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Pre-extension Demonstration of Fish-Poultry-Horticulture Integration Farming System in East Shoa, Dugda and North Shoa, Yaya Gulele, Oromia, Ethiopia

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Abstract

Fish-poultry-horticulture integrated farming system is a method of diversified food production to combat nutritional insecurity at small scale farmers' level under low cost and new to Ethiopia. Demonstration of the integrated farm was conducted at two different districts, Yaya Gulele, a high land at altitude of 2,650 m.a.s.l , and Dugda, a lowland within central rift valley at altitude of 1650m.a.s.l. The experiment was conducted in 2017/18 with the objective of evaluating, and demonstrating this technology. In each selected sites of the districts, one FRG having 12 member farmers considering gender participation was established. Earthen fish pond of 81 m^2 at Yaya Gulele/Nono Chemeri and 71 m^2 at Dugda, Girisa were prepared and stocked with three fish species, Nile tilapia, common carp and African catfish. Simultaneously rearing poultry and horticulture farms were conducted in the integrated farms. Thirty and 26 Egg producing Lohmann brown type pullets were used in the integration at Yaya Gulele and Dugda districts respectively to produce egg and fertilize fish pond and then vegetable farm. Large disparity was observed in yield of all the products. Fish Daily Growth Rate (DGR/g) was 0.16 and 0.68 for Nile tilapia 0.28 and 0.65 for common carp and 0.60 and 0.60 for African catfish at Yaya Gulele and Dugda respectively. Peak egg production in poultry were March at Yaya Gulele (82.4% of the chicken lay egg daily) and in July at Dugda (84.5%). Training on the importance of integrated fish-poultry-horticulture farming and its management was given to farmers and subject matter specialists of the districts before and after establishing the integrated farms at both sites. All products were evaluated and demonstrated. Knowledge and skill was obtained from this integrated farming systems in that different agro-ecologies where temperature fluctuation played great role on fish growth performance, poultry egg production and horticulture production. The fish-poultry-horticulture integrated farming system technology practices were equally applied on both sites.

Keywords: African catfish, common carp, fish, fingerling, farmer, FRG, integration, Nile tilapia, pond, Poultry, waste recycle, vegetable

1. Introduction

Aquaculture is a part of agriculture which is rearing aquatic organisms, plants and animals including fish under controlled condition. Fish culture can integrated with livestock and agronomy, especially vegetables using as one waste input for the other and enable to produce organic production. To alleviate animal source protein problem in the country, fish culture is essential to support terrestrial animal protein sources obtains from cattle, sheep, goat and poultry.

Aquaculture can create job opportunity, generating income; ensure food security and contributing to national/regional economy. Fish culture began in recent time in Ethiopia. From some authors stated the importance of fish culture, (DabaTugie, 2010) documented farmers in Oromia region practiced extensive fish farming in small ponds using Nile tilapia since 2008.

Pond management with poultry, fish and vegetables was proofed to be excellent approach for sustainable production, income generation and employment opportunity of the resource poor rural households (Alam *et al.,* 2009). Addition of organic fertilizers like poultry droppings to a fish pond increases fish production (Enamul Hoq *et al.*, 1999: Abbas *et al.,* 2004). The problem of fish feed faced in aquaculture development can be resolved by integrating fish farm with poultry.

In the integrated farming of fish-poultry-vegetable, waste from one component is used as input for the next component. In this case, waste from poultry is used to fertilize fish pond substituting feed supplement for the fish, and nutrient rich water from fish pond is used to irrigate the Vegetable/horticulture crop during the water exchange for fish, substituting fertilizer use in crops. This technique recycles waste for food production and saves environment from pollution. Provided the advantages of the integrated livestock-fish culture, this experiment was required to find a better approach of fish pond culture that can be practiced among farmers as a strategy for poverty reduction, ensuring nutritional security, creating job opportunity and diversifying income. This farming system is helps to boost sustainable production and enable farmers producing nutrient rich production on small scale farm, diversifying their products, minimizing their input cost and increasing production per unit area and enhances agriculture production.

Specifically the objective of this study was to evaluate the fish growth performance under poultry pond and vegetables production using waste from fish pond and demonstrating the integration farming system in a participatory approach on farmer's plot.

2. Materials and Methods

2.1 Descriptions of the study area

This research on integrated farming system was conducted in two zones of Oromia region, Yaya Gulele district of North Shoa zone, 120 km from Addis Ababa, the capital city in north direction and Dugida district of East Shoa zone, 130 km from Addis to in south direction on the way to Hawassa. The two districts are located in different agro-ecologies; the farm in Yaya Gulele was established at a village called Nono Chemeri which is situated in highland agro-ecology at an altitude of 2,650 m.a.s.l. whereas the farm in Dugda district was situated at Girisa peasant Association (PA) in mid rift valley with an altitude of 1650 m.a.s.l.

Inhabitants of the districts are practicing mixed-agriculture, rearing cattle, sheep and goats where this animal rearing activity became challenging due to scarcity of grazing land. Ethiopia, including Oromia region is a large country with more than hundred million populations where food insecurity had been chronic with 44% of the population undernourished, 47% of children under five are underweight, and 52% stunted (Haan *et al.*, 2006).

Yaya Gulele district is categorized in three agro-ecology zones, the highland 27.5%, amid altitude 41.17% and low land 31.78% with the population

of 66,336 (male 35,829 and female 30507). According to information from the agricultural office of the district, the district's average annual rainfall is 800-1000 mm and average temperature 16-20^{o}C. Major livestock in the district are cattle, sheep and poultry while from large crop diversity produced in the district, the majors are *teff*, wheat and beans.

2.2 Site selection for the technology

The two districts Yaya Gulele and the Dugda were purposely selected from the AGP beneficiary districts. The experimental sites in Peasant Associations (Kabales) within the respective districts were selected based on criteria of water resources availability and accessibility to culture fish in pond. As the farm is integrated, land availability and suitability for horticulture and poultry farming was also considered. After these criteria were fulfilled, host harmers' interest to receive the technology and manage the farm was assessed. Besides the host farmers' interest and land suitability, gender and age (younger is better to adopt technology) of the recipient farmers was also considered as a criteria.

2.3 Farmer Research Group (FRG) members' selection

Selection of FRG members was based on farmers' who have interest and irrigation access to implement the activity in their own lands. In each of the selected AGP-II districts, one Farmers Research Group (FRG) with 12 member farmers considering gender balance, were established. Selection of member farmers was conducted by multidisciplinary team including experts from districts' livestock and fishery office, DAs, PA representatives. These FRG members were trained and followed each of the production and management activities of the integrated fish-poultry-horticulture farming activities at the host farmers' site.

2.4 Fish pond construction and fish production

Fish pond constructions were carried out after training of the target groups/ FRG members and stakeholders (concerned livestock office staffs, DAs and PA chair persons).

At Yaya Gulele, earthen pond of 81 m^2 surface area with 1 m depth was prepared in participatory approach by involving the farmers. The pond was stocked with 105 Nile tilapia, 140 common carp and 33 African catfish, totally 363 fingerlings poly-cultured in one pond at stocking density of 4.5 fish/m^2. Sizes of the stocked fingerlings were 5.6 cm total length (TL) and 3.2 g weight (TW) for Nile tilapia, 6.6 cm TL and 33g TW for common carp and 9.4 cm TL and 15.6 g TW for African catfish. The fish was grown in pond under integration for a year and used for home consumption, subsistence use. Similarly, in Dugda, earthen pond of 71 m^2 surface area with 1 m depth was prepared in participatory way. The pond was stocked with 86 Nile tilapia, 98 common carp and 30 African catfish, totally 214 fingerlings at stocking density of 3 fish/m^2. The fish were grown in the pond under integration for a year and used for income generation.

2.5 Poultry house construction and production

Poultry house within the integrated farming in both districts were constructed from locally available materials after fish ponds were constructed. Walls of the house was built from eucalypts wood and plastered by mud at Yaya Gulele while it was built from mud bricks at Dugda Roof of the poultry house was covered by iron sheet at both sites. The poultry house had two compartments, with the first half 1.5 m X 4 m lying on ground and used for a night time resting place for the chicken and also used as a place to lay egg. The second half of the house with area 1.5 m X 4 m was open to air and light, hanging over part of the fish pond and used as feeding and drinking place for the chicken during day time. This part of the house lying over the pond was covered by mesh wire to protect chickens from predator birds, cats and others predators.

Thus, after the house was constructed, 30 and 26 pullets of 3 months age were purchased and stocked to the poultry houses at Yaya Gulele and Dugda districts respectively. The chicken were

fed adlib by commercial poultry feed purchased from animal feed processing company at Bishoftu. The chicken started laying eggs at the age of 5 months. The egg was collected every day and stored for sell.

2.6 Vegetable production

Horticulture production activities were carried out simultaneously with fish and poultry rearing. At Yaya Gulele/Nono Chemeri, Tomato (*Lycopersicon esculentum*) Galila variety, Adama Red Onion (*Allium cepa*), Gurage Cabbage *(Brassica oleracea)* and Carrot were cultivated on plot of 497 m^2 total area. While on Dugida/Girisa Tomato (*Lycopersicon esculentum*) Galila variety, Adama Red Onion (*Allium cepa*) and Gurage Cabbage *(Brassica oleracea)* was cultivated on plot of 344 m^2total area. The vegetables were grown by water coming out of the fish pond. Management of the horticulture was done according to their agronomic recommendation during the experimental period. Finally, the horticulture products were harvested and soled.

2.7 Trainings on management of the integrated farm

First training on FRG group organization and Fish-horticulture-poultry Integration farming system was given for 24 FRG farmers (19 males and 5 females) and 10 (male) SMS from zonal and district.

The second training (fig 1) was by the combination of theoretical and practical activity demonstration given for 91 farmers (74 M and 14 F) and 109 SMS (90 M and 9 F). Totally 200 (164M and 36F) participants were attended the training.

Fig 1: Training on management of the integrated farm and demonstration of the products.

2.8 Data analysis

Fish growth performance was expressed in terms of daily growth rate (DGR) using length and weight data taken monthly during the experimental period. The fish growth performances are presented in graphs and tables to compare the results at the two sites. Poultry and horticulture production data of the two sites were recorded from the plot and extrapolated to standard units of expression.

Fish Daily Growth Rate was calculated using the following formula

$$\text{Daily Growth Rate(DGRg/day)} = \frac{Final\ weight(g) - \text{Initial weight(g)}}{Experimental\ days}$$

3. Results and Discussion

3.1 Training

After FRG members were selected, training has two major components the importance of FRG group organization and management of Fish-horticulture-Poultry Integration Farming system was given for 24 FRG farmers (19 males and 5 females) and for10 male Subject Matter Specialist (SMS) invited from zonal and district governmental offices. The second training has the components of theoretical and practical activity demonstration given for 91farmers (74 M and 14 F) and 109 SMS (90 M and 9 F) totally 200 (164M and 36F) participants were attended. The farmers and the stakeholders have got concept knowledge on the importance of the fish-poultry-horticulture integrated farming.

At the practical training on production system, the farmers have got knowledge on fish pond management, fish harvesting, fish dish preparation and eating practices. The FRG members and also other local farmers have learnt the indoors poultry management fed commercial feed to produce better egg production. They also learned horticulture production by irrigating the field with water coming from fish pond under poultry house substituting inorganic fertilizer application.

3.2 Fish Production

The cultured fish species, Nile tilapia, common carp and African catfish which used as poly-culture for pre-extension demonstration in different agro-ecologies high land of Yaya Gulele where altitude is 2650m.a.s.l. and Dugida district located in mid rift Valley an altitude 1650 m.a.s.l. in both where mixed agriculture(crop and livestock) practiced. These warm water fish species growths can influence by warm temperature. Nile tilapia, Common carp and Catfish attained in 300 rearing days an average weight at Yaya Gulele and Dugida were 108.30 and 183; 88.93 and 224.61 and 152.25 and 205.80 g respectively.

Table 1: Summary of fish data in the fish-horticulture-poultry integration farm

Description	Yaya Gulele site/Nono Chemeri			Dugida/Girisa site		
	Nile tilapia	Common carp	Catfish	Nile tilapia	Common carp	Catfish
Altitude m.a.s.l.	2,650			1,650		
Rearing period/ days	300			300		
Initial average fish seed weight (g)	3.20	7.19	15.60	3.20	7.19	15.60
Final fish weight (g)	108.30	88.93	152.25	183.00	224.61	205.80
Final weight range(g)	57.6-168.34	65-120.5	125.30	48-292.02	157.42-374	132-262
Fish Daily Growth Rate(g) (DGR (g)	0.35	0.28	0.60	0.68	0.65	0.59

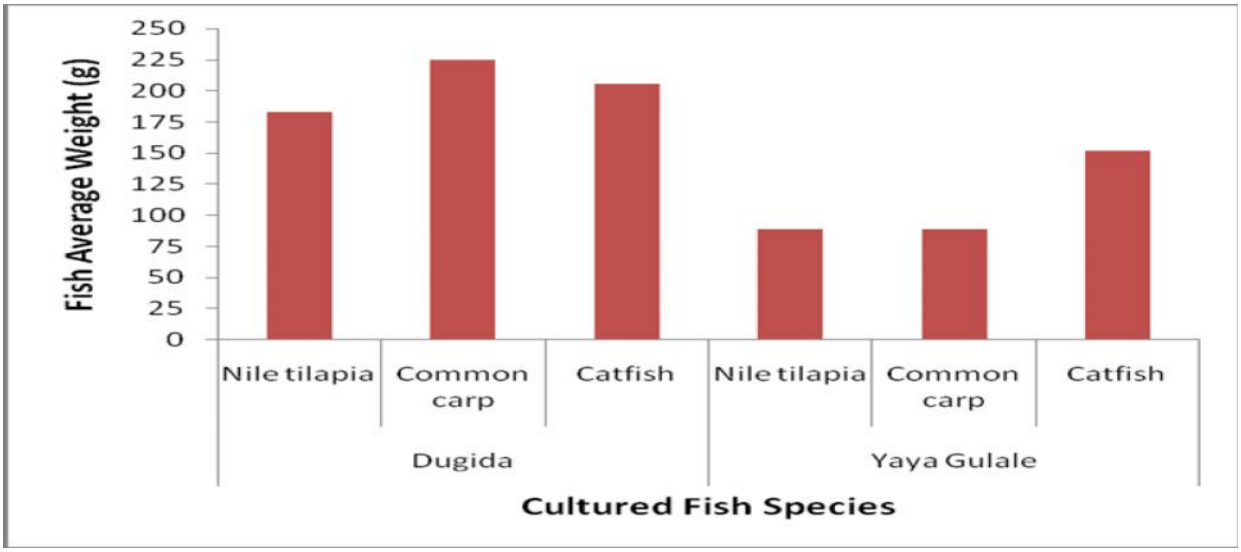

Fig 2: Growth performance of Nile tilapia in the integrated pond during the culture period.

Where similar experiment, integration farming system conducted in east Wallaga zone, Wayou Tuka district mid high land with an altitude of 1910 m.a.s.l. where fish growth performance was obtained better compared with this experiment DGR/g Nile tilapia 0.65, Common carp 4.01 and Catfish 3.25 g.

3.3 Egg Production

After poultry house was constructed for Yaya Gulele and Dugida districts activity 30 and 26 pullets of 3 months age were purchased and stocked. The stocked chickens were started laying eggs at the age of 5 months. In the similar condition by feeding commercial poultry feed, in average a hen in Yaya Gulele and Dugida districts laid 18 and 20 eggs per month respectively. The production fluctuation occurred in this experiment was not appeared in earlier research documents, (Lama Abara 2017, Daba, *et. al.*, 2017). The egg production in both sites in November and December 2017 were declined due to lack of commercial feed.

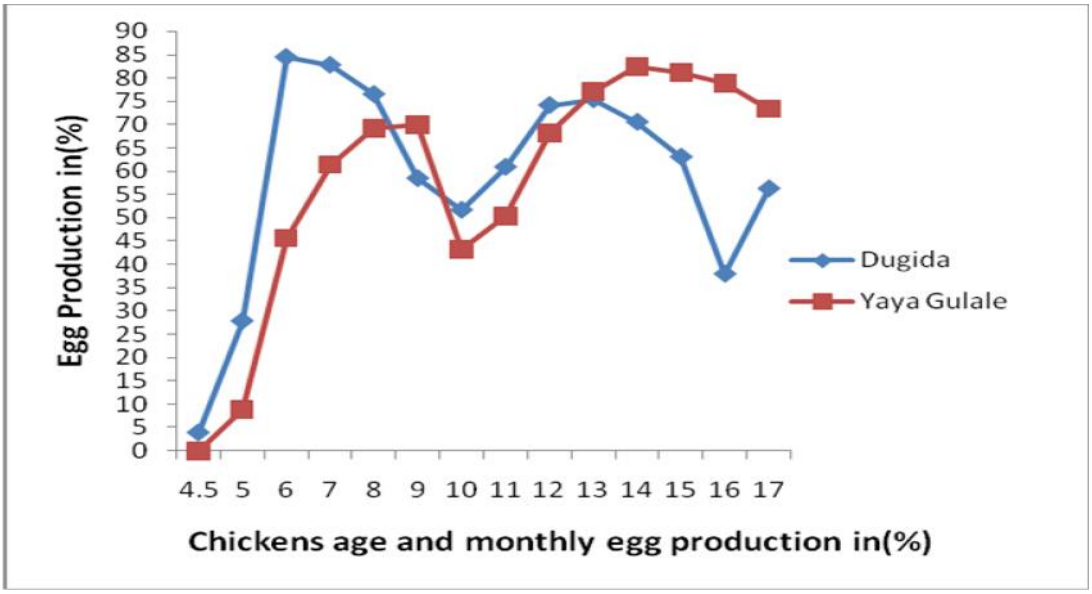

Figure 3. Egg production per chicken over time at Yaya Gulele and Dugda

Egg production was decreased in Nono Chemeri in cool season and raised in warm season from January 2018.

The egg production was almost similar comparing with earlier work (Lama Abara, 2017).

3.4 Horticulture production

Horticulture production activities were carried out simultaneously with fish and poultry rearing. At Yaya Gulele/Nono Chemeri, Tomato (*Lycopersicon esculentum*) Galila variety, Adama Red Onion (*Allium cepa*), Gurage Cabbage*(Brassica oleracea)* and Carrote were cultivated total on 497m^2 area plot while on Dugda/Girisa Tomato(*Lycopersicon esculentum*) Galila variety, Adama Red Onion (*Allium cepa*) and Gurage Cabbage*(Brassica oleracea)* was cultivated total on 344 m^2 plot. The horticulture production were estimated in the experimental plots and extrapolated to hectare's production (table 2).

Table 2. Horticulture production

Location	Type of Vegetable	Plot area(m^2)	Yield Kg/m^2	Estimated yield kg	Sale in Eth.birr	Estimated yield Kg/ha	Sale in Eth.birr
Dugda/ Girisa	Tomato	80	1	80	1200	10000	70000
	Onion	92	3	276	1370	30000	148800
	Gurage cabbage	172	0.40	60	680	3488.4	39535
	Total	344			*2630*		*258335*
Yaya Gulele/ Nono Chemeri	Tomato	252	2	500	1200	20000	48000
	Onion	119	0.42	50	237.50	4200	19950
	Gurage cabbage	72	0.44	32	320	4400	19580
	Carrot	54	4.82	260	1300	48200	192800
	Total	497			*3057.50*		*280330*

3.5 Partial budget analysis

The products from the integrated farms were sold to market and also consumed at home by the family members. The consumed products were also estimated in terms of money to estimate the profitability of the farms as a source of income. Production cost and revenue generated from the products were presented below in table (table 3).

Table 3: Summary of partial budget analysis of fish, egg and horticulture production

Fish					
Production cost (in birr)	Dugda	Yaya Gulele	Revenue generated from Fish (in birr)	Dugda	Yaya Gulele
Fingerling purchase (variable)	107	181.50	Fish selling (27.35 birr/kg x 42.88Kg at Dugda	1172.75	25kg x 35br = 875.00
Estimated labor cost	150	150	Profit (revenue-cost)	141.25	(156.5)
Fishing net depreci ation	300	300			
Pond depreciation cost	400	400			
Total cost in fish component	*950*	*1031.50*			
Poultry					
Cost	Dugda	Yaya Gulele	Revenue	Dugda	Yaya Gul.ale
Pullets purchasing	2600	3000	revenue from egg production	17,749	19,774.25
Poultry feed purchase	13,220	13,220	Estimated value of poultry at the end of the trial(Cull out hen)	2300	2800
Poultry feeders & equipment	300	300	Estimated value of equipments	200	200

Estimated labor cost	1650	1650	Total revenue from poultry	20249.0	22774.25
Poultry house depreciation	800	700	Total profit in poultry	3339.0	3604.25
Total cost in poultry	18,570	18,870			
Vegetable					
Production cost	Amount (Eth.birr)		Revenue generated	Amount (Eth.birr)	
	Dugda	Yaya Gulele		Dugda	Yaya Gulele
Estimated cost for land preparation, weeding, etc	300	300	Selling of horticulture production	3250	3057.50
Purchase of onion seedling	250	250	Profit in vegetable	2,550.0	2,357.5
Purchase of pesticide	150	150	Total profit in the system	6,030.45	6,118.25
Total cost	700	700			

At the experimental plot sample level, the profit obtained at Dugda, the lowland was 6,030.45 birr while that of Yaya Gulele, the highland was 2,201.0 birr. When this production is extrapolated to a ha of tilapia pond which is about 125 fold of the current experimental ponds, the profit becomes at a level of 750,000 birr at Dugda, in the lowland and 275,000 birr at Yaya Gulele, in the highland. Moreover, the products are diversified and gear towards nutritional security at subsistence farmers' level.

4. Conclusion and Recommendation

Generally, production of the integrated fish-horticulture-poultry farming system was valuable, so it contributes for further sustainable development to mitigate food insecurity in the region as well as in the country. The yield and production of egg and fish in the integrated farm were affected by temperature, during demonstration and evaluation of the technology on the field.

Effective and efficient delivery of technical advices to support farmers is highly required for proper management of this production system and to enhance production and productivity. Large fish pond with area above 100 m^2 and depth 1.50m, specially in the high land area at altitude of 2000 m.a.s.l. and above are recommended to maintain water temperature in required range and enough space for photosynthesis to produce sufficient natural feed in pond. Further follow up and support to the farmers as well as stocking fish for other FRG members is required.

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