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Research Article

Comparative Evaluation of Broad Leaf Mustard (BLM) under Different Boron Concentrations in Outdoor Barrel Aquaponics at IAAS, Paklihawa

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Abstract

An experiment was conducted at IAAS Paklihawa, Bhairahawa from 6th October 2018 to 15th November 2018 (40 days). An open barrel Aquaponics system with a double factor RCBD type experimental design was used consisting of 3 replications and 2 factors under study. The two factors were boron concentrations (1%, 2% and 3%) and BLM varieties (*Marfa Chauda Paat, Manakamana* and chinese-430). *Marfa Chauda Paat* (47.35 gm.) was the highest yielding variety followed by *Manakamana* (36.42 gm.) and Chinese-430 (26.82 gm.). 1% Boron was found to be the most suitable concentration among the test concentrations for leaf yield. A maximum weight gain of the fish was observed in tank 3 (96.44%) followed by tank 1 (86.26%) and tank 2 (82.18%). An excellent survival percentage of fish was observed as 88.89%, 95.56% and 91.11% in tank 1, 2 and 3 respectively. Similarly, the Average Daily Growth Rate (ADGR) was recorded to be 126.5mg, 91.5mg and 128.25mg in tank 1, 2 and 3 respectively. The Specific Growth Rate (SGR %) was obtained to be 1.26, 1.38 and 1.46 for tank 1, 2 and 3 respectively. Furthermore, final harvest weight of fish was obtained to be 437g, 349.21g and 428.2g in tanks 1, 2 and 3 respectively.

Keywords: Bighead carp; Common carp; Mrigal; Silver carp; Broad Leaf Mustard; Open Barrel Aquaponics

Introduction

Aquaponics is a Re-circulating Aquaculture System (RAS) that is simply the integration of Aquaculture and Hydroponics, the former being traditional farming of fishes and the later one, the production of plants in water based nutrient solution. Aquaculture has been an old global tradition in Rome, China, India and other ancient civilizations as recorded in various testaments (Jhingran, 1987). It is a type of soilless culture. It is an integration of fish and plants where fish excreta provide the necessary nutrients to plants and plants filter water for the fish in return. The major components in Aquaponics are fish, bio filters, physical infrastructures (fish culture tank, hydroponic tank, Water pumps, water filters, screening house) and inputs to the farming components.

With the millennial movement, the concept of sustainability has evolved giving birth to Aquaponics. From the development of its concept, Aquaponics incorporates measures to mitigate the usage of water and discharge of organic wastes, relative to aquaculture. The entire feed intake does not result in biological conversion. The decomposition of the unused feed along with the excreted suspension makes the culture tank unfavorable for aquaculture. The fish takes 20-30 % of the N supplied by the feed (Schneider et al., 2005) and the rest is deposited in the culture media (Krom et al., 1995). The use of the nitrification bacteria helps minimize the toxic levels of ammonia and nitrites by converting them into relatively less harmful nitrates. The bacteria may not be easily accessible in the third world. Therefore, hydroponic system substitutes the bacteria inoculums for bio-filtration (Mitsch and Gosselink 2000). The system considers water use efficiency since only 10% of water by volume is recommended to be replaced daily (Blidariu and Grozea, 2011).

Materials and Methods

Aquaponics System

An Aquaponics system was set up at IAAS, Paklihawa. The system had a hydroponic tank, an aquaculture tank, two water supply pipes, an aerator and a water pump. Such three replications were established for the study. The set up was surrounded by screening nets as illustrated in Fig.1. Ammonical water from the aquaculture tank poured into the hydroponics tank by the hydraulic gradient. Similarly, the bio-filtered water was forced up to the fish tank by a pump.

Aquaculture Tank

Each tank (500 L) was stocked with 50 fishes in the same breed ratio namely Common carp (*Cyprinus carpio*), Mrigal *(Cirrhinus mrigala)*, Silver carp (*Hypophthamichthys molitrix)* and Big head carp (*Hypophthamichthys nobilis)*. The average weight of fish stocked in tank 1, 2, 3 were 5.3 grams, 4.0 grams, 4.8 grams respectively. Floating pellet feed (1mm diameter) containing 32% protein (Table.1) was fed once in the morning. The adjustment of feed ration was based on the body weight of fish as presented in Table. 2.

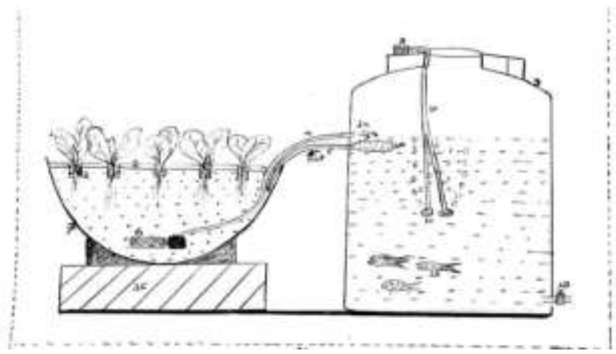

Fig 1: Experimental set-up for open barrel Aquaponics

Table 1: Composition of feed used

Parameters	Proportion (%)
Protein	32
Fiber	6.0
Mineral	N/A
Fat	2.8
Moisture	8.1

[Machhapuchre Agro Industry Pvt.Ltd]

Table 2: Amount of feed given.

Fish Wt. (Gm.)	**Ration by body wt. (%)**
<5	9.0
5	7.0
10	6.7
15	6.3
20	6.0

[Source: Piper et al., 1982]

Hydroponic Tank

Three BLM varieties (Chinese-*430, Manakamana and Marfa Chauda Paat*) were grown in nursery bed for 20 days before transplanting into the system. The seedlings were supported inside plastic cups containing pebbles. A RCBD double factorial experimental design was used. Each row of plants, as presented in fig. 2, had the same variety along the row which altered along the columns. This pattern was replicated in other 2 replications. All 9 rows in every replication were divided into 3 sub divisions; a sub division containing one row each of all the 3 varieties and 3 rows in total. The varieties were arranged randomly. In fig. 2, T1, T2 and T3 refer to the 3 different B concentrations 1%, 2% and 3% respectively. V1, V2 and V3 represent the 3 BLM varieties *Chinese 430, Manakamana* and *Marfa Chauda Paat* respectively. R1, R2 and R3 are the 3 replications of the treatments used (Fig. 2)

Chemicals and Equipments

The plants were sprayed upon with multivitamins and minerals once in 3 days. Borax (10.5% B) solution was used for the treatment. Acriflavine, Malachite Green and Aquarium Conditioner were used to maintain the rearing tank environment. ENPHO water test kit and API fresh water master test kit were used combined to analyze the water quality. HANNA's pH meter and Lutron's PDO-519 were used on a daily basis to measure the pH and DO cum water temperature respectively.

R1	R2	R3
V1	V1	V1
V3	V3	V3
V2	V2	V2
V1	V1	V1
V2	V2	V2
V3	V3	V3
V2	V2	V2
V3	V3	V3
V1	V1	V1

Fig. 2: Experimental design used for the hydroponics tank

Data Collection and Analysis

Water temperature, pH and DO were measured on daily basis. Leaf yield, Fish wt. and water quality parameters like ammonia, nitrite, nitrate and phosphate were measured at 10 DAT, 21 DAT and 40 DAT. Two-way ANOVA and post-hoc test (DMRT) performed to analyze the data obtained during the 40 days long experiment. A 95% level of confidence was used.

Formulae Used

1. Average weight of the individual fish species = Total weight of the individual fish species (gm)/Total no. of individual fish
2. Specific Growth Rate (SGR) (% / day) = (ln. Final body weight – ln. Initial body weight) / days} * 100
3. Average daily growth rate (ADGR) = (Final total wt. of the fish- Initial total wt. of the fish) / (Total no. of fish * total days of rearing)
4. Survival rate= (Remaining fish/ Initial fish) *100
5. Weight gain % = {(Final wt. - Initial wt.)/ Initial wt.} * 100%

Result and Discussion

With increasing population, the rate of pollution and its effects on the environment has become more evident and impactful. Agriculture is one of the human activities to produce polluting effects on land, air and water resources. Implementation of synthetic fertilizers and pesticides has been decreasing the productivity of the soil. The runoff and leached water from the farm lands has been pouring into and polluting the water bodies. The fish farms have been dumping highly ammonical water into the environment that mostly ends up into water bodies causing eutrophication and eventual death of aquatic flora and fauna. With arising concerns on environment conservation, many sustainable systems of farming have been developed among which Aquaponics is a prominent one. The experiment on the performance of Aquaponics in Nepalese condition have not been conducted which makes this study important.

Harvested Leaf Weight

Leaves were harvested on visual basis observing the shape, size and their health condition. From table. 3, it is clear that the highest leaf yield was observed in *Marfa Chauda Paat* with significant difference from both Chinese 430 and *Manakamana.* There was a significant effect of variety on harvest at p=0.025 with an effect size of 33.7%. Despite having no significant statistical relation upon the leaf yield, 1% B produced an overall higher output. In Table. 4, all the significant interactions between boron spray and varietal treatment, *Marfa Chauda Paat* was always found to be the superior variety, whereas, Chinese-430 was always found to be the inferior one.

Table 3: Effect of boron and varietal treatment on cumulative leaf weight (gm.) of BLM under open barrel Aquaponics

Boron %	**Cumulative Leaf wt. (gm.) 10 DAT**	**Cumulative Leaf wt. (gm.) 21 DAT**	**Cumulative Leaf wt. (gm.) 40 DAT**
1	10.96^{A}	22.98^{A}	37.85^{A}
2	10.61^{A}	21.75^{A}	36.34^{A}
3	11.28^{A}	21.74^{A}	36.40^{A}
Variety	**Cumulative Leaf wt. 10 DAT**	**Cumulative Leaf wt. 21 DAT**	**Cumulative Leaf wt. 40 DAT**
Chinese 430	8.65^{B}	16.60^{C}	26.82^{C}
Manakamana	11.72^{A}	23.15^{B}	36.42^{B}
Marfa Chauda Paat	12.48^{A}	26.72^{A}	47.35^{A}
Grand mean	10.95	22.16	36.86
SEm (±)	0.587	1.041	2.366

SEm (±) indicates Standard Error of mean and CV indicates Coefficient of Variance. Means followed by the same letters are not significantly different within same dates observed by DMRT at 5% level of significance.

Table 4: Effect of boron-variety interaction on cumulative leaf Weight (gm.) of BLM under open barrel Aquaponics

Cumulative wt. at 10 DAT	**Boron (%)**	**Varieties**	**Mean Difference (I-J)**	**Sig.**^{b}	
		Variety (I)	Variety (J)		
	1	Chinese-430	Manakamana	-5.800*	.010
	2	Chinese-430	Marfa Chauda Paat	-4.267*	.049
	3	Chinese-430	Marfa Chauda Paat	-7.600*	.001
Cumulative wt. at 21 DAT	1	Chinese-430	Manakamana	-12.514*	.010
	3	Chinese-430	Marfa Chauda Paat	-10.992*	.020
Cumulative wt. at 40 DAT	1	Chinese-430	Manakamana	-29.639*	.022
	3	Chinese-430	Marfa Chauda Paat	-32.617*	.013
	3	Manakamana	Marfa Chauda Paat	-29.794*	.021

Fish Growth

An overall survival rate of 91.85% (Fig. 3) and weight gain % of 88.29 (Fig. 5) was observed within 40-day experimental duration which is a significant output from the aquaculture unit even though it is the secondary enterprise in case of Aquaponics. ADGR was recorded to be 126.5mg, 91.5mg and 128.25mg in tank 1, 2 and 3 respectively as illustrated in Fig. 4. Mean values of specific growth rates, in Mirror carps, have been found to be 2.45±0.03 in the winters and 4.00±1.03 in the summers (Hossain *et al.*, 2014). These findings support the results obtained by the experiment as displayed in Fig. 6.

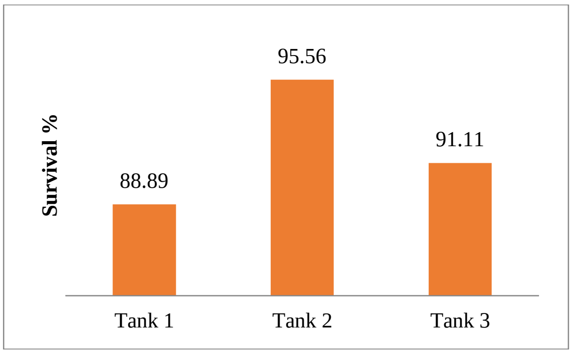

Fig. 3: Survival % of fish in different tanks

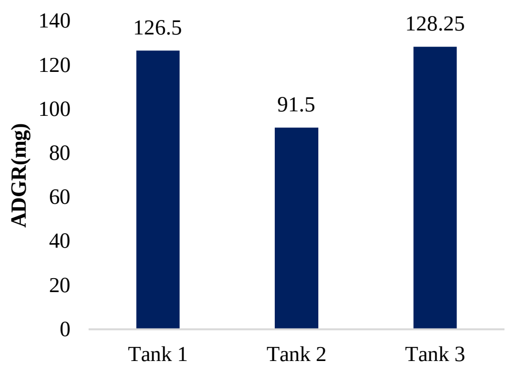

Fig. 4: Average Daily Growth Rate (mg) of fish in different tanks

Water Quality Parameters

Water temperature, Mean DO (13.635) and mean pH (8.594) recorded during the experimental period are shown in Fig. 7, Fig.8 and Fig. 9 respectively which are within the tolerable limits of fish as recommended by Graber and Junge (2009). The overall level of nutrients as tabulated in Table.5 was under tolerance level.

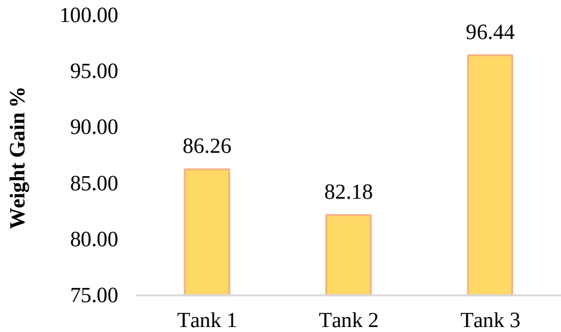

Fig. 5: Weight gain (%) of fish in different tanks

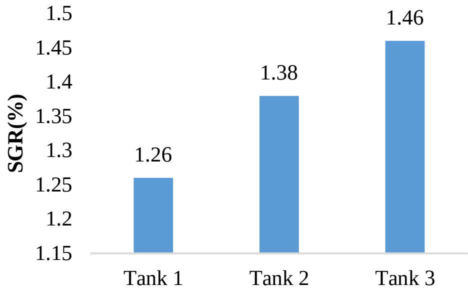

Fig. 6: Specific Growth Rate (%) of fish in different tank

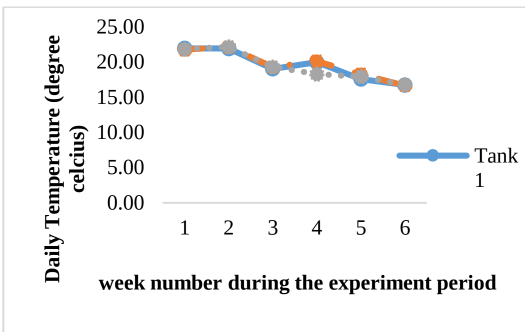

Fig. 7: Weekly water temperature in tanks during the experiment

Table 5: Water quality parameters during experimental period

DAT	Parameters	Tank		
		1	2	3
10	Ammonia	3	0.5	0.5
	Phosphate	0.8	0.2	0.8
	Nitrite	2	0.5	0.5
	Nitrate	10	8	8
21	Ammonia	1.5	1	3
	Phosphate	0.5	0.2	1
	Nitrite	0.5	0.5	0.5
	Nitrate	10	10	8
40	Ammonia	1.5	3	3
	Phosphate	1.5	0.2	0.8
	Nitrite	0.5	0.5	0.5
	Nitrate	10	10	8

*DAT= Days After Transplanting

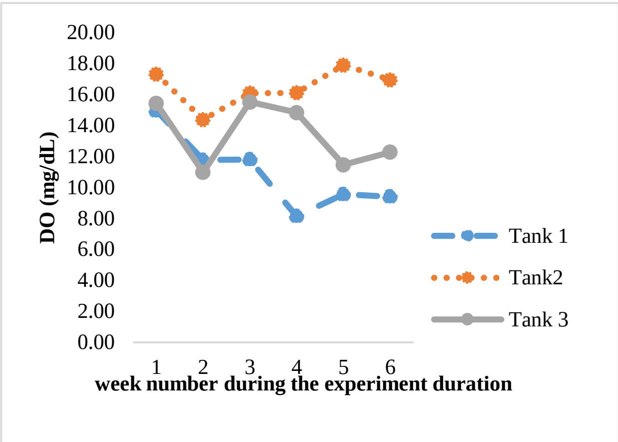

Fig. 8: Weekly DO levels throughout the duration of the experiment

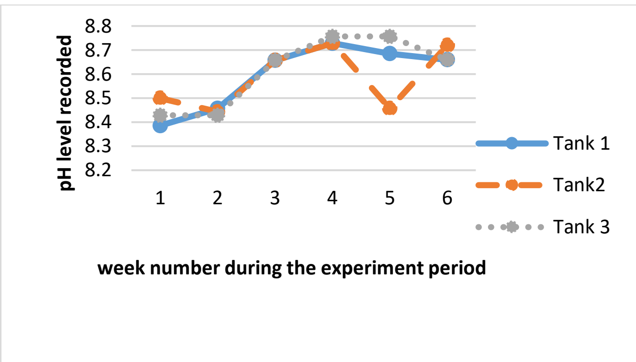

Fig. 9: Weekly pH recordings of tanks' water during the experiment

The open system was vulnerable to environmental aspects like physical-climatic factors and microbial pests of fish and BLM. The system lacked a mechanical water filtration unit causing the retention of feed and excreted residue from the aquaculture unit. This caused the infestation by larvae of midge fly on plant roots demanding manual removal of the pests and adding up to the practical cost of production. Further studies need to be carried out using other varieties of BLM or completely different high value crops.

Conclusion

Aquaponics has the scope of being a double output production system where plant produce is primary and fish produce is the secondary one, giving double the benefit, if managed correctly. An open barrel Aquaponics system is subject to inconsistent environment resulting in relative decrease of output. A controlled environment can influence a huge improvement into the barrel system. We propose the use of variety *Marfa Chauda Paat* over *Manakamana* and Chinese-430 under an open barrel Aquaponics for its huge difference in leaf yield from the rest.

Author's Contribution

All authors contributed equally in all stages from designing of the research work to the finalization of the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest with present publication.

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