An Investigation on Compatible Combinations of Vegetables for a Crop-Ornamental Fish Integrated Farming System at Subsistence Level

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ABSTRACT

Due to low and stagnant yield, popularity of rice cultivation decreases in an increasing manner. Therefore, a vegetable-ornamental fish integration system was experimented in a paddy land in order to develop a sustainable model for the abundant paddy lands available in Sri Lanka. Four vegetable combinations (T_1:Tomato and Carrot, T_2:Tomato and Radish, T_3:Okra and Carrot, T_4:Okra and Radish), two levels of bed types (Bed Type 1 with 15 cm height, Bed Type2 with 25 cm height) and two block types (Block Type 1 with 1 drain side, Block Type 2 with 2 drain sides) were tested. Each treatment was duplicated. Platy adults were introduced to the two pond refuges, at the rate of 5 pairs per drain and 10 pairs per refuge. Platy growers were introduced to the drains, which were covered by KangKong (*Ipomea aquatica*). Growth parameters of four crops (days taken to first flowering, days taken to 50% flowering, plant height at 50% flowering), yield parameters of crops (yield of crops, number of fruits per plant, length, diameter), incidences of diseases and abnormalities (percentage of carrot rot disease, percentage of malformed carrots), fish parameters (number of fry, percentage survival) were recorded.

Results revealed that, the best vegetable combination for this model was Okra and Radish, while best bed is Bed type-2 in Block-1. Fry collections in two pond refuges were not significantly different at pr>0.05.Lower survival percentage of platy growers was also observed (39%).

KEY WORDS: Bed Type, Block Type, Carrot, Okra, Radish, Subsistence level, Tomato, Vegetable-fish integration, *Xiphophorus masculatus* (Platy).

INTRODUCTION

Integrated farming is application of available farming practices with crops and animals having horizontal and vertical relations. This is one of the efficient land use methods, which encourages recycling of farm wastes and maximum utilization of the available area to the maximum. Integrated farming in aquaculture involves fish farming along with crop and or animal farming and it has been considered as an efficient and economic means of environmental management (Pillay, 1994). Aquaculture is integrated with agricultural crops such as rice, banana and coconut, thereby producing fish and agricultural produce under one interlinked system (Santhanam *et al.*, 1987). Fish culture can also be done along with fruits, vegetables and flowers. These horticultural produce would not only provide the additional income to the farmers but also improves the environment (Agrawal, 1994).Integrated aquaculture farming is the best exemplified by the workable pattern that has been practiced for centuries by the Chinese (Delmendo, 1980).

Among crop-fish integration systems, rice-fish integration systems play a major role. Due to low and stagnant yields, escalating production costs and diminishing profitability, most of farmers are ready to give up cultivation of rice (Weerakon and Senarathna, 2005). Today abandoned paddy fields can be seen throughout the island. Therefore, introduction of alternatives such as vegetables and other horticultural crops could be recommended. However, incorporation of suitable aquaculture species would lead to the sustainability of the system.

The raised bed farming of vegetables and fruits between trenches used for irrigation and cultivation of fish and fresh water prawns in lowland areas of Thailand and Southern Vietnam is a common practice(Anon 2006a) In Thailand, China and Taiwan, integrated systems with fish, Kangkong, swine and chickens are practiced (Anon 2006b). Terrestrial crops (beans, sweet potato) may be grown on paddy dikes while aquatic plants (*Ipomea, Colocasia sp.*) are grown in water. (Cruz, 1980). Dyke and ditch system was found to be successful for cultivation of vegetables such as radish, okra, brinjal, spinach, cucumber and knol kohl (Bandara, 2002). Therefore, raised beds can be used to cultivate crops like okra, tomato, carrot and bean like vegetables. In crop-fish culture, fish were provided with drains and ditches of varying depths and an advance version of that is preparation of 'pond refuge' (Cruz, 1990) in the field for survival of fish.

Export of aquarium fish from Sri Lanka has been increasing substantially over the past two decades. The value of ornamental fish exports increased from Rs.30 million in 1981 to Rs.370 million by 1997(Weerakoon, 1998). Higher percentage of bright colored goldfish can be obtained by stocking in paddy fish integration (Fernando *et al.*, 2005). The culture of high priced ornamental fish would be a solution to the economical difficulties faced by farmers in Sri Lanka, where rearing of 'table fish' is problematic and potential for production of suitable ornamental fish types under low input integrated systems (Edirisinghe, 1995). Hence, ornamental fish species such as goldfish (*Carassius auratus*), Platy (*X.masculatus*) can be reared in vegetable-ornamental fish integration systems. Platy is considered as the 'first fish to beginners' due to its hardiness and easiness to be reared. Hence, Platy was used as the ornamental fish species in this experiment.

It is well known that vegetables are heavy nutrient feeders. Hence, fertilizer is an essential component in any vegetable crop production system (Wijewardena, 1999). Poultry manure contains higher amount of plant nutrients when compared to the other organic manure (Natarajan and . Varhgse ,1980). Poultry manure has long been recognized as the most desirable of the natural fertilizers because of its high nitrogen and phosphorous contents. In addition, poultry manure supplies other essential plant nutrients and serve as a soil amender by adding organic matter. The most common procedure for determining the amount of manure to be added per hectare is to consider the manures nitrogen content and the nitrogen needs of the crop (Anon 2006c).

In rice-fish integration, the net cover and side polythene covers are essential protective measures to protect the fish from predators (Jayaweera, 2004).But, cultivation of kangkong along sides of the drenches and along the sides of the pond refuge play as a biological protective measure to protect the fish from predators.

2. METHODOLOGY

This study was carried out at the Department of Animal Science, Faculty of Agriculture, University of Peradeniya (Mid Country Wet Zone WM2B) during March 2006 to July 2006. Two plots of 49m^2 each including a pond refuge of 1m^2 at the centre was used for the experiment. Four main drains (45cm width, 3m length and 60 cm depth) were dug and the removed soil was used to prepare thirty-two raised beds of 1.5m long and 1m wide. Two types of beds and 2 types of blocks were prepared. Bed Type-1 was 15cm in height and Bed Type-2 was 25cm in height. Block Type-1 had 1 drain side, while Block Type-2 had 2 drain sides. They were prepared with a height of 15 cm and 25 cm from the water level, each level having 16 beds.

After land preparation, *I. aquatica* (KangKong) was planted on the edges of the drains and pond refuge. A *Lycopersicon esculentum* (Tomato) nursery was established during the land preparation period. *Vigna unguiculata(* Me) was planted around the field using the mesh of the fence. The four treatments (4 vegetable combinations) used for the experiment are,

T_1 - Tomato (*Lycopersicon esculentum*) variety T 245 +Carrot (*Daucus carota)* variety Kuroda

T_2- Tomato T 245 (*L. esculentum)* + Radish (*Raphanus sativus*) variety Beeralu

T_3 - Okra (*Abelmoschus esculantus*) variety MI 5 +Carrot (*D. carota*) variety Kuroda

T_4 - Okra (*A. esculantus*) variety MI 5 +Radish (*R. sativus*) variety Beeralu

Poultry manure was applied at the rate of 1kg/1m^2 (1.5kg/bed), before sowing of respective vegetable seeds. *L. esculentum* (Tomato) was transplanted one month after nursery establishment.

Two weeks after *I. aquatica* (Kangkong) planting, adult platy were introduced to the two pond refuge and to the drains. Five pairs and 10 pairs of adults were stocked to the two refuges. Platy growers were stocked randomly at the rate of 10, 20, 30 and 40 per drain, to the four drains in each plot. Fry of platy were collected continuously one week after introduction from pond refuges.

Poultry manure was applied as split applications, considering the N requirement of the crops (McConnell's, 1978). Watering was done by using the water in the drains. Poultry manure was applied to the drains and refuges as the feed material for fish at the rate of 0.1kg/m^2 bi-weekly.

Pest and disease control was done by using neem seed extraction, application of ash, removal of infected parts, maintaining proper drainage, and field sanitation. Synthetic pesticides and inorganic fertilizers were never used.

Data recording: Following data were recorded.

2:1 Growth and Yield Parameters of Crops.

2:1:1 Growth parameters of okra and Tomato.
2:1:2 Yield parameters of Okra and Tomato.
2:1:3 Yield parameters of Radish and Carrot.
2:1:4 Total yields of four vegetable Combinations

2:2 Diseases and Abnormalities

2:2:1 Diseases and disorders in Carrot
2:2:2Number of wilted plants of tomato.

2:3 Platy (Xiphophorus masculatus)

2:3:1 Number of fry collected.
2:3:2 Survival percentages of platy growers.

Statistical Analysis

The experiment was laid out in a two-factor-factorial with RCBD with two replicates. The data were analyzed by Statistical Analysis System (SAS) 1998(SAS,1998).

3. RESULTS AND DISCUSSION

3:1:1 Growth Parameters of Okra and Tomato.

A significant difference was not observed among the treatments, Bed Types and the Block Types with respect to days taken to first flowering and 50% flowering of Okra.

Results showed that there was no significant effect of treatment and Block Type on average plant height at 50% flowering of Okra. There was an effect by the Bed Type to the average plant height of Okra, as means of Bed Type-1 had a higher mean (38.539) while the Bed Type -2 had a lower mean (25.356) (Table1).

It may be due to, the hardiness of the Okra as a crop though in ill drained conditions. It was showed that, there were no significant differences among treatments, Bed Type and the Block for the days taken to first flowering and 50 % flowering of Tomato.

But, it affected the Block Type to the average plant height in Tomato, as Block-1 has higher mean (47.400) while Block 2 has lower mean (40.925)(Table 1).Tomato performs well in block-1 as it has the drain in only one side, as tomato needs well-drained soils.

Table 1- Mean Average Plant Height At 50% Flowering in Okra and Tomato and Diameter of Tomato in Two Bed Types and Block Types:

Crop	Parameter	Factor	Mean (cm)	LSD
Okra	Plant height	Bed Type-1	38.539^a	
		Bed Type-2	25.356^b	5.562
Tomato	Plant height	Block Type-1	47.400^a	
		Block Type-2	40.925^b	5.226
Tomato	Diameter	Block Type-1	15.820^a	
		Block Type-2	14.092^b	0.670
		Bed Type-1	13.917^a	
		Bed Type-2	15.995^b	0.670

Means followed by the same letter in each column are not significant at LSD 5%.

3:1:2 Yield Parameters of Okra and Tomato.

According to the CATMOD procedure, vegetable combination, Bed Type and Block and the two way and three-ways interactions between vegetable combination, Bed Type and Block were not significant for the number of pods per plant of Okra as likihood ratio is 0.943.

Vegetable combination, and Block and the two way and three-way interactions between vegetable combination, Bed Type and Block were not significant for the number of pods per plant of Tomato. But the Bed Type had a significant effect on fruits per plant in Tomato as likelihood ratio is 0.531.

It was observed that there was no significant effect to the length and diameter of Okra pods by the treatment, Bed Type and the Block.

There was no significant difference among vegetable combination, for the diameter of Tomato. But, there were significant differences among the Block Type and the Bed Type for the diameter of Tomato. Block Type-1 had a higher mean (15.820) while the Block Type-2 had a lower mean (14.092) (Table 3). Bed Type–2 had a higher mean (15.995) while Bed Type-1 had a lower mean (13.917) (Table 1).

3:1:3 Yield Parameters of Radish and Carrot.

There was no significant effect of vegetable combination for length of Radish. But, there were significant differences among Bed Type, Block and the interaction between Bed Type and the Block. Bed Type-2 had higher mean (12.308) while Bed Type-1 had lower mean (11.226) (Table 2). It is clear, when the bed height increases, length of Radish increases as the bed has less compacted soil depth. The higher mean length of Radish was recorded in Block Type-1 (12.217), while lower mean was recorded in Block Type-2 (11.317) (Table 2).

Observations proved that there was no significant difference among vegetable combination, for the diameter of Radish. But, there were significant differences among Bed Type and Block to the diameter of Radish. Bed Type-2 had the higher mean (10.601) while Bed Type-1 had lower mean (9.437) (Table 2).Block type-1 showed the higher mean (10.940) while Bed Type-2 showed the lower mean (9.098) (Table 2).

There was no significant difference of vegetable combination, for the diameter of Carrot.But, Bed Type and Block Type had effects on diameter of Carrot.

Observations were made, that there was no significant difference among vegetable combinations for the length of Carrot. But, there were significant differences among Bed Type and Block and interaction between Bed Type and Block Type for the length of Carrot. Bed Type-2 showed the higher mean (15.995) while lower mean (13.918) showed by the Bed Type-1. Results show, when the height of bed increases, the length of Carrot increases. (Table 2)Length of Carrot in Block-1 had a higher mean (15.820) while in Block-2 had a lower mean (14.092) (Table 2).

Bed type-2 and the Block-1 had the higher mean yield (13.325), while Bed Type-1 and Block-1, Bed Type-1 and Block-2 and Bed Type-2 and Block-2 means were not significantly different for the length of Radish. (Table 3).

In length of Carrot, Bed Type-2 and Block-1 had the higher mean (17.190). Bed type-2 and Block-2, Bed Type1 and Block Type-1, Bed Type-1 and Block Type-2 had lesser mean yields compared Bed Type-2 and Block Type-1(Table3).

3:1:4 Total Yields of Four Vegetable Combinations

Total yield in Bed Type-2 showed a higher mean (2.575) than the Bed Type-1 (2.228) (Table 4). This may be due to the better drainage of water observed as a result of higher height of the Bed Type 2.

Block-1 showed the higher mean (2.518) than the Block-2 (2.284) in total yield (Table 4). As Block-1 had a drain in only one side, moisture content in soil in Block-1 was lower than in Block-2. Hence, crops perform better in block-1.

Table 2- Average Mean Values in Length and Diameter of Radish and Carrot in Bed Type and Block Type:

Crop	Yield Parameter	Factor	Mean	LSD
Radish	length	Bed Type-1	11.226[a]	
		Bed Type-2	12.308[b]	0.306
		Block Type-1	12.217[a]	
		Block Type-2	11.317[b]	0.306
	diameter	Bed Type-1	9.437[a]	
		Bed Type-2	10.601[b]	0.282
		Block Type-1	10.940[a]	
		Block Type-2	9.098[b]	0.282
Carrot	length	Bed Type-1	13.918[a]	
		Bed Type-2	15.995[b]	0.670
		Block Type-1	15.870[a]	
		Block Type-2	14.092[b]	0.670
	diameter	Bed Type-1	8.685[a]	
		Bed Type-2	9.687[b]	0.211
		Block Type-1	9.421[a]	
		Block Type-2	8.950[b]	0.211

Means followed by the same letter in each column are not significant at LSD 5%.

Table 3- Means among interactions of Bed Type and Block Type in length of Carrot and Radish:

Crop	Bed Type	Block Type	LSMean
Radish	1	1	11.110[a]
	1	2	11.342[a]
	2	1	13.325[b]
	2	2	11.292[a]
Carrot	1	1	14.450[a]
	1	2	13.385[b]
	2	1	17.190[c]
	2	2	14.080[a]

LSmeans followed by the same letters are not significant at PDIFF 5%.

Table 4- Mean Average values among Bed Types And Blocks In Total Yield:

Factor	Mean(Kg)	LSD
Block Type-1	2.518[a]	
Block Type-2	2.284[b]	0.045
Bed Type-1	2.228[a]	
Bed Type-2	2.575[b]	0.045

Means followed by the same letter in each column are not significant at LSD 5%.

Bed Type-2 and Block Type-1 had a mean yield of (2.722), Bed Type -2 and Block -2, Bed Type -1 and Block -1 and Bed Type -1 and Block -2 had mean values 2.436, 2.315 and 2.132 respectively (Table 5).In combination between Block Type and Bed Type, the best one is Bed Type-2 in Block-1.Due to higher height and 1 drain side in it, crops in that showed higher yields.

Significant differences were observed in total yield, among the treatment (vegetable combination), Block Type, Bed Type and the interaction between Bed Type and the Block. The best yield was obtained in T_4 (3.125) while the lowest yield (1.786) was obtained in T_1 (Table 6). Okra and Radish showed higher yields, as they can grow better in moist soil conditions. Tomato and Carrot gave lower yields, as they can not show high performances under moist soil conditions. . Dyke and ditch system found to be successful for cultivation of vegetables such as radish, okra, brinjal, spinach, cucumber and knoll kohl (Banadara, 2002).Saturated soils increased growth and fresh pod yield in bush bean. (Iayasooriya and Edirisinghe, 1995).

Table 5- Lsmean among bed type and block in total yield:

Bed type	Block Type	LSmean
2	1	2.722[a]
2	2	2.436[b]
1	1	2.315[c]
1	2	2.132[d]

Means followed by the same letter in each column are not significant at LSD 5%.

Table 6- Average Mean Total Yield Values in Vegetable Combinations:

Treatment	Mean value(Kg)
T_1	1.782[a]
T_2	2.165[b]
T_3	2.530[c]
T_4	3.125[d]
CV	12.578
LSD	0.063

Means followed by the same letter in each column are not significant at LSD 5%.

3:2 Diseases and Abnormalities.

3 :2:1 Diseases and Disorders in Carrot.

There was no significant difference among vegetable combinations in the incidence of Carrot rot percentage in this experiment. But, there were significant impacts on Carrot rot by Bed Type and Block. Bed Type-2 had lower mean rot percentage (6.671), while Bed Type-1 had higher mean rot percentage (8.751)(Table 7).Carrot rot is caused by *Erwinia carotovora,* a bacteria which spreads through water. When the bed height is high, the drainage of water in soil increases, that creates conditions causing the lesser diseases incidence.

Block type-1 had lower mean of percentage Carrot rot(6.2613) while Block Type-1 had higher mean of Carrot rot percentage (9.167)(Table 7).In Block Type-1 has lesser soil moist condition than in Block Type-2.Hence, Block Type-1 has higher drainage than Block Type-2 ,resulting less disease incidence.

There were no significant differences among the vegetable combination and Block types in branched Carrot percentage. But, it was observed that, there was significant difference among Bed Types for branched Carrot percentage. Bed Type-1 had a higher mean of branched Carrot percentage (38.539) while Bed type-2 had lower value of branched Carrot (25.356) (Table 7).

Soil compactness affects to the branching of Carrot. When the bed height increases, lesser branched Carrot could be observed, as it had looser soil than lower height bed, causing lesser branched Carrot in higher height bed (Table 7). Percentage Mean Values in Diseases and Disorders in Carrot.

Table 7-Average Mean values of disease incidence (%) and disorder incidence in Carrot and Tomato:

Disease /Disorder	Factor	Mean	LSD
Carrot rot	Bed Type-1	8.751^a	
	Bed Type-2	6.671^b	1.730
	Block Type-1	6.261^a	
	Block Type-2	9.167^b	1.730
Branching of carrot	Bed Type-1	38.535^a	
	Bed Type-2	25.356^b	5.562
Wilting of Tomato	Bed Type-1	31.250^a	
	Bed Type-2	17.180^b	5.896
	Block Type-1	20.313^a	
	Block Type-2	28.125^b	5.896

Means followed by the same letter in each column are not significant at LSD 5%

3.:2:2 Numbers of Wilted Plants in Tomato.

There was no significant effect of vegetable combination for the number of wilted plants in Tomato. But, it had significant effects of Bed Type and the Block for the number of wilted plants in tomato. Bed Type-1 had higher mean (31.25) while, Bed Type-2 had a lower mean (17.18) (Table 7).

It is clear that, Block Type-1 had lower mean of wilted plants (20.313) while, Block Type-2 had a higher mean (28.125) as Block Type-1 has improved drainage than the Block Type-2(Table 7).

3:3 Production of Platy (Xiphophorus masculates).

3:3:1 Number of Fry Collected.

According to the CATMOD procedure, there were not significant effects of refuge number and the days after introduction and the interaction between refuge number and the days after introduction for the fry count of platy (*Xiphophorus masculates*)(Table 8).

Since the experiment was done in Mid Country Wet Zone (WM2B) where heavy showers occured the experimental period. When the heavy showers came, the drains and the refuges were all covered by rain water, resulting in escape of the fish from the refuge to the drains and mixing with introduced pairs in pond refuges.

Table 8 - Results of CATMOD procedure in The Number of Fry Collected:

	Probability Value
Refuge number	0.1528
Days after introduction	0.5397
Likelihood ratio	0.9998

Probability values <0.05 are significantly different.

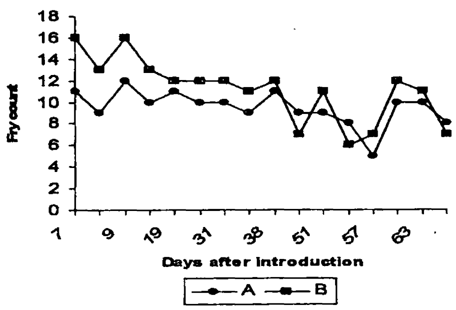

Figure 1: Number of Fry Count of Platy (*X.masculates*) In Two Pond Refuges:

3:3:2 Survival Percentages of Platy Growers.

Low survival percentage was observed in Platy (*Xiphophorus masculates)*, due to predation of fish by piscivorous animals such as water snakes, cranes, kingfishers and crustaceans.

Total number of introduced growers = 200
Final count of fish = 78
Survival percentage = (78/200)*100
=39%.

Incidence of other pests

Occurrence of Carrot rot disease, bacterial wilt in Tomato, basal rot in Radish and powdery mildew in Okra were observed as diseases. Leaf eating caterpillars in Radish, leaf rolling caterpillars in Okra were found as insect pest problems.

BENEFIT-COST RATIO

By taking the yield data into the account it is possible to say that the most compatible vegetable combination of the experiment was okra and radish, KangKong and me therefore it can be used for the cost-benefit analysis.

Table 9 - Expected Yields and Costs of Crop and Fish in 100m^{2}plot:

Crop	Yield	Item	Cost (Rs)
Okra	40.1 kg	seeds	250.00
Radish	33.06kg	Platy growers	1000.00
KangKong	195 bundles	Platy adults	225.00
Me	6.56kg	Total cost	1475.00

Table 10- Income generated by crops and fish for 100m^2 Plot:

Item	Income(Rs)
Okra	1503.75
Radish	1074.45
Kangkong	1950.00
Me	246.00
Platy growers	390.00
Platy fry	1150.00
Total income	6314.20
Net return	4839 .20

Benefit-Cost Ratio = Benefit/cost
=6314.20/1475.00
=4.28

CONCLUSIONS

Out of the four vegetable combinations tested, Okra and Radish showed the better performances, than the other vegetable combinations in this experiment. Crops established in Bed Type-2 (25 cm height) had higher growth parameters, yield parameters and less disease occurrences compared to the Bed Type-1 (10 cm height). Therefore, use of bed types with 25 cm height or more than that could be recommended for vegetable-ornamental fish integrated systems to obtain better results. Block Type-1 is found to be better for controlling of diseases like Carrot rot and Bacterial wilt as those diseases are spreading mainly due to poor drainage. When the system has beds in Block Type-2, higher levels of Bed Types should be used.

Results revealed that the development of the integrated system is more beneficial for the production of Platy fry, rather than the rearing of Platy growers due to the possible higher amount of predation.

Further experiments are needed to test the adaptability of these types of systems.

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