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Horti/Silvi- pisciculture: agroforestry system for the efficient use of water and fertilizers

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Food production is a high requirement activity of water and nutrients, so generating production systems with high efficiencies of these inputs are highly relevant. Horti/Silvi- pisciculture is an agroforestry system where fish, wood, fruits, annual species, medicinal plants, and spices are cultivated synergistically. Trees have various functions within this system, for example, retention, and fixing of pond walls or leaves are used for feeding fish, while the water of the fish presents useful nutrients as fertilizer for fruit trees and associated crops. The main objective of this work is to show some combinations used in Horti/Silvi- pisciculture system to promote global farmer's adoption, national subside, and scientific research. Agroforestry is an emerging science that has been shown to have different contributions to the well-being of humans and other biological species.

Keywords: Fish, Wood, Fruits, Annual Species, Medicinal Plants, Spices

INTRODUCTION

Agroforestry systems have demonstrated positive economic, ecological and social effects, in addition to offering important advances in the resilience of global agri-food systems that face a reduction and deterioration of natural resources. The Horti/Silvi- pisciculture is an agroforestry system where the wood tree, fruit tree, annual crop, and fish are cultivated integrated, this system provides better water and fertilizer efficiencies compared to the same separately established crops. Trees have various functions within this system, for example in the retention and fixing of pond walls, for feeding fish or diversifying income. Sometimes in this system, annual crops are added, mainly rice or another crop with a high water requirement, so around the world, there are various traditional agroforestry systems that include aquatic components.

In India the rice-fish based integrated farming system is an eco-efficient land management practices with the integration of crop-livestock agroforestry system having judicious use of farm resources and waste recycling with lesser dependence of non-renewable resources, this system enhances resilience and reverses soil degradation, providing nitrogen-rich residues and increasing soil organic matter (Adelakun et al. 2014), Wu and Zhu (1997) reported combination of tree-crop-fish which includes paulownias, willow, poplar, and fruit trees, along with ponds in which fish is cultivated (Table 1), and Karshie et al. (2017) reported the association of *Carica papaya, Mangifera indica Azadirachta indica*, vegetables, with fish ponds. In this type of system, fruit trees are normally benefited due to good and constant levels of humidity in the soil and some concentrated nutrients in the water of the fish production. The main objective of this work is to show some combinations used in Horti/Silvi-pisciculture system to promote global farmer's adoption, national subside, and scientific research.

Agroforestry and pisciculture

In Agroforestry the presence of trees in agroforestry offers better water use dynamics (Paut et al. 2018), around the world, there are various traditional agroforestry systems that include aquatic components, for example, Mangrove in Madagascar where wood is used extensively for making the fishing traps and the canoes, for processing the prawn and fish catch, and for domestic use including fencing, housing, and fuel for cooking (Rasolofo, 1997), the Chinanpas in Mexico are artificial islands created by the accumulation of sediments and litters (Embarcadero et al. 2015), or rice-fish-fruit tree system in India (Adelakun et al. 2014), at present these systems have been taking relevance due to the reduction of natural resources and the high costs of fertilizers, agricultural water, and fertilizer requirements are increasingly unviable economically, ecologically, and socially, therefore, viable technological alternatives compatible with agricultural producers must be sought. Table 1 shows some Horti/Silvi- pisciculture systems.

Another important interaction between the components of these systems is the feeding of the fish with leaves of various tree species (normally dehydrated, sifted or in pellets), legumes standing out for their high protein content, some of the leguminous trees of which their leaves are used in feeding fish are used are *Cajanus cajan* (Ogunji et al. 2008; Hammed et al. 2013)**,** *Gliricidia spp.* (Seijas et al. 1994; Nnaji et al. 2010)**,** *Sesbania grandiflora* (Dorothy et al. 2018), *Leucaeana leucocephala* (Amisah et al. 2010), however, some research has also recently been carried out the contribution of compounds that can improve the health of fish, for example, *Mangifera indica* (Amisah et al. 2010).

However, various factors must be considered; one of the most important is the presence of antinutritional compounds that can reduce the health and development of fish cultures. For example, mimosine in *Leucaena leucocephala* leaf meal as an ingredient for nile tilapia (*Oreochromis niloticus*) were contributed to the low growth of fish (Wee and Wang, 1987). To solve this problem, the use of probiotics inoculated in leaf-based food has been proposed, Bairagi et al. (2004) used *Leucaena leucocephala* leaf meal at 20%, 30% and 40% levels replacing other ingredients partially, this food was inoculated with fish intestinal bacteria *Bacillus subtilis* (isolated from *Cyprinus carpio*) and *B. circulans* (isolated from *Oreochromis mossambicus*). The results showed that it is possible to incorporate *Leucaena* leaf meal inoculated with enzyme-producing fish intestinal bacteria in carp diets up to a 40% level of inclusion (Amisah et al. 2010).

Other tree species investigated for their value as fish food are *Terculia setigera* (Adelakun et al. 2014), *Samanea saman* (Rath et al. 2014), *Albizia julibrissin* (Kirecci et al. 2014), *Moringa olerifera* (Afuang et al. 2003; Richter et al. 2003), *Jatropha curcas* (Kumar et al. 2010), *Morus alba, Carica papaya* (Dorothy et al. 2018), and *Juglans spp.* (Avant, 2016). Rain tree leaf (*Samanea saman*) pod is identified as a good source of protein (25.2%) and energy for carp feed (Rath et al. 2014), silk tree (*Albizia julibrissin*) seed can be used up to %20 of diet as protein source in diets of koi carp (*Cyprinus carpio*) without any adverse effects (Kirecci et al. 2014), the solvent-extracted moringa leaf meal could replace about 30% of fishmeal from nile tilapia diets(Afuang et al. 2003), and finally, *Mangifera indica* kernel stimulates the immunity and makes *Labeo rohita* more resistant to *Aeromonas hydrophila* infection (Sahu et al. 2007).

The world population is projected at 9.7 billion for 2050 (United Nations, 2015; Chouchane et al. 2018), human civilization is mostly dependent upon food, fodder, and fuelwood, the development, and progress of human civilization lie with the sustainability of the environment (Jhariya et al. 2019), many foods are needed, currently, the challenge is intensification methods that have not succeeded in providing sufficient food for the world population in a sustainable way and has contributed to an increase in the negative effects of climate change (Mauricio et al. 2019).

Agroforestry practices show great potential as biodiversity interventions contributing to an ecological intensification of agriculture. The Horti/Silvi- pisciculture system can be a powerful tool for multiple productions of goods and services, in addition to providing better water and fertilizer efficiencies. This system must be integrated into the development policies of the countries in search of economically resilient economies and food security.

Table 1: Horti/Silvi- pisculture system

Fruit tree	Vegetable	Aquatic component	Tree	Other crop	Reference
Mangifera indica, Carica papaya	Vegetables	Fish	*Azadirachta indica*		(Karshie et al. 2017).
Mangifera indica Artocarpus integrifolia		Fish	Timber trees	*Oryza sativa*	(Wangpakapattanawong et al. 2017).
Fruit tres	Vegetables	Fish	*Paulownia sp., Salix sp., Poplar sp.*	Herbs, wheat, oil crops	(Wu and Zhu, 1997).
Fruit trees		Fish and Ducks	Fodder trees	*Brachiaria mutica, , Pennisetum glaucum, Megathyrsus maximus*	(Sheriff, 1998).
C. nucifera, Musa sp., P. guajava, Citrus sp., M. indica, C. papaya, P. granatum		Fish and Ducks	*Tectona grandis*, Fodder tree		(Sheriff, 1998).
Morus alba	Vegetables	Fish		*Oryza sativa*	(D'Silva and Maughan, 1994).
Prunus pérsica	*Brassica juncia*	*Labeo spp., Catla catla, H. molitrix, C. idella* and *Puntius japonicus*			(Tornar and Bhatt, 2005).
Cocos nucifera		Fish			(Dagar and Tewari, 2016).
Morus alba	Aquatic plants	Fish			(Krishnan et al. 2016).
Musa sp. Carica papaya	*Ananas comosus*	Fish and Ducks			(Upadhyay and Yadava, 2009).
P. guajava, C. nucifera, E. officinalis, M. indica, Citrus spp., Litchi chinensis		Fish	*Aquilaria malaccensis, Terminalia cebula, Sesbania grandiflora*		(Gogoi 2015).

CONFLICT OF INTEREST

Authors declare absence of conflict of interest. The work sent has the approval of the entire team of authors mentioned, who are pending the work processes. Without further ado, receive a cordial and respectful greeting. I am pending any instructions, thanks for your attention and fine attention.

AUTHOR CONTRIBUTIONS

All authors contributed in this work. All authors read and approved the final version.

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