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Effect of *Wolffia arrhiza* (L.) on soil quality parameters in a feed based semi-intensive carp culture system

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Abstract
Aquatic and free-floating water meal (*Wolffia arrhiza* L.) known for its fast reproduction rate was grown in differing restricted zones of supplementary feed based intensified carp polyculture in cement tanks (5m x 4m x 1m) with soil beds. While wolffia could not spread beyond the restricted zone, fishes could consume wolffia as per their desire by entering in the wolffia-zone from below. The main objective of the study was to evaluate the effects of area of wolffia-growing zone as % of total water surface area of the culture system on the overall soil quality of the culture system .Three levels of wolffia-zones viz. 10% (T_1), 20% (T_2), 30% (T_3) of the total surface area were evaluated against control without any wolffia (C). The culture period was 75 days and stocking density was 2 fish m^{-2}. The seeding rate of wolffia (0.5kg m^{-2}), feeding regime (constant feeding rate @2% d^{-1} offered once a day) and fertilization rate involving cow dung, urea and single super phosphate were the same in all treatments throughout the study period. While no marked differences in the soil quality parameters between treatments with wolffia-zone and control (without wolffia zone) were noticed. The present investigation suggested that last stage of culture period unused feed, fertilization, excretory product used to sedimented and increase different nutrient level i.e. Total Nitrogen, Total Phosphorous, organic carbon, and iron but due to co-cultivation of wolffia difference between final stage to nutrient load is not significant difference than the intial stage of nutrient level. However, in the later stage of experiment, the improved soil quality parameter was noticed than the initial stage of experiment. Therefore, it appears to be advantageous to grow *Wolffia arrhiza* in part of the aquaculture production in supplementary feed based intensified carp culture systems in integrated manner.

Keywords: *Wolffia*, soil quality, nutrient stripping, semi intensive culture, carp polyculture

Introduction

Fertilization, supplementary feeding and higher stocking density employing major carps have been the most important interventions for fish yield enhancement per unit area per unit time in India. However, substantial part of the supplementary feed is released back in the environment as excretory products containing nitrogen and phosphorus and therefore feeding has often been associated with production of effluent that has tremendous impact on not only on aquaculture environmental itself but also the surrounding environment as well. For that matter, only about 20% C, 25% P and 25% N in the form of feed is harvested in the form of fish and remainders are lost to the environment in the form suspended or dissolved forms in case of salmon farming that traditionally utilizes high quality feed ingredients like fish meal (Hakanson, 1986, Kryvi, 1989) [5, 6]. If the nutrient inputs exceed the self-purification potential of the culture system, eutrophication of the water column and underlying sediments may be resulted over a period of time. The resulted eutrophication promotes the algal bloom, increases the biochemical oxygen demand of the ecosystem causing oxygen deficiency in water especially in night and/or cloudy days and anaerobic sediments.

Recent approach towards overcoming the environmental impact of intensified aquaculture has been to utilize excessive nutrient for beneficial purposes employing plants that can be reutilized as a feed source. Floating aquatic macrophytes have been employed to reduce the concentration of noxious phytoplanktons in the effluent from stabilization ponds and to remove nitrogen and phosphorous from the water (Steward, 1970) [9]. Similarly, duckweeds have been utilized to treat agricultural and municipal waste waters as it absorb and metabolize pollutants Dasgupta *et al.* (2008) [3], Suppadit *et al.* (2008) [10]. Members of free floating duckweed (*Lemnaceae*) have shown potential usefulness in the treatment of eutrophicated water (Sutton and Ornes, 1975) [11], Fujita *et al*. (1999) [4], (Appenroth & Augsten, 1996) [1], Bergmann *et al*. (2000) [2]. In particular, *W. arrhiza* appears to be a highly potential candidate in regard to its usefulness. As it grows at very fast rate, relatively high protein content (30-45%) on dry matter basis and its essential amino acid profile is comparable to that of animal protein with substantially high lysine and metheonine as compared to other plant proteins (Porath and Agami, 1986) [8]. More importantly, it is highly preferred food for large number of filter-feeding and herbivorous fishes. It is grown as fresh carp feed in countries like China and Taiwan (Mueller & Lautner, 1954) [7].

Therefore, it appears to be advantageous to grow *Wolffia arrhiza* in part of the aquaculture production in supplementary feed based intensified carp culture systems in integrated manner. It would possibly on one hand stabilize the water quality through uptake of nutrients while on the other would act as live food for carps. On the other hand however, since it floats on surface if its growth outcompetes the feeding pressure of the stocked fishes, it may prevent light penetration and create undesirable situation. Therefore, in such integrated *Wolffia*-fish production system, it is important to make provisions to restrict *Wolffia* in specific portion of the culture system. There appears to be no work done on optimizing the *Wolffia*-growing zone as percentage of total surface area of the culture system. In the present study, effects of incorporating *Wolffia* in restricted portions of the pond covering 10%, 20% and 30% of the surface area in a semi-intensively managed polyculture carp culture system, and study its impact on soil quality parameters.

Materials and Methods

A series of 12 rectangular outlet cement tanks of 20 m^2 at College of Fisheries, Lembucherra were utilized. The bottoms of the ponds were plain with 6 inches soil bed. All the ponds were completely independent having facility of water supply from ground source of water. Fishes were randomly distributed into 4 groups: control (T_0) (no wolffia); T_1 (10% *Wolffia* zone); T_2 (20% *Wolffia* zone); and T_3 (30% *Wolffia* zone) were arranged in triplicates following a completely random design (CRD) design. The tanks were drained and sun dried for one week. Dried tanks were limed (500g $Ca(OH)_2$ $tank^{-1}$) at the rate of 250 kg ha^{-1} and then filled with water from ground water source. All ponds were fertilized about one week after liming with cow dung (4kg/tank). After 1 week of fertilization, tanks were stocked with six species namely rohu (*L. rohita*, average individual weight 11.64 g), catla (*C. catla*, 38.45 g), mrigal (*Cirrhinus mrigala*, 8.1g), grass carp (*Ctenopharingodon idella*, 9.42), amur carp (*C. carpio*, *H*. 7.4 g) and puntius (*Puntius gonionotus*, 7.6 g) in all the tanks at the ratio 40:15:15:5:10:15 respectively. All the tanks were stocked at a total stocking density of 2.0 fish m^{-2} (40 fish/tank). Fish were collected from the college farm, College of Fisheries, Lembucherra. Fresh duckweed were supplied to the tanks at the rate of 1kg, 2kg, 3kg in 10%, 20% and 30% *Wolffia* coverage enclosure area in *Wolffia* zone, respectively and were available to the fishes for 24 h per day. The live *Wolffia* was supplied periodically to the *Wolffia* zone of experimental tanks, whenever there appeared to be no *Wolffia* in any treatment.

Fertilization

Fertilization of tank was done weekly with urea and single super phosphate at the rate of 60g/tank & fortnightly with organic fertilizer cow dung at the rate of 500g. Loading rates of Nitrogen and Phosphorous through fertilizers were 2kg/ha/day and 0.7 kg/ha/day respectively. Fertilization was performed weekly during 10.00 – 12.00 hrs. Required amount of fertilizers were dissolved and were sprayed over the almost whole surface area. When transparency was less than 2 cm, fertilization was stopped.

Experimental Feed and Feeding

Experimental diet (sinking type) of protein level 22.5% was formulated with locally available feed ingredients viz. wheat flour, masturd oil cake,rice bran and fish meal. The required amounts of ingredients were mixed in mixer. Maida was gelatinized before adding to the mixture of rest of the ingredients. Roughly about 35 to 40% by weight of ingredients, potable water was added to result in semi-moist dough mixture, which was then extruded through a 2 mm dia. The resulted nodule like strands were broken into pellets and sun dried to moisture level 5-10%. Dried diets were stored in a polythene bag until utilized.

1st one week, only available natural foods formed the basis of nutrition of experimental fish. 2nd week onward similar amount of feed were offered to all the tanks in order to familiarize them with feed. Fish were fed with Experimental feed and covered (wet) to all the treatment tanks. Control treatment was without *coverage* with same amount of experimental diet. During first 3 week of experimental period, feeding rate was decided 4% body weight of fish in all the tanks. Feeding frequency in experiments was decided as once a day (feeding time 09:00 – 10:00hrs), when abundance of natural food is somewhat lesser. Amount of feed was adjusted after regular sampling of fish during experiment. Then later part of experiment feeding rate was decided 2% body weight of fish.

Effect of wolffia on soil quality

Initial sediment sample was taken before application of lime and final sediment sample was taken after harvesting of fish. Sample were collected in marked polythene bags, brought to the laboratory and dried by exposing to air in dry place.

Soil pH, Organic carbon (%), Organic matter (%), Total Nitrogen(%),Total Phosphorous(mg/100g of soil) were recorded and estimated initially and finally

1. Soil pH:
2. Total phosphorous:
3. Iron: APHA,1998; using atomic absorptionspectrophotometer
4. Organic Carbon:
5. Organic Matter:
6. Total Nitrogen:

The mean values of all the parameters were analyzed by one-way analysis of variance (ANOVA). Comparisons made at 5% probability level by using statistical package SPSS, Version 16. Duncan's multiple range tests was used to determine the significant difference between the control and treatment means.

Results and Discussion

Mean values of soil pH shown in Fig 1. There were no significant differences in final pH in different treatment. The mean value of final pH were increased all the treatment than initial.The range of the initial soil pH (5.7 to 6.4), final pH were and (6.1 to 6.5) respectively. Mean values of total phosphorous of sediment shown in Fig 2. There were no significant different in different treatment as well as no significant difference between initial and final. The range of the initial & final phosphorous were (5.8 to 6.1mg/100g) and

(6.6 to 7.6 mg/100g) respectively. Mean values of iron content of sediment shown in Fig 3. There were no significant different in different treatment although there were significant difference between initial iron content and final iron content in all the *Wolffia* productive treatment. The range of the initial & final Iron were (0.16 %to 0.24%) and (0.28% to 0.34%) respectively. Mean values of organic carbon shown in Fig 4. There was no significant difference in different treatment. In 30 % *Wolffia* productive treatment mean value of organic carbon were significantly different than initial organic carbon. Mean values of oraganic matter shown in Fig 5. There were no significant different in different treatment, although significant difference between initial and final organic matter in all the treatment. Mean values of Total Nitrogen shown in Fig 6. There were no significant differences in different treatment although the mean values of total nitrogen were increased significantly initial to final.

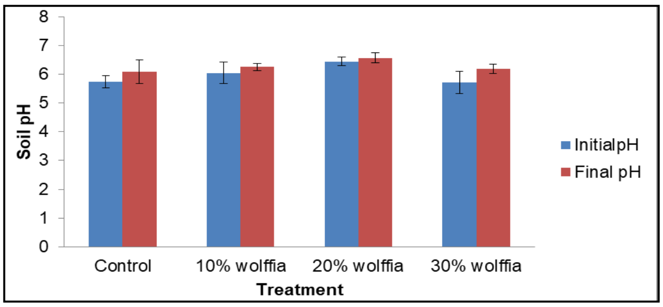

Fig 1: Soil pH in different treatment

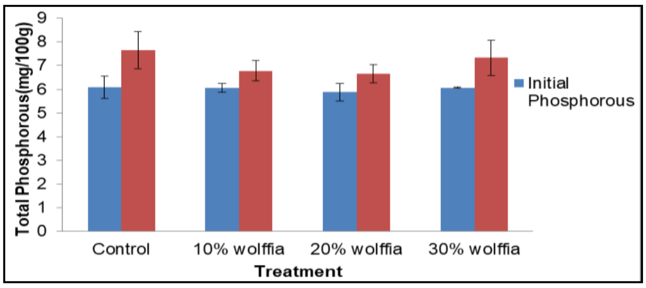

Fig 2: Total phosphorous of sediment in different treatment

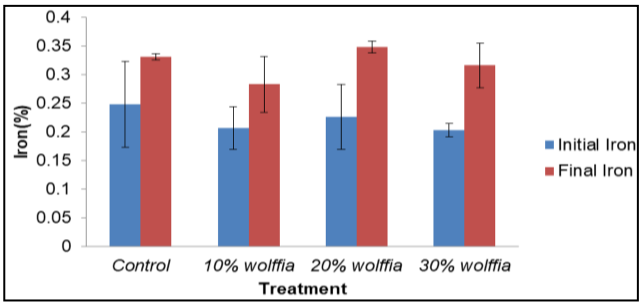

Fig 3: Iron(Fe) content of sediment in different treatment

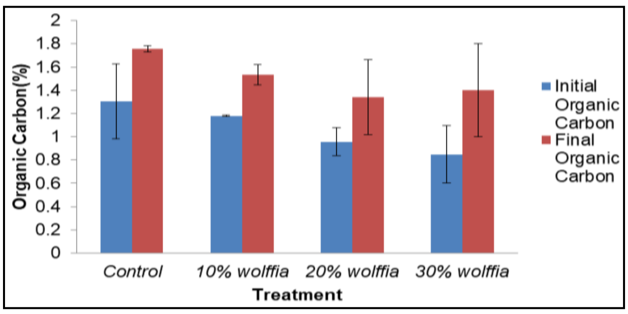

Fig 4: Organic carbon of sediment in different organic carbon

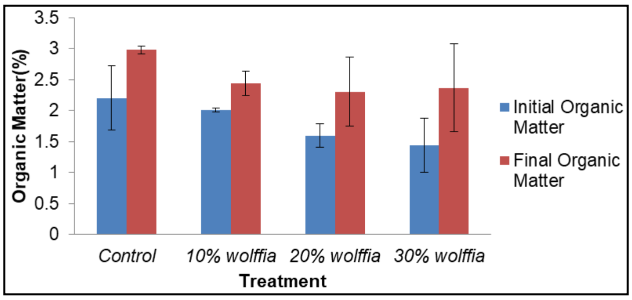

Fig 5: Organic matter of sediment in different treatment

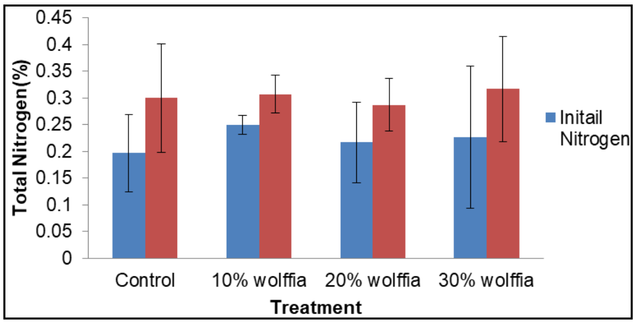

Fig 6: Total nitrogen of sediment in different treatment

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Agami, 1986) [8]. More importantly, it is highly preferred food for large number of filter-feeding and herbivorous fishes. It is grown as fresh carp feed in countries like China and Taiwan (Mueller & Lautner, 1954) [7].

Conclusion

The overall outcome of the present investigation suggested that last stage of culture period unused feed, fertilization, excretory product used to sedimented and increase different nutrient level i.e. Total Nitrogen, Total Phosphorous, Mineral etc but due to co-cultivation of wolfia diffence between final stage to nutrient load is not significant difference than the intial stage of nutrient level. These results may be useful for the farmers to improve the fish production per unit area.

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