to12 ducks per 10 m^2) as a biological method for pest control in rice. Insect pests were also reduced from 9.8 to 2.5 insects per hill, achieving 74.5% control efficiency. The optimum level was identified as 8 ducks per 10 m^2, providing effective pest suppression during 30 to 40 days after transplanting. However, beneficial insect populations decreased from 1.60 to about 0.70 insects hill $^{-1}$, indicating a trade-off. Overall, duck integration offers an eco-friendly alternative for weed and pest management in rice systems (Singh *et al*., 2021).

Effect of Aigamo farming on Improved soil fertility

Aigamo farming contributes to improved soil fertility through multiple biological and physical processes. The continuous deposition of duck droppings enriches the soil with essential nutrients such as nitrogen, phosphorus and potassium, thereby enhancing nutrient availability for rice plants. Although the nutrient contribution from duck faeces alone may not fully meet crop requirements, it plays an important role in supplementing soil fertility within the integrated system. Air-dried faeces were reported to contain about 26.6 mg g^{-1} nitrogen, 18.2 mg g^{-1} potassium, and high levels of calcium (over 150 mg g^{-1}). However, the readily available ammonium nitrogen fraction was relatively low (approximately 1.1 mg g^{-1}), indicating that most nitrogen is not immediately accessible to rice plants (Isobe *et al*., 2005). In addition, the constant movement of ducks in the paddy field helps in mixing organic matter with the soil, improving its structure and promoting better nutrient cycling. Their paddling action also enhances microbial activity by increasing soil aeration, which facilitates the decomposition of organic residues and the release of nutrients in plant-available forms. Furthermore, the reduced use of chemical fertilizers in Aigamo systems helps maintain long term soil health and prevents issues such as soil degradation and nutrient imbalance. Overall, Aigamo farming supports the development of a more biologically active and fertile soil environment, contributing to sustainable rice production.

Effect of Aigamo farming on Climate resilience

Methane emission

Rice fields are recognized as a significant source of methane (CH_4) emissions, responsible for about 6 to 11% of global methane emissions. This is primarily due to anaerobic conditions in flooded soils that favour the activity of methanogenic bacteria. However, studies have shown that Aigamo farming can effectively reduce cumulative methane emissions through the active behaviour of ducks, including paddling, trampling and foraging within the field. These activities enhance the aeration of both soil and water, leading to increased dissolved oxygen levels. The improved oxygen availability suppresses the activity of methanogenic microorganisms responsible for methane production. Additionally, the continuous disturbance of the soil by ducks alters the redox potential, further limiting anaerobic conditions. As a result, Aigamo farming not only contributes to sustainable crop production but also plays a role in mitigating greenhouse gas emissions, making it an environmentally beneficial agricultural practice (Wang *et al*., 2020; Bharadwaj *et al*., 2024).

Reduced chemical use

The integration of ducks significantly reduces the need for chemical pesticides and fertilizers. By naturally controlling weeds and pests, the system promotes organic farming practices and minimizes environmental pollution.

Effect of Aigamo farming on economics

Additional returns

Integrated rice-duck farming can generate 50 to 60% higher net returns per hectare compared to sole rice cultivation, due to higher rice yield and reduced input costs (Hossain *et al*., 2005). In addition, Aigamo farming provides an extra source of income through the sale of duck meat and eggs. This diversification of farm outputs improves economic stability and enhances livelihood security while increasing overall farm profitability.

Labour reduction

Ducks perform essential tasks such as weeding and pest control, thereby reducing the need for manual labour. This lowers labour costs and allows farmers to allocate time to other productive activities.

Drawbacks of Aigamo farming

Disease Transmission

- Ducks can spread diseases (e.g.,*Avian influenza*) that affect both birds and humans.
- Requires careful monitoring and biosecurity measures.

Limited Scale and Mechanization

- Not easily adaptable to large-scale commercial farming.
- Difficult to integrate with modern mechanized equipment as ducks can get in the way or be harmed.

Labour Intensive

- Daily management of ducks is required (feeding, herding, protecting from predators).
- Farmers need to supervise both rice and animal care, increasing workload.

Seasonal and Climate Limitations

- Best suited to specific climates and seasons—requires warm, wet environments.
- Not viable to year-round conditions in colder regions without significant infrastructure.

Initial Cost and Knowledge Barrier

- Requires training and knowledge to balance duck and rice needs.
- Infrastructure for duck care and fencing adds to start-up costs.
- Supplementary feed for ducks increases the cost.

Incomplete Weed Control

- Some weed species, particularly *Persicaria thunbergii, P. hydropiper*, and *Scirpus juncoides*, were reported to persist even after duck grazing. This indicates that the system may not provide complete weed eradication.

Management Requirements

- Effective implementation requires proper water management (optimal depth of 5 to 6 cm) and well levelled fields to facilitate duck movement and maximize weed control efficiency.

Potential Crop Damage

- If not managed properly, ducks may damage young rice plants, especially if introduced too early or at high stocking densities.

Scope and future prospects

Aigamo farming has great potential in countries like India, especially in rice-growing regions such as Tamil Nadu, Assam and West Bengal. It supports,

- Climate-resilient agriculture
- Organic farming systems
- Sustainable intensification
- Smallholder farmer livelihoods

With proper training and policy support, this system can be widely adopted to address food security and environmental challenges.

Conclusion

Aigamo farming is a successful example of integrating traditional knowledge with modern ecological principles. By combining rice cultivation and duck rearing, it creates a self-sustaining agroecosystem that enhances productivity while protecting the environment. This method offers a promising pathway toward sustainable agriculture and should be promoted through research, extension, and farmer education. However, certain limitations such as incomplete weed control and management challenges need to be addressed for wider adoption. Overall, Aigamo farming represents an effective alternative to chemical intensive agriculture, particularly in the context of organic and environmentally friendly farming systems.

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