JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

A HOLISTIC CLIMATE RESILIENT APPROACH WITH RICE-FISH –DUCK –AZOLLA SYSTEMS

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ABSTRACT

A number of Asian nations engage in integrated rice-duck farming. Duck faeces and feed waste are two examples of on-farm resources that are not properly utilized and recycled in the system. This suggests that there is need for research to improve the rice-duck system's production. The addition of fish and the nitrogen-fixing aquatic fern azolla has the potential to boost the system's output capacity. For marginal and small farmers the organic, low-cost practice rice-duck cultivation is gaining momentum as farm resources like feed waste and duck excrement are not utilised to their full potential. Despite the fact that India's agricultural land is running out, the country is integrating fish and free-floating nitrogen-fixing fern to meet the country's growing population's demand for food. In addition to azolla integration with rice-duck farming system, azolla and fish integration in rice-duck farming boost the rice output and prove to be a viable solution. It can result in nutrient enhancement, biological control of weeds and pests, methane suppression in anaerobic rice, and a reduction in the use of chemical fertilizers and pesticides when fish, azolla, and duck are integrated with rice production. Through this approach, the weeding, nutrient application activities are lessened alleviating the drudgery of women's labor in paddies which will cut out on the tedious task and time. Although it is important to spread the word that ducks and fish won't affect rice, their beneficial effects go far beyond simply generating extra cash. They also help small-scale farmers better their situation with regard to food security.

Keywords: (Azolla , food security, soil fertility, drudgery, climate resilient. ducks integration)

Introduction:

India's most important crop for producing essential foods is rice, but yields have been gradually dropping, necessitating substantial measures to increase rice production. Indian rice production faces challenges such as water scarcity, pests, diseases, and climate change impacts, including changing rainfall patterns and extreme weather events. On the contrary, modern agriculture requires high external inputs, such as inorganic fertilizers and pesticides, can also increase production costs and reduce farmers income and leads to water, soil, and air pollution, which does not support the concept of sustainable agriculture .Additionally, there are concerns about the sustainability of rice cultivation due to water usage and environmental impacts. Utilizing integrated agriculture aims to lessen reliance on agrochemicals while increasing the uptake of nutrients, particularly nitrogen, to spur plant growth and productivity. While ducks can enhance the availability of N, P, and K as well as the efficiency of nitrogen utilization, azolla is an algae that can supply nitrogen for rice.(Safriyani et al ,2020).

Indian farmers have been gradually adopting modern farming practices and technology to enhance rice productivity. In order to counterbalance and reduce the high external inputs on rice cultivation, integrated agriculture concepts have been developed (Mandavi etal.,2016).This includes the use of improved rice varieties, mechanization, and precision agriculture, prioritising integrated farming systems and organic farming for sustainable agriculture .The adoption of sustainable farming practices, such as integrated farming systems, organic farming, integrated pest management, and reduced chemical inputs, can improve soil health and long-

term sustainability. Farmers are unable to employ expensive chemical fertilizers and cannot produce their best yields as a result of the high costs of these fertilizers and the inefficient use of the natural resources that are available. Before sowing paddy, an aquatic floating fern called azolla is added to the field. Fish farming will become a more lucrative industry because it is a cheap source of protein. Practice of integrated agriculture contributes mutual benefits to crops and livestock (Manjunatha et al., 2014), an example of which is rice–Azolla application (Brouwer et al., 2014; Cheng et al., 2015 ; Feyisa et al., 2013; Kollah et al., 2016; Mahalingam et al., 2014; Teng et al., 2016; Xu et al., 2017; Yuan et al., 2012).

Rice-Duck Farming System

An integrated agricultural approach called rice-duck farming is particularly ideal for farmers with little resources to produce rice at a low cost. Ducks and fish are successfully and effectively integrated into rice fields in numerous nations, including Japan, Bangladesh, the Philippines, Vietnam, and Nepal. But for small and marginal farmers in India, raising ducks on a modest scale is a popular activity. The social, economic, and environmental aspects of rice-duck farming are all positive. After planting the rice, the ducks are released in the field for the next 15 to 20 days, until the panicle initiation stage, which occurs around two months later. Ducks improve the paddy field's ecological conditions for rice development by increasing biodiversity, soil microbial activity, and the effectiveness of rice growth. (Lopes A.R etal ,2011; Mohammadi etal2014). The procedure of rice-duck integration is fairly straightforward, but the benefit duck offers is enormous, and the result is known as the duck effect. The effects of ducks include those for weed and insect management, full-time muddying and ploughing, bird tillage, rice stimulation, methane suppression, and others. Duck herds are allowed on the harvested rice fields in Tamil Nadu, or South India, allowing them to pick the falling rice grains. This follows the custom of keeping ducks in rice fields before or after harvest, which dates back to ancient times. Contrary to the conventional rice farming method, integrated rice-duck farming lowers production costs, boosts rice productivity, protects the environment, and raises farmers' revenue through the sale of organic rice and duck meat. Rice productivity can be increased by 20% ,thanks to rice-duck farming technology, and farmers can make 50% more money overall. The problem of food poverty and malnutrition can be greatly helped by the high protein and other nutritional content of duck meat.

Integrating Azolla and Fish in Rice-Duck Cropping System

There is a driven potential for growth in the productivity of the current rice-duck farming techniques. Fish farming and the aquatic fern Azolla , which fixes nitrogen, can be combined with rice-duck farming. Azolla grows symbiotically with the blue-green alga *Anabaena azollae* and is easily cultivated in ponds or other moist areas. Fish can also be raised, and doing so will yield larger returns. While the spilt feed can be eaten by fish directly, the duck faeces acts as an organic fertilizer for the growth of plankton. Fish can also be raised, and this will yield a bigger profit. After the paddy has been harvested, the ducks are herded onto the rice field. Until the fish are at least two to three weeks old, they are kept to their sheds. In the meantime, all chemicals have disappeared, and fish are big enough to deter ducks from eating them. Till the harvest, ducks are free to roam the rice field. Inoculation of fresh Azolla 200kg/ha biomass occurs 7–10 days following rice implantation in the main field. The sigmoidal growth curve of Azolla starts out slowly in the rice field but eventually reaches a doubling period of 3–4 days. Azolla can be used as fish and duck feed in addition to being an organic fertilizer for crops. The blending of Azolla and fish fosters a symbiotic relationship with rice-duck farming, which benefits mutually in the following ways.;

1.The integration of Azolla and fish in rice-duck farming minimizes the buildup of hazardous gases in the rhizosphere, resulting in a decrease in the emission of methane gas, hydrogen sulfide, and other poisonous gases from rice fields, which helps to slow down global warming.
2. It lessens the arduous work that women must perform in the field.

3. Ducks and fish can serve as additional and alternative sources of food and revenue.

4.The oxygen produced by azolla as a result of oxygenic photosynthesis assists other soil microbial life as well as the respiration of the plant roots.

5.Azolla promotes fish growth as well as the egg and meat production of ducks.

Fish and azolla in rice-duck farming lower the rate of evaporation from an irrigated rice field.

Effect on Yield of Rice

The number of tillers per hill, the number of grains per panicle, and the average grain weight of the rice plants were all improved by the rice-duck system. According to Ahmed et al. (2004), rice-duck sub-plot yields are 20% greater than those of solely rice sub-plots. To a certain extent (20 kg/ha), azolla can often replace chemical nitrogen fertilizers and improve crop output and quality. There is a 58% increase in output over traditional rice monoculture when Azolla and fish are integrated into rice-duck farming (Cagauan et al., 2000) Through integration of Azolla and fish in rice-duck farming, there is 58% increase in yield over conventional rice

Effect on Insect Pest

Integrated Azolla-fish-rice-duck plots had much reduced insect pest populations than typical rice-duck fields of the green leafhopper, brown plant hopper, zigzag leaf hopper, rice bug, short-horned grasshopper, and long-horned grasshopper. Ducks consume insects as part of a healthy diet. Snails are biologically attracted to azolla. In addition to saving money on feed, fish and ducks are also very good at keeping herbivores like snails under control. . It's vital to remember that duck integration for pest control efficiency can vary based on elements including duck breed, population density, and management techniques used in rice fields. Farmers must find a balance between the quantity of ducks introduced and any possible harm (such as trampling) to rice plants. While duck integration can be helpful for pest control in rice farming, it's frequently employed as part of an integrated approach that incorporates multiple pest management tactics, including crop rotation, biological control, and the adoption of resistant rice cultivars. By doing this, it is possible to maximize rice production while ensuring a thorough and sustainable approach to pest management. strategy that increases rice harvests. Ducks are omnivorous and feed on a wide range of pests that affect rice crops, including insects like rice borers, grasshoppers, and snails. By foraging in the rice fields, ducks can consume many of these pests, reducing their populations, thereby achieving natural pest predation

Effect on Weed Population :

Weeds reduce rice yield by 15 to 35%. As much as 90% of the weeds were controlled by *Echinocloa crusgalli, Scirpus mucronatus*, *Monochoria vaginalis*, and other plants, oxygenating the water and promoting strong root growth in the rice plants. According to Isobe et al. (1998), Kim et al. (1994), and Choi Song Yoel et al. (1996), this is in line with their findings. Furthermore, compared to Japanese agrochemical-applied plots, rice-duck cultivation plots had greater control over total weed biomass, according to Furuno (1996) and Manda (1992). Cagauan (1997) stated that total weed biomass in the rice field was reduced by ducks at rates ranging from 52-58% based on an on-station study conducted in the Philippines. These investigations found that ducks directly consumed plant components and seeds, and that their feeding behaviour disrupted weed growth, which is how they controlled weed growth.

Effect on Nutrient Cycling and Soil Health

Recycling of nutrients is more important than only rice-duck or rice-fish farming. Rice is not fertilized with chemicals because the excreta from ducks enriches the soil's nutrients. The constant swimming and duckling activity in the rice field stimulates the soil naturally and improves aeration, which boosts the availability of nutrients like nitrogen, phosphorus, and potash to the rice crop. According to Furuno (1996), the movement of ducks and their feeding activities in rice fields disrupted the soil, improving its physical characteristics and growing the rice root systems. After decomposition, azolla increases the amount of accessible nitrogen for crop uptake and the amount of organic carbon in the soil. It also solubilizes Zn, Fe, and Mn and makes them available to the rice. Azolla can fix ambient nitrogen and CO2 for the creation of ammonia and carbohydrates, respectively. According to a soil investigation, the rice-duck plots' soils had higher amounts of N, P, K, Ca, and S after cultivation than they had before . This suggests that the nutrients in the soil were enhanced by the ducks' grazing, perhaps as a result of their excrement. There might be additional mechanisms at play. The ducks' mobility in the rice field improves soil aeration and reduces the build up of toxic gases in the rhizosphere. The movement and feeding of ducks in the rice-duck plots disrupted the soil, improving its physical properties and increasing the root systems of the rice. Similar to what Zheng et al. (1997) reported, rice-duck field's total NPK and organic matter content both increased significantly. According to Castro et al. (2003), applying Azolla to rice plants can enhance plant height, the number of active tillers, leaf area, dry weight of the rice plants, growth, and rice plant production (Mahalingam et al. 2014). Azolla has a symbiotic association with the Cyanobacteria-producing *Anabaena azollae*, which can fix up to 30 to 60 kg of nitrogen per hectare per annum (Kollah etal, 2016). According to research findings, rice-duck application can also increase rice growth and production (Xu et al., 2017), maintain rice production stability without applying fertilizers and pesticides (Sue et al., 2012), increase the availability of N, P, and K (Lie et al., 2008; Long et al., 2013), preserve the environment (Yuan et al., 2012), and increase soil biodiversity (Tenget al., 2016). Using ducks can enhance nitrogen uptake in rain by 17.8%, reduce nitrogen loss by 6.52% and minimize the use of nitrogen fertilizers by 50% .Because of the activity of the ducks, rice-duck systems can reduce leakage because the oxidized layer of the soil's surface changes, the lower layers are reduced, and the nitrogen and nitrate fertilizer nitrification and de nitrification appear to favour each other when there is flooding. . This could prevent nitrification, which would enhance the accumulation of nitrogen in the soil and microbial activity around the roots .Due to duck activities that enhance the physical qualities of the soil, rice-duck farming also promotes the accumulation and transfer of nutrients in the rice (Liu et al., 2017). While research on integrated agriculture with rice is progressing, rice-duck-Azolla research is still in its early stages.

Conclusion

The integration of Azolla and fish in the rice-duck farming system not only boosts rice productivity but also reduces weed and insect pest infestations. As a result, the costs of labor and pesticides for controlling weeds and insects are reduced. The long-term negative impacts of insecticide, herbicide, and chemical fertilizer use were also significantly decreased because it is eco-friendly in nature. These activities would provide excellent participation opportunities for women. The economic worth of the fish and duck farmed alongside the rice contributes to the farm's overall improvement in production. Although it greatly benefits farmers and helps those with limited resources, government organizations should organize programs to raise awareness of the issue among smallholder farmers. This method of integrating Azolla and fish in rice-duck farming is a promising one for tackling ecological issues relating to the preservation of aquatic biodiversity and rice production's sustainability. The combined rice-duck system was highly advantageous for the farmers from an economic standpoint, according to the results. Ducks were used in the rice-duck system to manage weed growth and insect pest infestation in addition to enhancing rice yield. As a result, expenditures for labor and pesticides used to control weeds and insects dropped or disappeared. The technique was good for the environment since it significantly reduced the long-term harmful impacts of pesticides, herbicides, and chemical fertilizer use on human health and the ecosystem. In addition to being financially profitable, the farmers also found the system to be quite simple to use. This exercise would be a wonderful opportunity for female participation. The device has the innate capacity to help resource-constrained farmers' nutritional status.

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Published: Wednesday 22 March 2023
Safriyani, E.; Hasmeda, M.; Munandar; Sulaiman, F.; Holidi; Increasing the Growth and Production of Irrigated Rice Through the Integrated Application of Rice-Duck-Azolla Acta Agrobotanica 73(2): 7322 2020

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