

Integrated Agro-Aquaculture: The role of water from fish ponds on growth performance of *Cenchrus ciliaris*

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Abstract

*This study assesses the contribution of water from fish ponds on growth performance of African fox grass, *Cenchrus ciliaris*. Twelve plots each with a dimension of 2 m by 6 m were prepared and planted with African fox grass. Six plots received water from fish ponds (Treatment one) and another six plots were irrigated using stream water (Treatment two). The distance between one plot and another was 50 centimeters while the distance between the two treatments was 3 m apart and each plot was sown with 40 cuttings of *Cenchrus ciliaris*. Each plot received 40 liters of water during morning and evening hours (7:00 am and 6:00 pm). The experiment lasted for 72 days when all plots were harvested. Soil samples were collected from each plot and taken to soil laboratory for further analysis. The following parameters were determined: total Nitrogen, Phosphorus and Organic Carbon. During harvesting the wet weight for above ground biomass was measured using spring balance. The nutritive values of the pasture samples were determined using the Standard Analytical Procedure. Results showed that there were slightly higher total Nitrogen and Organic Carbon from plots received water from fish ponds. However, there was no significant difference ($P>0.05$) in all parameters measured between the two treatments. Although*

there were no significant differences between the treatments, water effluents from fish ponds can be utilized for irrigating pasture as one way or recycling nutrients. It is recommended that further study should be conducted during the dry season because the present study coincided with the onset of rainy season.

Keywords: *Pasture, Total phosphorus, Total Nitrogen, Pond water, Stream water*

Introduction

Integrated agro - aquaculture systems (IAAS) are defined as the concurrent or sequential linkage between two or more agricultural activities, of which at least one is aquaculture (Edward *et al.*, 1988). This implies that such systems operate at the same time while depending on each other. For example, water from the ponds can be used to clean animal sheds or can be used for irrigating the crops but on the other hand the waste from animals and leaves from crops can be used as food to the fish ponds. Therefore, the major linkage between agro-livestock activities and aquaculture involves the direct use of crops or livestock wastes as well as the recirculation of crop or manure-based nutrients which may work as fertilizers to stimulate natural productivity of food webs (Prein, 2002; Pant *et al.*, 2005). The prime objective of IAAs is to increase farm productivity (Cavalett *et al.* 2006; Rupasinghe, *et al.*, 2010; Limbu *et al.*, 2019). The integration of aquaculture and agriculture enables the generation of synergies among different components of the farm. In most cases, synergies occur when an output from one sub-system which may otherwise being wasted becomes an input to sub-system resulting higher farm productivity (Bhatt *et al.*, 2011). Synergies management would minimize the need for external inputs, thus increasing total

farm productivity and profitability in an ecologically sound manner through an increase in resource-use efficiency (Bhatt *et al.*, 2011). The irrigation of terrestrial crops with aquaculture effluents have been conducted and provide good results at the end (Dey *et al.*, 2007; Kumaresan *et al.*, 2009; Sydorovych and Daniels, 2011).

Most of the plant species that are planted as pastures belong to either one of the two plant groups; legumes or grasses. One of the grass species which is cultivated as pastures for semi-intensive and intensive livestock keeping systems in Morogoro is African fox tail, *Cenchrus ciliaris* (Morris *et al.*, 2014). Pasture quality is influenced by many factors including stocking density (Yoshihara *et al.*, 2016) and fertilization (Yoshihara *et al.*, 2016; Lambert *et al.*, 2004). Poor pasture production is a challenge for many dairy cattle farmers which in turn affects livestock productivity. Despite the fact that pasture is essential for livestock production, dairy cattle farmers and grazers face a challenge of poor productivity due to the use of poor quality pastures (Lambert, 2007; Dickhoefer *et al.*, 2010). These authors emphasized that in order to have pastures in good condition as much water has to be used. According to Lambert (2007) in order to increase livestock productivity the following philosophy should be considered: ***“Look after your grass, your grass will look after your animals and the animals will look after you and your assets”***. Therefore, the use of fertilized water from fish ponds can contribute significantly on availability of Nitrogen as a fertilizer to pasture and therefore improve livestock production. This study intended to determine the importance of fish ponds effluent on the growth performance of *Cenchrus ciliaris* in terms of yield and nutrients.

Materials and Methods

Study area

The experiment was conducted at Magadu Farm, Sokoine University of Agriculture. Magadu Farm is situated at 37° 39'E and 06° 5' S about 5 km from the centre of Morogoro Municipal. The average annual temperature in the Morogoro region is ranging from 18°C to 30°C (Pavola, 2004). The rainfall is bi-modal, ranging from 600-900 mm per annum (Kizima et al., 2014; Selemani, 2018). The seedbeds for establishment of *C. ciliaris* were prepared near the existing fish ponds.

Experimental design

In this study six (6) plots at one side (treatment one), and the other (6) plots (treatment two) at the other side were established. Six plots at the first side were irrigated with water from fish ponds and the other 6 plots were irrigated with water from a stream making a total 12 plots. Size of each plot was 2 m by 6 m. The distance between the plots (treatments) was 3 m to avoid mixing of water from pond and stream. The distance between one plot and the other was 50 centimeters. The distance between one plant to another was 25 cm horizontally and 45 cm vertically.

Data collection

Biomass of pasture

Destructive method was used to measure biomass; sampling was done by cutting grasses at 10 cm above the ground level as recommended by Lambert (2007) and wet weight measured using spring balance.

Nutritive values

For proximate analysis fresh samples of grass from each treatment were collected and transported to laboratory of Animal, Aquaculture and Range Sciences for analysis. At laboratory, the samples were dried using an oven at 105°C for 16 hours. The Proximate Analysis was carried out that involves partitioning of compounds into six categories based upon chemical constituents of the samples that is moisture, crude protein, crude lipid, crude fiber and ash contents. Proximate analysis was conducted according to AOAC (1990).

Total Nitrogen, Phosphorus and Organic Carbon

Soil samples were collected from each plot using soil cores and kept into plastic containers. Analysis was done in soil laboratory in the Department of Soil and Geological Sciences, Sokoine University of Agriculture. Analysis of total Nitrogen was done using Kjeldahl digestion method. Total Phosphorus was analyzed using Bray and Kurtz method because the soil samples were acidic (Bray and Kutz 1987). Organic carbon was analyzed using Walkley-Black chromic acid wet oxidation method.

Results

Biomass of *C. ciliaris*

Results on biomass of pasture showed that the pasture plot irrigated with water from fish ponds had relatively higher biomass ((51783 kg/ha) wet weight compared to the plots irrigated with water from a stream (46017kg/ha) (Figure 1).

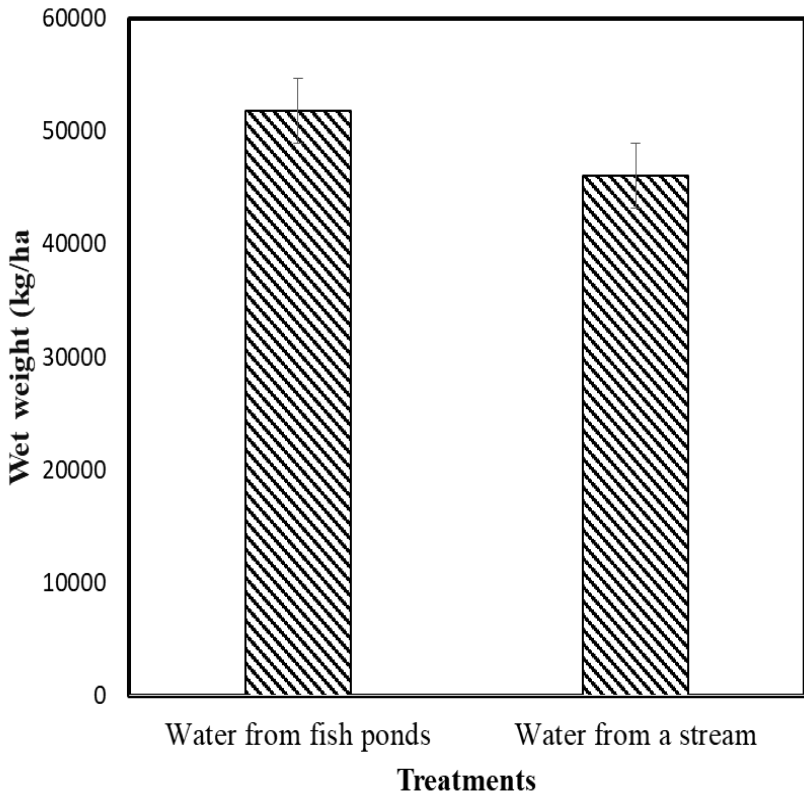


Figure 1. The above ground biomass of *Cenchrus ciliaris* irrigated with water from fish ponds

4.2 Total Nitrogen, Phosphorus and Organic Carbon

Amounts of Phosphorus, Nitrogen and Organic Carbon from pasture plots are given in Figures 2, 3 and 4. The Phosphorus from plots irrigated with water from a stream was slightly higher compared with plots received water from fish ponds. Total Nitrogen and Organic Carbon were relatively higher in plots irrigated with water from fish ponds compared with those plots irrigated with water from a stream. However, in all parameters

there was no significance difference ($P>0.05$) between the treatments.

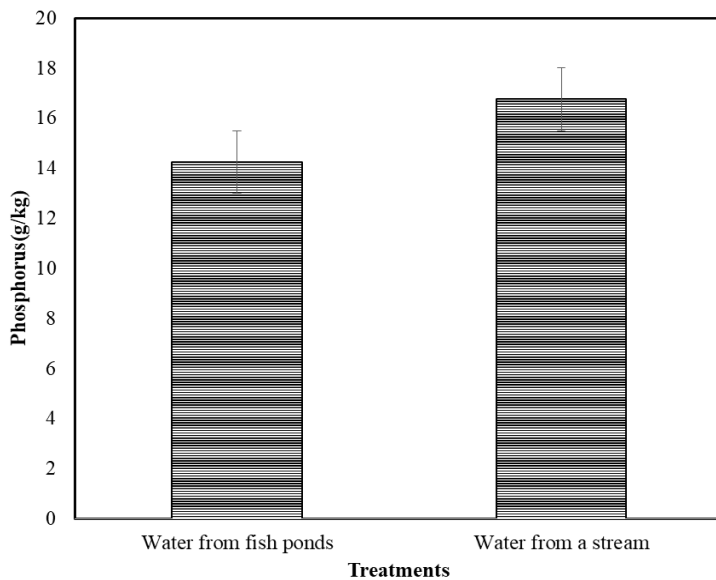


Figure 3. Total phosphorus (mg/kg) from pasture plots irrigated with water from fish ponds and a stream

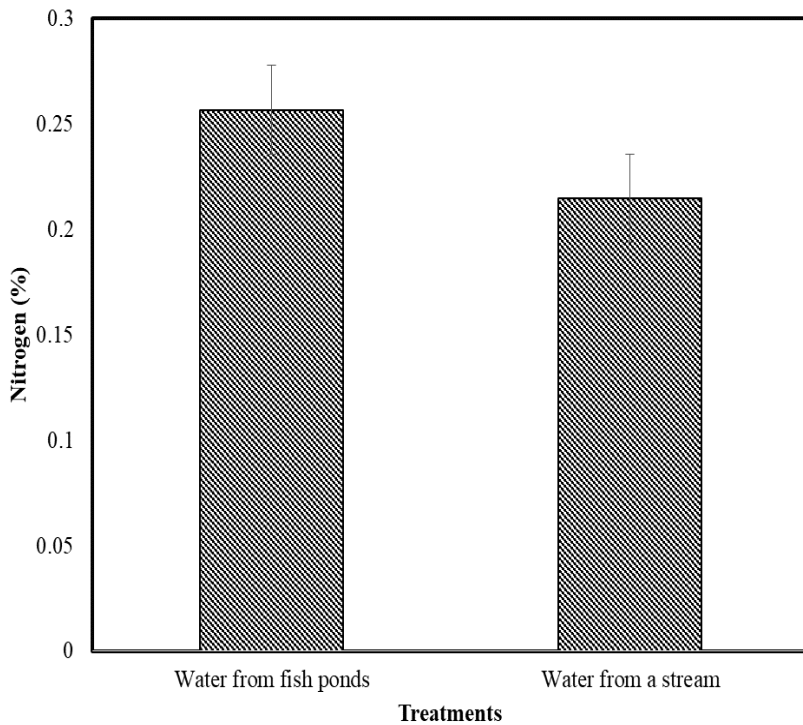


Figure 4. Total nitrogen (%) from pasture plots irrigated with water from fish ponds and a stream

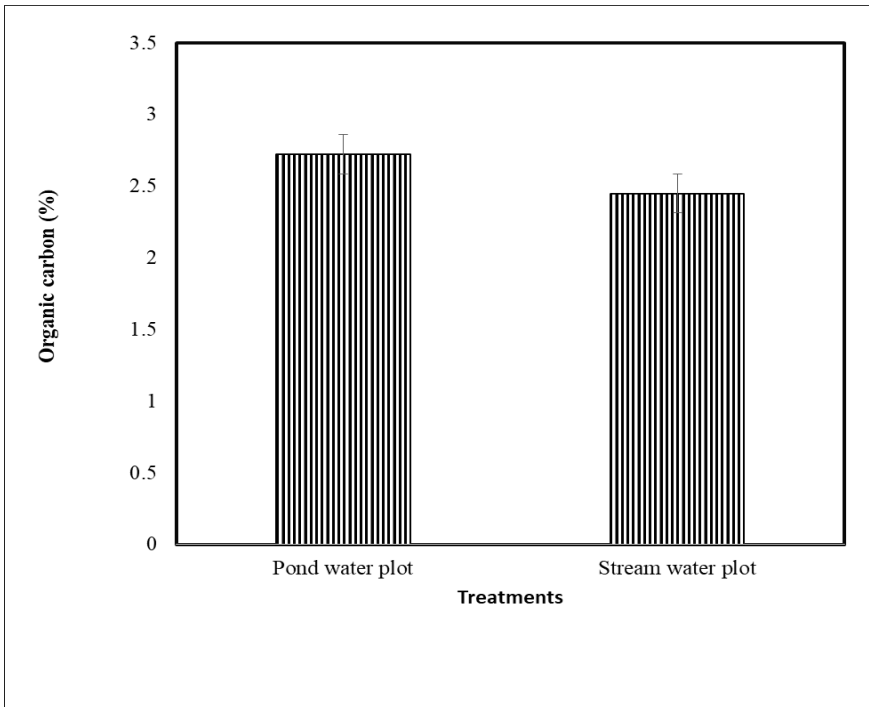


Figure 4. Organic carbon (%) from pasture plots irrigated with water from fish ponds and a stream

Table 1. Proximate analysis of the pasture irrigated with water from fish ponds and a stream

Treatments	Nutritive values (g/kg)			
	Dry matter	Ash	Crude lipid	Crude fiber
Water from fish ponds	940.74	120.82	10.78	220.41
Water from a stream	930.82	120.58	10.72	280.42

Results from proximate analysis showed that with an exceptional of crude fibers, *C. ciliaris* harvested from plots irrigated with water from fish ponds had relatively higher amount of total dry matter (940g/kg) ash content (120.82g/kg), and crude lipid (10.78g/kg) Table 1).

Discussion

The objective of this study was to assess the importance of integrating fish farming and growth performance of pasture. Yield, soil nutrients and nutritive values of *Cenchrus ciliaris* were determined after irrigating this grass with water from fish ponds. The slightly higher nutrients from fish ponds was associated with utilization of ponds' inputs in pasture production. According to Prein (2002) in IAA systems flow of nutrients between enterprises i.e. wastes from one enterprise become inputs to another to increase production. Most of the studies on integrated agriculture have been focusing on fish, livestock and crops or vegetables see for example (Prein, 2002; Schneider *et al.* 2005; Khan *et al.*, 2007; Phong *et al.*, 2011; Abdul-Rahman *et al.*, 2011; Shoko *et al.*, 2011; Limbu *et al.*, 2017; Shoko *et al.*, 2019). According to Lambert (2007) dry matter is one of the factors showing the quality of pasture. The relatively higher biomass recorded from plots of *C. ciliaris* irrigated with water from fish pond is probably due to the fact that water from fish ponds contains relatively higher total Nitrogen.

The present study agrees with the finding by Abdul-Rahman *et al.* (2011) and Shoko *et al.* (2011). These authors reported improved soil nutrients and higher biomass of plant received pond effluents. The use of water from fish ponds for pasture establishment agreed

with studies conducted by Khan *et al.* (2007) and Phong *et al.* (2011); these authors evaluated the recycling of nutrients particularly nitrogen and phosphorus in integrated systems in Asia. Effluents from fish ponds contain significantly amount of phosphorus and nitrogen and when produced in intensive system may become pollutants (Li and Yakupitiyage (2003). Therefore the water or effluents from fish pond can contribute to the yield of the irrigated plant. It has been reported that soil nitrogen is the primary nutrients deficiency limiting pasture production (Lambart *et al.*, 2004). The present findings from the present integrated system support the four species of pasture establishment; perennial, productive, palatable and persistent.

A relatively higher total Nitrogen and Organic Carbon from plots received water from fish ponds was probably due integration system applied. Banas *et al.* (2008) and Tipraqsa *et al.* (2007) reported positive correlation between soil organic carbon with increasing level of integration. The relatively high amount of nitrogen recorded in this study confirms the importance of IAA systems as evaluated by other researched elsewhere (Pant *et al.*, 2005; Phong *et al.*, 2010; Murshed-E-Jahan and Pemsil, 2011)). The contribution of nutrients from fish pond is supported by the relatively higher biomass and nutritive values. The sources of nutrients in the fish ponds could be from fertilizers and decomposition of uneaten feed. Chicken manure used to fertilize the ponds contains three important nutrients namely; nitrogen, phosphorus and potassium in various proportions. According to Sydorovych (2011) fish pond effluents benefits plants/crops through filtration and associated soil organisms.

Proximate analysis showed that *C. ciliaris* harvested from plots irrigated with water from fish ponds had relatively higher percentage of total dry matter, ash and crude lipid. This suggests that water from fish pond contributed to an increase in nutrients contents into the soil which finally increases the nutrient contents the pastures. It can be concluded that the growth performance of *Cenchrus ciliaris* in plots irrigated with pond water showed slightly higher biomass and nutritive values compared to those plots irrigated with stream water. The same trends were observed for total nitrogen and organic carbon. It is recommended that in order to increase productivity of cultivated grass fodder integrated systems should be emphasized to livestock keepers.

Conclusion

The study investigated the influence of water effluent from fish ponds on soil fertility and pasture productivity at Magadu Farm. The key findings from this studies indicated that, irrigated plots with water from fish ponds had relatively better performance in terms of biomass yield and nutritive values. In addition, soil sampled from plots irrigated with water from fish ponds had more nutrients in terms of total Nitrogen, Phosphorus and Organic Carbon compared to stream irrigated plots. Since the present study was conducted in short period during wet season, further integration studies are recommended especially during dry season.

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