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Article

Effects of aspirin on aquaponics tomato (*Solanumly copersicum*) production in laboratory condition

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Abstract: The experiment was conducted to visualize the effect of exogenous aspirin on tomato production in aquaponic system. Aspirin, a derivative of salicylic acid, acts as a potential non-enzymatic antioxidant and plant growth promoter, hence regulates plant physiology. The experiment employed three treatments (T) with three replications (R) each where, 60 ppm and 120 ppm aspirin were used in T_1 and $T_{2,}$ respectively and T_{con} was control with no aspirin. Media filled plastic containers (0.29m×0.30m×0.21m) as growbeds and plastic tanks of 120 liter capacity as fish tank were installed to construct each aquaponic systems indicating each replication. Tilapia, was stocked at 111 fish /m^3 in the fish tank and fed commercial floating feed containing 30% protein at the rate of 3% body weight twice daily. In each replication, two tomato saplings were planted. Fish tank water was oxygenated with a 10 watt air pump, then waste water from tank was pumped to grow bed with a 12 watt submersible pump. Survival rates were 70, 85 and 50% in T_1, T_2 and T_{con} respectively. While fish productions were 0.42, 0.34 and 40.49 (kg/m^2/60 days) in T_1, T_2 and T_{con} respectively. The water quality parameters were within the suitable ranges for tilapia as well as tomato in the aquaponic system. Foliar spray of aspirin was applied fortnightly. Tomato production was hampered with various diseases in all the treatments although the aspirin treated plant (T_1 and T_2) were free from few diseases. The highest tomato production was found 0.44 kg/m^2/60 days in T_2 followed by T_1 (0.42 kg/m^2/60 days) and T_{con} (0.34 kg/m^2/60 days). Noticeably, Plant growth and tomato production were higher in T_2 and T_1 with less disease prevalence than T_{con}, suggesting positive impacts of aspirin on tomato. However, further research is needed to justify the aspirin doses at user level.

Keywords: aquaponics; aspirin; foliar application; tomato

1. Introduction

Tomato as one of the most widely produced and consumed vegetable in the world (Heuvelink, 2005), contains high levels of antioxidant active compounds such as vitamin C, polyphenols and carotenoids (Tommonaro *et al*., 2012). Tomato is known as the nutritional powerhouse for human being, containing low-calorie (just 18 calories per 100 g), and low in fat contents and have zero cholesterol levels. However, tomato in aquaponic system or in conventional systems sometimes get affected by diseases due to lack of hormones and reduce the production. Salicylic acid (SA) act as a potential non-enzymative antioxidant as much as plant growth regulator, playing an important role in regulating a number of plant physiological processes (Fariduddin *et al*., 2003; Raskin, 1992). Aspirin or Acetylsalicylic Acid (ASA) is one of the derivatives of Salicylic acid (SA), is a medicine properties normally used to treat human diseases. It triggers plant's defenses against disease, protect the plants from fungal, bacterial and viral infections. ASA behaves like a hormone and acts as a growth promoter in plants. Salicylic acid, acetylsalicylic acid or other analogues of SA can function as a plant hormones (Pallag *et al*., 2014). SA is an important mediator of the plant defense response to pathogens (White, 1979). Exogenously supplied SA was shown to affect a large variety of processes in plants, including stomatal closure, seed germination, fruit yield and glycolysis (Cutt and Klessing, 1992). The first indication for a physiological effect of SA was the discovery of flower-inducing action and bud formation in tobacco cell cultures (Eberhard *et al*., 1989). The stimulatory effect of SA on flowering was latter demonstrated in other plant species and this was ground for suggesting that SA functions as an endogenous regulator of flowering (Cleland and Ajami, 1974). Singh and Kaur (1981) stated that foliar application of SA (100 ppm) on baby corn increased the plant height, leaf area, crop growth rate and total dry matter production. On the other hand, aquaponics, as a closed loop system consisting of hydroponics and aquaculture elements, is increasingly practiced in many parts of the world (Goddek *et al*., 2015). It is the perfect engineering of ecology, is the combination of aquaculture (fish or crustaceans) and hydroponic cultivation of plants (hydroponic vegetables, flower, and/or herb) in a re-circulating system, utilizing the nutrients present in the aquaculture effluents to produce plants with commercial value (Gollardo-Colli *et al*., 2014; Yildiz *et al*., 2017). Intensive re-circulating aquaponic system reused relatively small volumes of water by circulating through bio-filters to remove toxic waste products before returning the water to production tanks. The system allowed production of fish much higher than in extensive pond culture with carrying capacity kgm^{-3} and 0.6 kgm^{-3} respectively (Losordo *et al*., 1998). Therefore, the present experiment was conducted to increase the tomato production, reduce the prevalence of diseases and improve the nutritional quality of tomato by using foliar application of aspirin.

2. Materials and Methods

2.1. Site selection

The experiment was carried out at the aquaponics laboratory of the faculty of Fisheries in the Bangladesh Agricultural University (BAU), Mymensingh. The laboratory was well protected and had good locked door system. Besides, it is a clean and dry place. The experimental set up was in well exposed to sunlight.

2.2. Experimental design

The duration of the experiment was 60 days from 19th March to 18th May, 2018. Among different types of aquaponic system, media based system was selected to conduct the experiment. The experimental design was comprised of nine fish holding tanks, each containing 90 liter of water and nine plastic containers for vegetable growing bed. Those were cut longitudinally 0.5 inch below the upper surface to make it a bed. These containers were randomly allocated as treatments T_1, T_2 and control. Each treatment and control were have three replications (R_1, R_2 and R_3) and these were denoted as T_1R_1, T_1R_2, T_1R_3, T_2R_1, T_2R_2, T_2R_3, $T_{Con}R_1$, $T_{Con}R_2$, $T_{Con}R_3$ (Figure 1). For oxygenation, an air pump of 18 watt with one air stone was added in each fish tank. The water from the fish tank was irrigated to the tomato bed by a 12 watt submersible pump.

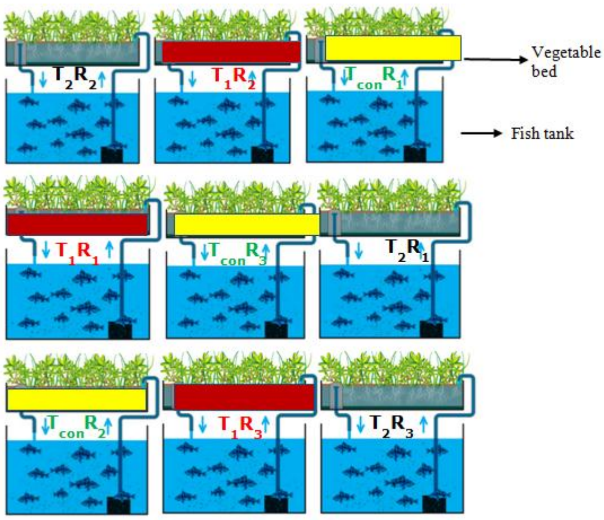


Figure 1. Experimental layout of aquaponic systems.

2.3. Stocking and rearing the fish

Monosex tilapia fingerlings were bought from the local renowned hatchery. After acclimatization they were stocked in the tank at the density of 10 fingerlings/90 liter tank. A 12 watt submersible water pump was added in each tank to lift up waste water from fish tank to vegetable bed from 9:00 am to 5:00 pm. One aerator along with one air stone was set in each tank to facilitate dissolve oxygen to prevent oxygen deficiency in the tank water. The fish was fed with commercial floating feed containing 30% protein twice (10.00 am and 4:00 pm) daily at the rate of 3% body weight.

2.4. Bed preparation for tomato cultivation

Locally available, cheap, good quality plastic container was used as tomato culture bed. Nine plastic container were bought from local market. The size of each container was 0.29m×0.30m×0.21m. Those were cleaned with detergent, rinsed with clean water for 3 to 4 times and sun dried before use. Those were cut longitudinally 0.5 inch below from the upper surface with a sharp knife to make it a bed. One pore was made above 0.5 inch from the bottom of each container to connect outlet pipe with m-seal to facilitate clean water from the tomato bed to the fish tank after filtering. A PVC plastic pipe (length 0.27 m and diameter 0.12 m) was used as siphon in each bed by making pores in it. Plastic containers were set on wooden structure.

2.5. Fish and vegetable sampling

Fish and vegetable were sampled fortnightly. The number of bunches, flowers and fruits were counted and plant height was measured fortnightly during the study period. The ripe tomato was weighed and recorded during harvesting. During each sampling, all fishes were caught from each replication with scoop net and individual length-weight was measured with an electronic compact balance (EK-600i) and wooden fish length measuring scale.

2.6. Fish and vegetable harvesting

After 90 days all the fish were harvested and their growth Performance was measured such as length gain (cm), weight gain (g), percent weight gain, food conversion ratio (FCR), survival rate (%) and fish production (kg/m^2). Ripen tomato was harvested and weighed up to the experiment completion. After final harvesting roots were picked up from the beds and washed carefully with tap water. Both the roots and plants were weighed by using electric balance.

2.7. Physico chemical parameter of fish tank water measurement

Physico chemical parameters of tank water were measured to know the suitability of fish culture. Temperature and pH were measured every 7 days interval. Electric conductivity (EC), Carbonate (CO_3), Hydrogen carbonate (HCO_3), Potassium (K), Total nitrogen (N), Sulphur (S) and Sodium (Na) were measured three times interval during experiments. The tests were done in the Humboldt Soil Testing Laboratory, Soil Science department, Bangladesh Agricultural University.

2.8. Data processing and analysis

The collected data were entered in MS Excel 2010 and significant differences between treatments were tested employing ANOVA (one-way analysis of variance) using statistical software SPSS-20 and Duncan's New Multiple Range Test (DMRT).

3. Results and Discussion

3.1. Plant growth performance

The highest mean leaf number, flower number and bunch number of tomato plant were found 48.5±12.5, 19.00±3.60, 5.33±0.57 in $T_{1.}$ Whereas the lowest mean leaf number, flower number and bunch number were 34.5±1, 0.76±0.5 and 5±5 recorded in T_{con}. The highest mean leaf area was 21.61±2.6 cm^2 in T_1 followed by T_2 (15.83 ±2.69 cm^2) and T_{con} (14.79±0.32 cm^2) (Figure 2). These might be due to the presence of aspirin (a derivative of SA) in the treatments that function as an endogenous regulator of flowering (Cleland and Ajami, 1974). According to Singh and Kaur (1981), foliar application of SA (100 ppm) on baby corn increased the plant height, leaf area, crop growth rate and total dry matter production that conform to the present findings. Plant heights were measured fortnightly. The highest mean height of the plant was 286.0±64.00 cm in T_1 at the end of experiment which was higher than the findings of Cole *et al.* (2016). At the same time the plant height in T_2 was 231.75±36.75 cm whereas, the lowest mean height of the plant was 167.50±23.00 cm in T_{con}. There was significant difference in mean height of plant among the three treatments on different dates (Figure 3). Total plant weight, Root length and weight were calculated after harvesting on 18th May 2018. The highest mean weight of plant was 178.75±100.23 g in T_2 whereas 147.92±96.17 g was found in T_1 and 136.34±43.18 g in T_{con} (Table 1). The highest mean length and weight of root 42.50±5.13 cm and 94.47 ±134.49 g was obtained from T_1. In contrast, the length and weight of T_2 and T_{con} were 39.52±4.87 cm, 12.89±0.40 g and 29.83±8.04 cm, 11.29±4.57 g, respectively. There was no significant difference in mean length and weight among the treatments

(Table 1). The highest fruit numbers were counted 15.33±0.57 in T_1 and the lowest number were found in T_2. Though the fruit numbers were little bit higher in T_1 but the total fruits weight were significantly higher in T_2 than T_1 and T_{con}. All these ascertained the positive attributes of aspirin in the treatments although most suitable concentration of aspirin was ambiguous.

Table 1. Growth parameters of plant in different treatments at harvesting date.

Sampling date	Parameter	T_1 Mean (±SD)	T_2 Mean (±SD)	T_{con} Mean (±SD)	Level of significance
18/5/2018	Plant wt. (g)	147.92±96.17	178.75±100.23	136.34±43.18	NS
	Root length (cm)	42.50±5.1	39.52±4.8	29.83±8.04	NS
	Root wt. (g)	94.47±134.48	12.89±0.40	11.29±4.57	NS
	Fruits number	15.33±0.58^{a}	9.0±1.0^{b}	9.33±0.58^{b}	**
	Total fruits wt. (g)	46.35±6.8^{ab}	48.6±4.24^{a}	37.26±0.86^{c}	*

Note: Values are mean ±Standard deviation from triplicate group. T_1= Treatment 1 (60 ppm aspirin), T_2=Treatment 2 (120 ppm aspirin), T_{con}=Control (No aspirin). Values in a row having similar letters (s) or without letters do not differ significantly whereas values bearing the dissimilar letter (s) differ significantly as per DMRT (Duncan's New Multiple Range Test).
** Significant at P≤0.01; * significant at P≤ 0.05; NS non-significant at P> 0.05

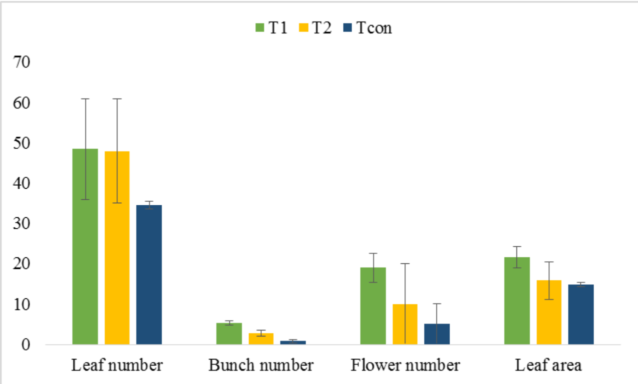


Figure 2. Mean leaf number, Bunch number, Flower number and leaf area (cm ±SD) of salicylic acid treated (T_1 and T_2) and non-treated (T_{con}) tomato plants during experimental period in aquaponic system. Vertical bar of each treatment represents standard deviation (±SD).

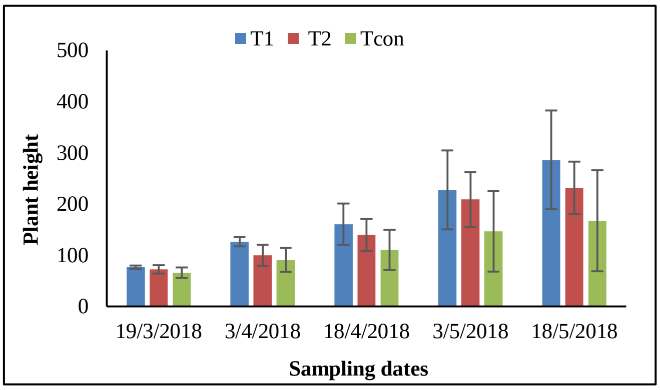


Figure 3. Height (cm ±SD) of salicylic acid treated (T_1 and T_2) and non-treated (T_{con}) tomato plants at different sampling dates in aquaponic system. Vertical bar of each treatment represents standard deviation (±SD).

3.2. Tomato production

The highest production was 0.44kg/m^2/90 days in T_2 where tomato plants were treated with 60ppm aspirin (Figure 4). In the other treatments, these were 0.42kg/m^2/90 days (T_1) and 0.34kg/m^2/90 days (T_{con}). According to USDA (2019), the proximate composition of tomato was estimated as moisture 94.52%, ash 0.53%, crude fiber 1.2%, crude protein 0.88%, crude fat 0.20% and carbohydrate 3.89%. Amount of protein and crude fiber content were higher but the carbohydrate content was lower than the aforementioned reference. Although, other nutrients' contents were nearly similar. The highest amount of lipid and fiber were found 0.87±0.01% and 3.20±0.1% in T_1. The highest moisture content was 94.35±1.0% in T_2 and the highest mean protein, ash and carbohydrate were 1.25± 0.01%, 0.567±0.001% and 1.09±0.001% in T_{con} (Table 2). Therefore, the use of aspirin increased the moisture content but decreased the nutritional value of experimental tomato.

Table 2. Proximate composition (% moisture basis) of tomato found at different treatments.

Treatment	Protein Mean ±SD	Lipid Mean ±SD	Ash Mean ±SD	Crude fiber Mean ±SD	NFE Mean ±SD	Moisture Mean ±SD
T_1	0.99±0.001^c	0.87±0.01^a	0.517±0.001^b	3.20±0.1^a	0.16±0.001^b	94.24±0.99
T_2	1.05±0 .01^b	0.84±0.01^b	0.511±0.001^c	2.94±0.01^b	0.308±0.001^a	94.35±1.0
T_{con}	1.25± 0.01^a	0.76±0.01^c	0.567±0.001^a	2.60±0.1^c	1.09±0.001^c	93.72±0.99
Level of significance	**	**	**	**	**	NS

Note: Values are given with (±Standard deviation). T_1= Treatment 1 (60 ppm aspirin), T_2=Treatment 2 (120 ppm aspirin), T_{con}=Control (No aspirin). Values in a column having similar letters (s) or without letters do not differ significantly whereas values bearing the dissimilar letter (s) differ significantly as per DMRT (Duncan's New Multiple Range Test).
** Significant at P≤ 0.01; * significant at P≤ 0.05; NS non-significant at P> 0.01

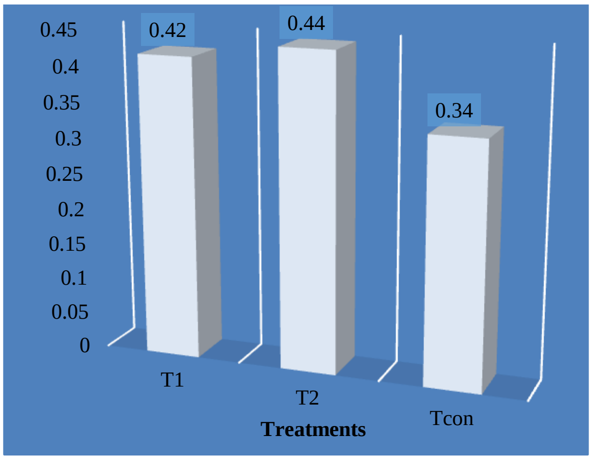


Figure 4. Total production of tomato (kg/m^2/60 days) from aspirin treated (T_1 and T_2) and non-treated (T_{con}) tomato plants after final harvesting. Vertical bar of each treatment represents standard deviation (±SD).

3.3. Plant health

Leaf miners, blossom-end rot, cracking diseases and cutworms were found in T_1, T_2 and T_{con}. In addition TMV (Tobacco Mosaic Virus) and bacterial spot diseases were also found in T_{con}. According to Fuentes *et al.* (2016) symptoms of leaf miners producing pest are shown in a specific way on the leaf surface. The damage is visualize as a tubular leaf puncture or a fan-shaped leaf puncture with irregular mines. Several leaf miners can be found even in the same leaf or plant. Blossom-end rot disease occur due to calcium deficiency. Tomato cracking diseases may occur due to excessive moisture, fluctuations in temperature, and an overabundance of nitrogen. According to Vlot *et al.* (2009) the plant hormone SA plays a major role in disease resistance signaling. Glazebrook (2005) reported that the SA response pathway is typically (but not exclusively) effective against microbial biotrophic pathogens. In previous experiment it is found that SAs ability to induce acquired resistance is not restricted to tobacco and TMV, but is effective in many plants against various necrotizing and systemic viral, fungal, and bacterial pathogens. However, it should be noted that not all plant-pathogen systems respond to SA (Pennazio *et al*., 1985; Roggero and Pennazio, 1988). SA also induces various PR proteins in a broad range of both dicotyledonous and monocotyledonous plants including tomato (White *et al*., 1987), potato (White *et al*., 1983), bean (Hooft *et al*., 1986). Losanka *et al*. (1997) reported that salicylic acid (SA) influence on different physiological processes. It has role on plant growth and development, flowering, ion uptake, stomatal regulation and photosynthesis. SA also act as a natural inducer of thermogenesis and disease resistance in plants.

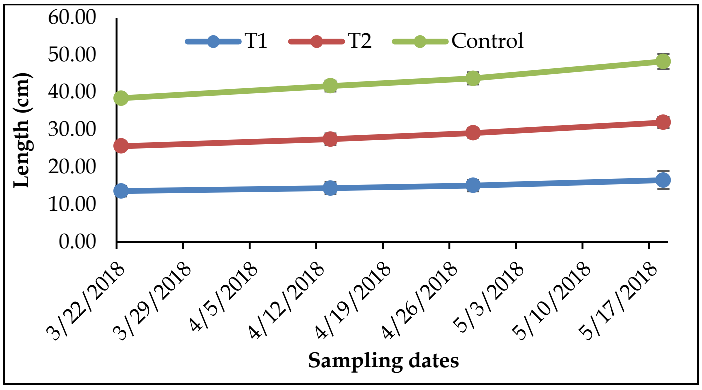
3.4. Fish growth performance

Tilapia was reared for 90 days from 19th March to 18th May. The initial mean length of the fish were 13.62±0.05, 12.03± 0.20 and 12.8±1.46 cm which were increased to 16.56 ±0.001, and 15.51±.36 and 15.93±1.08cm in T_1, T_2 and T_{con} respectively and the mean initial weight were 53.16±2.05, 34.34±2.69 and 41.05±1.46g that increased to83.27±1.24, 65.35±5.0 and 76.56±3.27g in T_1, T_2 and T_{con} respectively. After a certain stage, tilapia length gain was slower compared to the weight increment (Figure 5). There was no significant difference among fish length and weight in different sampling dates. That might be due to small experimental unit. The length and weight gain, percent length gain, percent weight gain and Specific growth rate (%/day) were lower but the survival rates were higher than the previous observation (Zahan *et al*., 2018). The FCR for tilapia in the present experiment was bit higher 3.05, 3.38 and 3.19 in T_1, T_2 and T_{con} respectively than the findings of Rahmatullah *et al.* (2010) and Quagrainie *et al.* (2011) which were 2.69 and 3.1, respectively. The productions of tilapia were 0.42, 0.34 and 0.49 kg/m^2/90 days in T_1, T_2 and T_{con} respectively. There was no significant difference among the treatments (Table 3) although the productions were comparatively lower, which might be attributed to high stocking density. Notably, there was no impact of aspirin on fish growth. As before spraying aspirin to the tomato leaves water pumps were kept stopped, tomato beds were covered with polythene bags so that the aspirin solution could not mix to the water of fish tank.

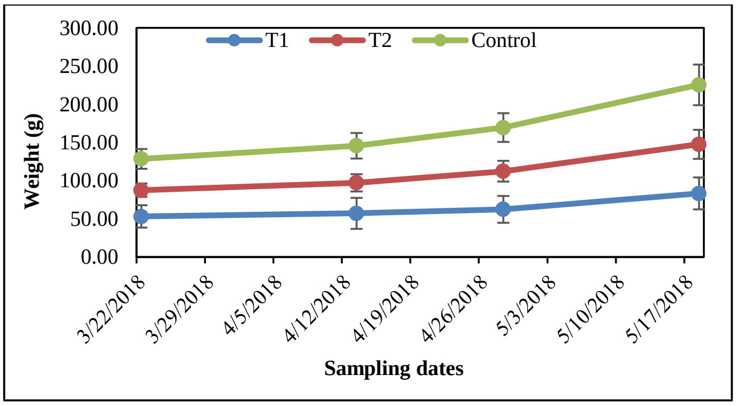
Table 3. Growth performances of tilapia observed in different treatments during the study period.

Parameters	T_1	T_2	T_{con}	Level of significance
Mean Initial Length (cm)	13.62±.05	12.03± 0.20	12.8± 1.46	NS
Mean Final Length (cm)	16.56±0.001	15.51±.36	15.93± 1.08	NS
Mean Length Gain (cm)	2.94±0.05	3.48±0.56	3.12±1.18	NS
Percent Length Gain (%)	21.56±0.45	28.98±5.112	25.18±12.22	NS
Mean Initial Weight (g)	53.16±2.05^a	34.34±2.69^b	41.05±1.46^{ab}	*
Mean Final Weight (g)	83.27±1.24^a	65.35±5.00^b	76.56±3.27^a	**
Mean Weight Gain (g)	30.11±0.88	31.02±7.69	35.50±9.88	NS
Percent Weight Gain (%)	56.74±3.73	91.89±29.61	95.85±53.65	NS
Specific growth rate (%)	0.749±0.04	1.0729±0.26	1.08±0.44	NS
Survival Rate (%)	70%	85%	50%	-
Feed Conversion Ratio	3.05	3.38	3.19	-
Production (kg/m^2/60 days)	0.42	0.34	0.49	-

Note: Values are given with ±Standard deviation. T1= Treatment T1 (60 ppm aspirin), T2=Treatment T2 (120 ppm aspirin), Tcon=Control (No aspirin). Values in a row having similar letters (s) or without letters do not differ significantly whereas values bearing the dissimilar letter (s) differ significantly (P<0.05) as per DMRT.
** Significant at P≤ 0.01; * significant at P≤ 0.05; NS non-significant at P> 0.01



A. Length gain of tilapia.



B. Weight gain of tilapia.

Figure 5. Growth pattern of fish in terms of length (A) and weight (B) gain during culture period.

3.5. Water quality parameters

The water quality parameters of the fish tanks were within the suitable range for aquaculture. As observed, the mean temperatures and pH values in fish tank water were (26.1±0.75)ºC and 6.92±0.13;(26.5±0.83)ºC and 7±0.18; and (25.9±0.75)ºC and 7.1±0.01 in T_1, T_2 and T_{con} respectively that was suitable for tilapia and tomato. In aquaponic system optimum temperature and pH for tilapia ranges from 28-32ºC and 6.0-8.5 respectively and for nitrifying bacteria ranges from 25-30ºC and 7.0-8.0, respectively (Tyson and Simonne, 2014).The reported mean dissolved oxygen content (DO) of the tank water over the study period were7.97±0.7, 7.91±0.91 and 7.92±0.7 in T_1, T_2 and T_{con} respectively (Figure 6). Highest electric conductivity (EC), hydrogen carbonate (HCO_3) and total Nitrogen (N) were counted at 1388.5 ±26.27µs/cm, 292.8±45.78 and 11.45±1.76mg/l, respectively in T_1 and the highest phosphorus (P), Sulphur (S) and Sodium (Na) were found at 11.22 ±1.32, 7.68±0.52 and 163.88 ±8.6mg/l, respectively in T_2 at the end of the experiment (Table 4). The highest Carbonate (CO_3) value was 24.0±13.86mg/l in T_1 at the middle of the study which was totally absent in the source water. The highest potassium (K) value was 13.12±2.33mg/l in T_{con} at the end of the experiment (Table 4). There was no impact of aspirin on water quality parameter also.

Table 4. The water quality parameters of lab test results in different treatments during the experimental period.

Parameter	Initial data	T_1		T_2		T_{con}	
		17/4/18	18/5/18	17/4/18	18/5/18	17/4/18	18/5/18
EC (µs/cm)	747	999.0±8.08	1388.5 ±26.27	990.0 ±8.37	1352.0±72.75	972.5±9.53	1331.0 ±36.95
CO_3^-(mg/l)	0	24.0±13.86	0.00±0.00^{b}	33.0±5.19	0.00±0.0^{b}	30.0±3.46	9.00±3.0^{a}
HCO_3^-(mg/l)	286.7	207.40 ±14.09	292.8±45.78	231.80 ±10.56	265.35 ±8.80	209.60 ±0.00	240.95 ±12.33
Total N(mg/l)	2.8	2.1±0.40	11.45±1.76^{a}	0.7±0.40	6.3 ±0.40^{b}	2.1±0.40	6.3±0.40^{b}
P(mg/l)	0.294	3.89±0.49^{b}	10.98±0.18	4.87 ±0.26^{a}	11.22 ±1.32	4.18 ±0.28^{ab}	9.05±0.31
K(mg/l)	1.21	1.31±0.05	5.55±0.40	2.21±0.46	12.51 ±3.85	3.62±0.23	13.12±2.33
S(mg/l)	3.47	5.77±0.60	6.82±0.15	5.74±0.36	7.68±0.52	5.21±0.22	6.56±0.13
Na(mg/l)	109.25	94.35 ±2.87^{a}	99.32 ±11.47^{b}	114.21 ±2.87^{b}	163.88 ±8.6^{a}	114.21 ±2.87^{b}	124.15±14.34^{ab}

Note: Values are given with (±Standard error). T_1= Treatment 1 (60 ppm aspirin), T_2=Treatment 2 (120 ppm aspirin), T_{con}=Control (No aspirin). Values in a column having similar letters (s) or without letters do not differ significantly whereas values bearing the dissimilar letter (s) differ significantly (P<0.05) as per DMRT.

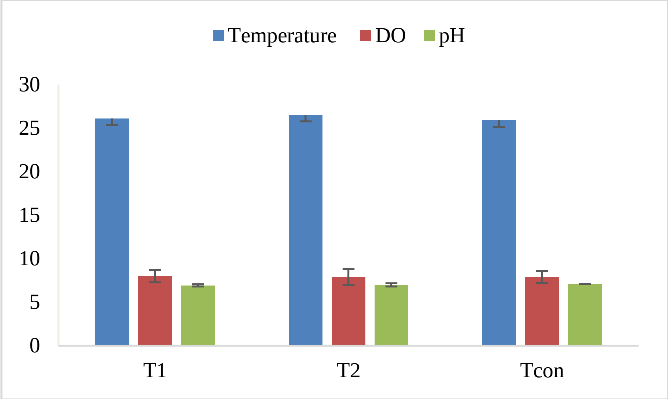


Figure 6. Mean values of temperature, DO and pH in different treatments during the study period. Vertical bar of each treatment represents standard deviation (±SD).

4. Conclusions

The present study was conducted with a view to find out a feasible way of producing organic vegetable (tomato) using foliar spray of aspirin from aquaponic system. Firstly it was observed that plant growth and tomato production were higher in T_2 (120 ppm aspirin) than T_1 (60 ppm aspirin) and T_{con} (Control). Secondly, higher aspirin level (120 ppm) in foliar spray reduced the prevalence of disease in tomato plants. This indicates that aspirin has positive impact on tomato production in aquaponic system. Therefore, further research is needed to verify and optimize the aspirin doses at the user level to get representative results.

Conflict of interest

None to declare.

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