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On Station Evaluation of Integrated Agriculture Aquaculture (IAA) on Yield of Potato (Solanum Tuberosum) and Tomato (Lycopersiconesculentum).

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Abstract

Evaluation of integrated agriculture aquaculture (IAA) was conducted on station in the National Fisheries and Aquatic Life Research center (NFALRC), Sebeta. In this trial the effect of irrigation with pond water and spring water and application of inorganic fertilizer on yield and other parameters for Tomato (Lycopersiconesculentum) and potato (Solanum tuberosum) were evaluated using randomized complete block design with three replications. Results show that there is variation in total yield and marketable yield as well as clusters per plant of tomato with plots treated with fertilizer having higher values. Among examined parameters, only clusters per plant of tomato varied significantly ($P<0.05$) among treatments. However, marketable yield and yield per plant did not show significant variation ($p>0.05$) among treatments. Nevertheless, all parameters in this trial did not show significant difference among treatments ($P>0.05$). The results of this trial indicate that using pond water to irrigate horticulture plots can partially replace the use of inorganic fertilizers thereby reducing both cost and environmental effects.

Key Words
IAA
Inorganic Fertilizer
Pond Water
Potato
Tomato

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1. Introduction

Declining soil fertility, high input (fertilizers, pesticides, herbicides etc.) costs, dependence on rain fed agriculture and environmental degradation are some of the major challenges facing Ethiopian small-scale farmers. Some of these problems are believed to be addressed by promotion of sustainable resource management system in which physical and biological resources on a farm are integrated in order to give a higher production than would be generated by the individual farming sub system independently.

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One of such systems is the Integrated Aquaculture Agriculture (IAA) system that involves fish farming and other terrestrial based farming systems.

Aquaculture, the cultivation of aquatic organism in a confined water area, presents an opportunity for integration with other agricultural systems as it requires inputs to grow the fish and induce production of plankton as well as produces waste in the form usable by plants. IAA has been advocated to be vital in the development of sustainable aquaculture [1,2].

IAA can be defined as a diversification of agriculture towards nutrient linkages between aquaculture and other terrestrial components within a farm [3]. The key characteristic of the IAA- is the linking of farm components through interconnected flows of nutrients [2]. The objective is to increase the whole farm productivity through maximized synergies and minimized antagonisms between components.

In Ethiopia aquaculture can play an important role in providing protein for the small holder farmer. The fish pond can serve as a Centre for integration with other farming systems such as horticulture. Irrigation of crop plots with pond water can reduce the use of fertilizers thereby increasing income for the farmer and reducing environmental impacts of inorganic fertilizer at the same time. The stabilization and increments of household incomes by 36 % in farmers using IAA system has been reported in Malawi [4]. In the Philippines integration of various farm activities with pond culture of fish doubled the income of farmers while increasing the biomass produced by 14% [1].

The role of IAA in production of vegetables has not been well studied in Ethiopia. Thus, this study was designed to evaluate the production of tomato and potato under IAA system in National Fishery and Aquatic Life Research Center, Sebeta.

2. Materials and Methods

On station trial was conducted in the National Fisheries and Aquatic Life Research Center, Sebeta from November 2012 to April 2013. The experiment was conducted by using randomized complete block design (RCBD). Three treatments (pond water, spring water and fertilizer) with 3 replications each were assigned randomly to 9 plots each measuring 3*5m (15m^2). 48 tomato and 48 potato seedlings were planted in each plot with space of 30 cm and 0.75cm between plants and rows, respectively.

Proper management practices including weeding and hoeing took place throughout the growing period while pesticides were applied once. In treatment one, plants were irrigated with spring water while in treatment 2 plants received water from fish pond. Nine ponds stocked with Nile tilapia (Oreochromis niloticus) at 2 fish m^{-2} served as the source of the pond water for treatment 2. The fish were fed on pelleted feed (30% CP) twice daily. In the 3rd treatment fertilizer (DAP and Urea) at 200kg per hectare was applied and plots were irrigated by spring water. Concentrations of nutrients (NH_3, NO_2, NO_3SRP and TP) in the pond water and spring water were determined at the beginning of the experiment. Watering of the plants took place twice a day at 08:00and 18:00hrs.

The weight of marketable and unmarketable fruits was determined at each harvest in the tomato experiment. Total yield was then determined as the total weight of fruit from each harvest. The numbers of clusters per plant and number of flowers per cluster of randomly selected plants were totally counted at the third harvest. In the potato experiment the weight of marketable and unmarketable tubers was determined at final harvest. Number of tubers per plant was also determined at this stage. The yield obtained in both experiments was then converted to yield per hectare.

Data was analyzed by the use of R, freely available statistical software. ANOVA was used to see if there is significant difference between treatments. Turkey HD test was applied when significant differences were detected.

3. Results

Table 1 summarizes concentrations of nutrients in the pond and spring waters at the beginning of the experiment. Pond water had higher concentrations of NH3, NO2 and TP while spring water had higher concentrations of NO3 and SRP. Table 2 provides some growth parameters of the fish raised during the experiment.

Table 1. Concentrations of nutrients (μg/l) in pond and spring water at the beginning of the experiment

Nutrients	Pond water	Spring water
NO_2	7.1	0.9
NO_3	99.87	133.56
NH_3	79.13	73.37
SRP	22.38	58.19
TP	76.6	61.74

Table 2. Some growth parameters of Nile tilapia grown in integrated system with potato and tomato

Parameter	Values
Total Initial weight	5.1 kg
Total final weight	17.6 kg
Growth rate	52.2 g/d
Yield per hectare	250 kg

Total yield of tomato per plant ranged from 492.49g to 2082.52 g the highest being recorded in the DAP-Urea fertilized plots and the lowest in the spring water fed plots. Higher total yield per plant was observed in the fertilizer treatment while the spring water treatment showed lowest total yield per plant (Fig 1). However, the observed difference in total yield per plant was not significant ($p>0.05$) among the treatments. Similarly, total yield was not significantly different ($p>0.05$) among treatments even though the fertilizer treatment had higher yield than the other two treatments

The highest number of clusters was obtained in the fertilizer treatment and the lowest were found in the spring water treatment (Table 3). Significantly different ($p<0.05$) number of clusters was observed among treatments. Tukey HD analysis revealed that fertilizer treatment was significantly different ($p<0.05$) from both spring water and pond water treatment. However, the difference between pond water treatment and spring water treatment was not significant ($p>0.05$).

In both total marketable yield and marketable yield per plant of tomato, the fertilizer treatment had higher values and the spring water treatment had the lowest (Table 3). No significant difference ($p>0.05$) was observed between treatments. Similar results were also found in both the total unmarketable yield and unmarketable yield per plant (Table 3). Here also the difference between treatments was observed to be not significant ($p>0.05$).

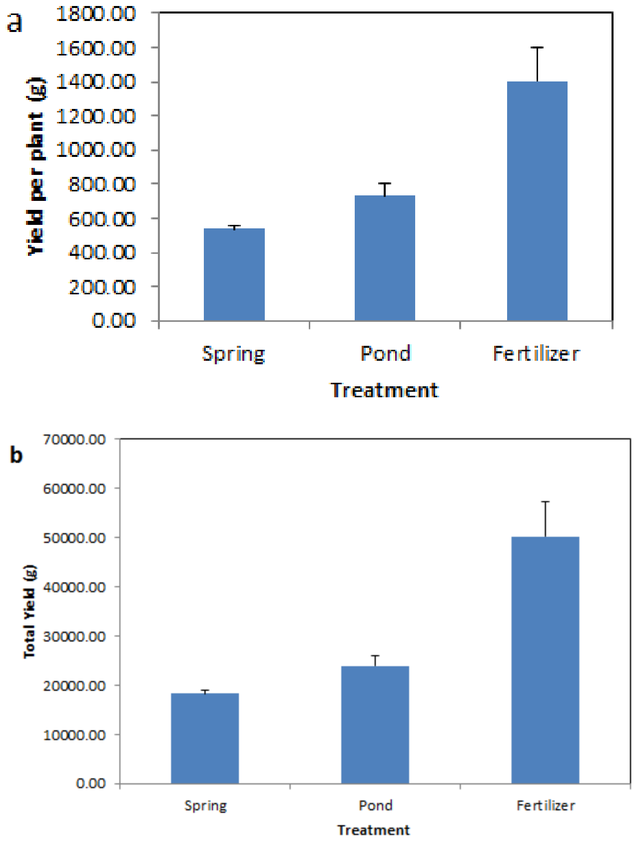

Figure 1. Yield per plant(a) and total yield per plot (b) of tomato fruit in spring water, pond water and fertilizer treatments.

Total yield per hectare of tomato was found to range from 110.3quintals to 496.23 quintals, the highest yield being found in the fertilizer treatment and the lowest in the spring water treatment. Total yield per hectare was not significantly different ($p>0.05$) between treatments (Table 3).

Total yield of potato per plant ranged from 900 g in spring water treatment to 2006g in the fertilizer treatment. (Table 4). However, the observed difference in total yield per plant was not significant ($p>0.05$) among the treatments. Similarly, total yield was not significantly different ($p>0.05$) among treatments even though the fertilizer treatment had higher yield than the other two treatments (Fig 2).

In both total marketable yield and marketable yield per plant of potato, the fertilizer treatment had higher values and the spring water treatment had the lowest (Table 4). No significant difference ($p>0.05$) was observed between treatments.

Total yield per hectare of potato was found to range from 99.33quintals in spring water treatment to 296.67 quintals, the highest yield being found in the fertilizer treatment and the lowest in the spring water treatment. Total yield per hectare was not significantly different ($p>0.05$) between treatments.

4. Discussion

In this study yield of both tomato and potato didn't show significant variations among treatments. However, in the tomato yield from the fertilizer treatment was considerably higher than the other two treatments. In contrast the variation in yield of potato among treatments was not significantly different. Similar results were reported in Kenya where fertilizer application had higher yield than pond water irrigation [5]. Increased yields in various crops were also reported when canal water was substituted by pond water [6-8].

The results of this study failed to conclusively affirm the importance of IAA in the yield of vegetables, as significantly different results were not recorded between spring water and pond water treatments. However, absence of significant variation among the fertilizer and the pond water treatments suggest that pond water can partially replace the use of fertilizers especially when the additional yield of the fish is considered.

The fact that yields from the spring water treatment, which served as a control, and the pond water treatment didn't vary significantly can be attributed to the low density of the stocked fish in the ponds which in turn may have resulted in a low concentration of nitrogen. Increased stocking density resulted in increments in N concentration which had effects on growth of crops (Palada et al., 1999). The finding of comparable concentrations of P and N in the spring and pond waters can further strengthen this assertion (Table 1).Wood et al. (2001) found that when N concentration of 6 mgl^{-1} applied at 2.3mmd^{-1} resulted in increased yield in French beans.

Higher unmarketable yield was observed in plots treated with fertilizer (44.5%) than plots treated with the pond water (33.4%). Good quality fruits and lesser unmarketable yield in Bell pepper irrigated with pond water [9]. This finding might be related to the higher number of fruits per plant and the faster rate of growth of the plants in the fertilizer treatment.

Table 3. Effects of spring water, pond water and fertilizer on number of clusters, marketable and unmarketable yield and total yield per hectare of tomato.

Treatments	No. of cluster per plant	Marketable yield(g)	Unmarketable yield(g)	Marketable yield per plant (g)	Unmarketable yield per plant (g)	Total yield per hectare (Q/ha)
Spring	13	16350.50	1974.80	480.89	56.94	122.17
Pond	15	17940.77	5995.07	527.67	202.16	159.57
Fertilizer	39	34788.67	15492.4	1024.00	378.29	335.21

Table 4. Effects of spring water, pond water and fertilizer on marketable and unmarketable yield and total yield per hectare of potato.

Treatment	No. of plants	No. of tubers per plant	Marketable yield (Kg)	Unmarketable yield (Kg)	Yield per plant (Kg)	Total yield (Kg)	Yield per hectare (q)
Spring	20.33	12.17	23.17	1.97	1.11	25.13	167.56
Pond	23.33	15.78	27.67	2.50	1.26	30.17	201.11
Fertilizer	19.00	13.33	32.67	1.67	1.72	34.33	228.89

5. Conclusion and Recommendation

This study showed that fish pond water can be used to irrigate horticulture plots to a satisfactory degree. The additional harvest of fish in this system can compensate for the yield difference that is inevitable in the case of reduction in the use of inorganic fertilizers. The properly managed IAA, where ponds can produce the required amount of N and P for plants, can be feasible for producing crops and protein for the small holder farmer in Ethiopia.

Further investigations into the optimal amount of water, optimal level of N and P in the pond water, optimal stocking density of fish, suitable species of fish and the socio-econmoic impacts of the IAA system should be carried out for a complete and up scalable technology output

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