Quality Evaluation of Vegetables Irrigated with Fishpond Wastewater- A Case Study

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Abstract

Irrigated agriculture has the potential to overcome the twin problems of increase in cropping intensity and food production. With different potential sources of irrigation sometimes it is very much crucial to assess the fruit quality. An effort has been made in this paper to evaluate the fruit quality of tomato and okra irrigated with fishpond wastewater for consecutive three years. Intensive aquaculture requires water exchange. Hence, a symbiotic combination of intensive aquaculture and olericulture was practiced to study the efficacy of this integrated system. Quality of test crops okra for rainy season and tomato for non-rainy season was evaluated. Crude fiber content was found to be around 3% for okra crop. The value of pH of fruit pulp, ascorbic acid content and total soluble solid content of the tomato was found to be ranged between 4.59 to 4.67; 18.36 to 18.84; 4.62 to 4.82, respectively. All the fruit quality parameters evaluated was found to be non-significant and the values were found to be at par with the control treatment.

Keywords**:** Potential sources of irrigation; fruit quality; fishpond wastewater; tomato and okra.

Introduction

Under the context of global water crisis multiple water usage is one of the alternatives to ensure higher production. Sustainable food production not only ensures quantity but also quality to a greater extent. Multiple usage water considering a system comprising of aquaculture and

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olericulture can solve the problem of irrigated agriculture to a greater extent (Ray, 2014). Aquaculture is predominantly a non-consumer of water but it requires water for its sustenance. Intensive aquaculture requires water exchange and this water can be made use for irrigation (Brugère, 2006). Reused water may have the advantage of being a constant and reliable source of irrigation. Several works has been done with alternate potential sources of irrigation like saline or brackish water irrigation, municipal wastewater, grey water, fishpond wastewater and waste water from meat processing units (Singh *et al*., 2013). The quality of fruit irrigated with different sources of irrigation water needs to be evaluated before consumption. An attempt has been made in this paper to evaluate the quality of fruit irrigated with fishpond wastewater for three consecutive years.

Materials and Methods

Field experiments were conducted at the Aquacultural experimental farm of the Agricultural and Food Engineering Department, Indian Institute of Technology Kharagpur, West Bengal in eastern India, during the years 2005-06, 2006-07 and 2007-08. The site selected for the field experiments represents a typical upland condition seen in the eastern Indian region. It is located at latitude of 22° 19' N and longitude of 87° 19' E with an altitude of 48 m above the mean sea level. The experimental site falls under sub-humid, sub-tropical region with an annual rainfall of 1400 mm, 80% of which is received during the rainy season that spreads over June to September. The rainfall pattern of this region is quite erratic. Dugout lined ponds of 1.5 m depth and 150 square meter of water spread area were constructed for intensive fish culture. Three Indian Major Carp (IMC) species, *viz*., surface-feeder Catla (*Catla catla* L.), column-feeder Rohu (*Labeo rohita* L.), and the bottom-feeder Mrigal (*Cirrhinus mrigala* L.) were considered for this poly-culture system. Fishes were raised at stocking ratio of 4:3:3 (CIFA, 2006). The trial was conducted at three levels of higher stocking density, *viz*., 20,000; 35,000 and 50,000 numbers of fingerling stocking per hectare of water spread area. Alternate two day monitoring of major water quality parameter was done using standard protocol (APHA, 2000). The water exchange from fishpond was done before the fishpond water reaches stress level. This exchanged water was used to irrigate the crop grown adjacent to the fishponds. In between the fishponds, experimental plots were prepared for conducting agronomic field trials for growing vegetables during rainy and non-rainy seasons. Tomato and Okra were grown as trial crop during non-rainy and rainy season, respectively, in a split plot experimental design. Four irrigation sources constituted four treatments and three reduced doses of nitrogen fertilizer constituted sub-treatments, with three levels of replication. Thirty-six plots of 30 square meter each and separated by a 60 cm bund were prepared adjacent to the fishponds to use the fishpond waste water as a source of irrigation. The field layout with experimental details is shown in Fig.1. The detailed description of the treatment and sub-treatment is presented in Table-1.

Table 1: Detailed Description of the Treatments and Sub-treatments

Main Treatment (symbol)	Description	Subplot treatment (symbol)	Description
I_0	Irrigation with tubewell water	F_1	90% of recommended N
I_1	Irrigation from S.D-2.0	F_2	80% of recommended N
I_2	Irrigation from S.D-3.5	F_3	70% of recommended N
I_3	Irrigation from S.D-5.0		

For tomato, total soluble solid (TSS), pH, and ascorbic acid contents were evaluated by collecting samples from all the four treatments and using standard methods. Similarly, for Okra crop, fiber content was measured from the harvested crop using standard procedure.

The Total Soluble Solid (TSS) content of tomato fruit pulp was determined by using a hand held refractrometer. A drop of pulp solution was placed on its prism. The percentage of TSS was obtained from direct reading of the refractrometer. Temperature correction was made by using the methods described by Rangana (1979). The pH of the sample was determined by the method described by Rangana (1979). One gram of sample was homogenized in 1 ml of boiled distilled water and 1 ml of de-ionized water of pH 7.0 and the pH of tomato juice was recorded by using an electronic pH meter. The pH meter was standardized with the help of buffer solution.

Ascorbic acid in tomato pulp was estimated by 2, 6-Dichlorophenolinduphenol visual titration method also as described by Rangana (1979). Ascorbic acid content (mg per 100 g of fruit pulp) is given by the following equation (Eq. 1).

$$\text{Ascorbic acid content} = \left(\frac{T \times D \times V_1}{V_2 \times W}\right) \times 100 \qquad \ldots (1)$$

where, T = titre; D = dye factor; V_1 = volume made up; V_2 = volume of extract taken for estimation; W = weight of sample taken for estimation. Crude fiber content for okra crop was calculated for different treatments using the following equation (Eq. 2) (Thimmaiah, 1999).

$$Crudefiber\ \ content\ = \left(\frac{b-c}{a}\right) \times 100 \qquad \ldots (2)$$

where, a = mass of sample, g; b = loss of mass after ashing during determination, g; c = loss of mass after ashing during blank test, g.

Results and Discussion

Fruit Pulp pH

Data pertaining to pulp pH are listed in Table 2. The mean pH value of tomato fruit pulp was found to be around 4.6. There was no effect of irrigation and N on the pH of tomato fruit. However, the mean pH value ranged from 4.59 to 4.64 with irrigation sources and 4.58 to 4.67 with fertilizer levels. There was no conspicuous effect of year on pH. The interaction effect of irrigation and N levels was found non-significant.

The pH values of mature tomato fruit obtained were always within the range of 4 to 5 typical to tomato fruit (Balibrea *et al*., 1997; Al-Lahham *et al*., 2003 and Juroszek *et al*., 2009) well agreement with the present experimental findings.

Table 2: Effect of Irrigation Sources and Nitrogen Levels on pH of Tomato

Treatment	2005-06	2006-07	2007-08	Mean
Irrigation sources				
I_0	4.65	4.61	4.62	4.63
I_1	4.54	4.56	4.68	4.59
I_2	4.57	4.67	4.68	4.64
I_3	4.62	4.65	4.64	4.64
SEm (±)	0.06	0.03	0.05	0.03
CD (0.05)	NS	NS	NS	NS
Fertiliser level				
F_1	4.61	4.57	4.70	4.63
F_2	4.64	4.66	4.70	4.67
F_3	4.54	4.64	4.57	4.58
SEm (±)	0.06	0.06	0.07	0.04

CD (0.05)	NS	NS	NS	NS
Interaction (I × F)				
SEm (±)	0.11	0.10	0.12	0.07
CD (0.05)	NS	NS	NS	NS

Ascorbic Acid Content (mg per 100 g of fruit pulp)

Ascorbic acid content of fruit pulp was not affected significantly by the sources of irrigation during the experimental seasons (Table 3). The mean ascorbic acid content of tomato fruit pulp was found to be about 18.5.

Table 3: Effect of Irrigation and Nitrogen on Ascorbic Acid Content (mg per 100 g of fruit pulp) of Tomato Fruit Pulp

Treatment	2005-06	2006-07	2007-08	Mean
Irrigation sources				
I_0	18.33	18.40	18.36	18.36
I_1	18.48	18.26	18.40	18.38
I_2	18.97	18.47	18.16	18.53
I_3	18.87	18.83	18.81	18.84
SEm (±)	0.20	0.15	0.26	0.12
CD (0.05)	NS	NS	NS	NS
Fertiliser level				
F_1	18.84	18.51	18.35	18.57
F_2	18.61	18.56	18.38	18.52
F_3	18.55	18.40	18.56	18.50
SEm (±)	0.34	0.23	0.20	0.15
CD (0.05)	NS	NS	NS	NS
Interaction (I × F)				
SEm (±)	0.60	0.40	0.42	0.28
CD (0.05)	NS	NS	NS	NS

The mean ascorbic acid content of fruit pulp was 18.36, 18.38, 18.53 and 18.84 for I_0, I_1, I_2 and I_3, respectively. Pooled data analysis show that the maximum value of ascorbic acid content was 19.0 mg per 100 g of fruit pulp for I_3F_1 combination. The mean data reveal that ascorbic acid content values were F_1 (18.57 mg/ 100 g); F_2 (18.52 mg/ 100 g) and F_3 (18.50 mg/ 100 g). The interaction effect of sources of irrigation and N doses was non-significant. Ascorbic acid content of tomato fruit was found within acceptable range in the present investigation. This obtained value of ascorbic acid content was well supported by (Woese *et al.*, 1997; Haukioja *et al.*, 1998 and Brandt and Molgaard, 2001).

Total Soluble Solid (^{0} Brix)

The total soluble solid content value of fruit pulp was not affected significantly by sources of irrigation during any of the years (Table 4). The mean total soluble solid content of tomato fruit pulp was found to be about 4.8. The mean total soluble solid content values of fruit pulp were 4.82, 4.97, 4.98 and 4.62 for I_0, I_1, I_2 and I_3, respectively. Pooled data analysis also shows that the values were statistically non-significant. The mean data reveal that the total soluble solid content values were 4.85 for F_1. The interaction effect of sources of irrigation and N doses was non-significant.

Table 4: Effect of Irrigation Sources and Nitrogen Levels on Total Soluble Solid (^{0}Brix) of Tomato

Treatment	2005-06	2006-07	2007-08	Mean
Irrigation sources				
I_0	4.45	4.69	5.32	4.82
I_1	4.59	4.99	5.32	4.97
I_2	4.99	5.12	4.83	4.98
I_3	4.28	4.90	4.69	4.62
SEm (±)	0.24	0.24	0.22	0.14
CD (0.05)	NS	NS	NS	NS
Fertilizer levels				
F_1	4.82	4.61	5.11	4.85
F_2	4.44	5.23	5.09	4.92
F_3	4.47	4.93	4.91	4.77
SEm (±)	0.18	0.19	0.17	0.10
CD (0.05)	NS	NS	NS	NS
Interaction (I × F)				
SEm (±)	0.38	0.40	0.35	0.22
CD (0.05)	NS	NS	NS	NS

Sugar to acid ratio of tomato was estimated from total soluble solid and acidity of the fruit. The flavor intensity, sourness and sweetness are determined by the amount of sugar and acid present in tomato (DeBruyn *et al.*, 1971 and Stevens *et al.*, 1977). The result found in the present investigation is confirmed from the findings of Reganold *et al*. (2001), Chassy *et al*. (2006) and Hebbar *et al*. (2004).

Crude Fiber Content (%)

The crude fiber content of okra fruit was not affected significantly due to variation in N fertilizer doses during any of the years (Table 5). The mean crude fiber content of okra fruit was found to be around 3.0%. Pooled data analysis shows that the values were statistically non-significant. The mean data reveal that crude fiber content (%) values were F_1 (3.15); F_2 (3.11) and F_3 (3.18). It is revealed from the pooled data that no single combinations resulted in significant response to okra fruit crude fiber content value. The crude fiber content value of okra obtained from the experiment is also supported by the findings of (Akingbala *et al.*, 2003 and Adelakun *et al.*, 2009).

Table 5: Effect of Nitrogen Levels on Crude Fiber Content (%) of Okra

Treatment	(2006)	(2007)	(2008)	Mean
Nitrogen levels				
F_1	3.32	3.07	3.06	3.15
F_2	3.19	3.05	3.08	3.11
F_3	3.22	3.17	3.14	3.18
SEm (±)	0.13	0.10	0.11	0.07
CD (0.05)	NS	NS	NS	NS

Conclusion

The evaluation of quality of tomato and okra shows that there is hardly any difference in the value of quality parameters. The values of the respective fruit quality were found to be at par with the control. Hence, it may be concluded that the fishpond wastewater is a safe source of irrigation water and is of course a constant and reliable source. This irrigation source does leave any scar mark, so far as quality of fruit is concerned.

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Reference

Adelakun O.E., Oyelade, O.J., Ade-Omowaye, B.I.O., Adeyemi, I.A. and Van de Venter, M. 2009. Chemical composition and the antioxidative properties of Nigerian Okra Seed (*Abelmoschus esculentus* Moench) Flour. Food and Chemical Toxicology 47: 1123-1126.

Akingbala, J.O., Akinwande, B.A. and Uzo-Peters, P.I. 2003. Effects of colour and flavour changes on acceptability of ogi supplemented with okra seed meals. Plant Foods for Human Nutrition 58: 1-9.

Al-Lahham, O., El Assi, N.M., Fayyad, M. 2003. Impact of treated wastewater irrigation on quality attributes and contamination of tomato fruit. Agricultural Water Management 61: 51-62.

APHA (American Public Health Association). 2000. Standard methods for the examination of water and wastewater. American Public Health Association. Washington DC, New York.

Balibrea, M.E., Cayuela, E., Artes, F., Alfocea, F.D. 1997. Salinity effects on some post harvest quality factors in commercial tomato hybrid. Journal of Horticultural Science 72(6): 885-892.

Brandt, K. and Mølgaard, J.P. 2001. Organic agriculture: does it enhance or reduce the nutritional value of plant foods?. Journal of the Science of Food and Agriculture 81(9): 924-931.

Brugère, C. 2006. Economics of integrated irrigation-aquaculture. In M. Halwart & A.A. van Dam, Eds. Integrated irrigation and aquaculture in West Africa: concepts, practices and potential, Rome, FAO. pp. 135-150.

Chassy, A.W., Bui, L., Renaud, E.N., Van Horn, M., and Mitchell, A.E. 2006. Three-year comparison of the content of antioxidant micro constituents and several quality characteristics in organic and conventionally managed tomatoes and bell peppers. Journal of agricultural and food chemistry 54(21): 8244-8252.

De Bruyn, J.W., Garretsen, E and Kooistra, E. 1971. Variation in taste and chemical composition of the tomato (*Lycopersicon escufentum* Mill.). Euphytica 20: 214-227.

Haukioja, E., Ossipov, V., Koricheva, J., Honkanen, T., Larsson, S. and Lempa, K. 1998. Biosynthetic origin of carbon-based secondary compounds: cause of variable responses of woody plants to fertilization?. Chemoecology 8(3): 133-139.

Hebbar, S.S., Ramachandrappa, B.K., Nanjappa, H.V. and Prabhakar, M. 2004. Studies on NPK drip fertigation in field grown tomato (*Lycopersicon esculentum* Mill.). European Journal of Agronomy 21: 117-127.

Juroszek, P., Ledesma, D., Ma, C.H., Yang, R.Y., Lumpkin, H.M., Lin, C.C., Tsai, H.H., Wu, D.L., Hanson, P.M., and Palada, M.C. 2009. Plant virgor and yields of organically and conventionally grown tomato crops in Taiwan. Acta Horticulture 767: 257-265.

Rangana. 1979. Manual Analysis of Fruits and Vegetables Product. Tata McGraw- Hill Co. Ltd., New Delhi, pp: 2-95.

Ray, L.I.P. 2014. Techno-Economic Feasibility of Integrated Agri-Aquaculture System. Unpublished PhD thesis submitted to Indian Institute of Technology, Kharagpur, West Bengal, India.

Reganold, J. P., Glover, J. D., Andrews, P. K., and Hinman, H. R. 2001. Sustainability of three apple production systems. Nature 410(6831): 926-930.

Singh, A.K., Ram, V., Ray, L.I.P., Bora, P.K., Thakuria, D. and Singh, N.J. 2013. Alternate potential sources of irrigation. Published by Dean, CPGS, Barapani-793103. Meghalaya.

Stevens, M.A., Kader, A.A., Albright-Holton, M. and Algazi, M. 1977. Genotypic variation for flavor and composition in fresh market tomatoes. Journal of American Society of Horticultural Sciences 102: 680-689.

Thimmaiah, S.R. 1999. Standard Methods of Biochemical analysis. Kalyani Publisher, Ludhiana, India. p 64.

Woese, K., Lange, D., Boess, C. and Bogl, K.W. 1997. A comparison of organically and conventionally grown foods-results of a review of the relevant literature. Journal of the Science of Food and Agriculture 74: 281-283.

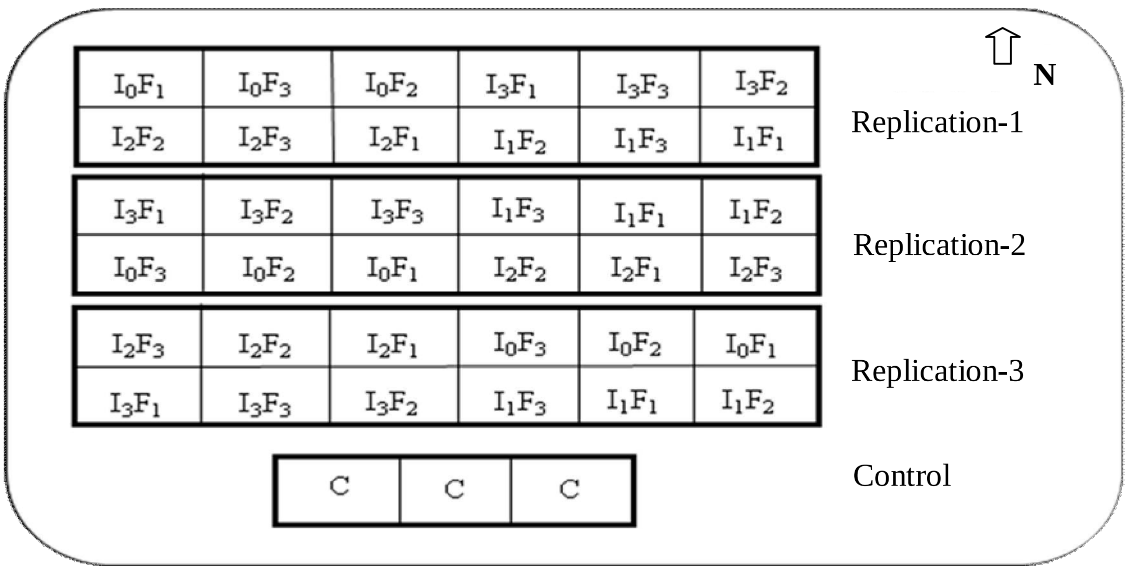

Fig. 1: Layout of the Experimental Plot

where, I = Main treatment, source of irrigation; F = Sub treatment, fertilizer and C = control plot