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Effect of Organic Fertilizer and Irrigation Intervals on the Yield and Quality of Cherry Tomato (*Solanum lycopersicon* var. *cerasiforme*)

Md. Farid Hossain
School of Agriculture and Rural Development, Bangladesh Open University, Gazipur-1705, Bangladesh

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Abstract
To investigate the effects of organic fertilizers and irrigation frequencies on yield and quality of cherry tomato an experiment was conducted using six fertilizer doses including control (no fertilizer), NPK fertilizer (urea at 300 kg, TSP 200 kg and MoP 250 kg), cow-dung at 5 t ha^{-1}, cow-dung at 10 t ha^{-1}, poultry manure at 5 t ha^{-1} and poultry manure at 10 t ha^{-1} with two levels of irrigation frequencies including alternate day irrigation and two day interval irrigation in a split plot design with three replications. Data on yield and quality attributes of cherry tomato like plant height, number of fruits per plant, fruit yield per plant (g), yield (t ha^{-1}), TSS (%) and vitamin C contents (mg 100 g^{-1}) were recorded. Results revealed that poultry manure had significant effects on the yield and quality of cherry tomato. Among the fertilizer treatments, poultry manure at 5 t ha^{-1} showed the best results on yield and quality of cherry tomato. On the other hand, cherry tomato showed best performance in relation to yield and quality when field was irrigated in one-day interval. It can be concluded that application of poultry litter at 5 t ha^{-1} in combination with one day interval result in highest yield and quality on cherry tomato.

Keywords: Fertilizer, irrigation, yield, vitamin C, TSS (%), cherry tomato.

Introduction

Tomato (*Solanum Lycopersicon* L.) is one of the most economically important vegetable crops in the world (Lahoz et al., 2016) and cultivated in almost all home gardens and also in the field for its adaptability to wide range of soils and climates (Islam et al., 2016). It is one of the popular vegetables consumed by most people, which is enriched in nutrients and taste (Sainju et al., 2003). Fruits of tomato contain about 94% water, 2.5% total sugars, 2% total fiber, 1% proteins, and other nutritional compounds like acids, lipids, amino acids, and carotenoids (Koh et al., 2012). This nutritious and delicious vegetable is used in salad, soups and processed into stable products like ketchup, sauce, pickles paste, chutney and juice (Islam et al., 2016). The tomato fruit is a reservoir of potentially healthy molecules, such as ascorbic acid, vitamin E and phenolic compounds, particularly flavonoids (Beecher 1998; Raffo et al.,

* Corresponding Author, Email: faridhossain04@yahoo.com

2002) and regular consumption of tomatoes has been associated with decreased risk of chronic degenerative diseases due to the presence of different antioxidant molecules such as carotenoids (particularly lycopene), ascorbic acid, vitamin E and phenolic compounds (particularly flavonoids) (Frusciante et al., 2007). Tomato flavonoids, due to their high antioxidant power and significant biological activities, can have a substantial role for the health of human (Bourne and Rice-Evans, 1998; Bhowmik et al., 2012). Cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunal) A. Gray] is a newly cultivated variety of tomato in many parts of the world. It has become more popular all over the world because of a good source of vitamins A and C, solids content, good taste and fruit set even at high temperature (Prema et al., 2011). Agronomic practices have been recognized as a critical factor in determining the nutritional quality of crops (Barrett et al., 2007; Souri and Dehnavard, 2018). Tomato variety and maturity of fruits at harvest are the main factors affecting nutritional value of tomatoes (Erba et al., 2013). The proper supply of nutrients in balance amount is very essential for maximum production of tomato (Khan et al., 2017). Nutrient management plays an important role in yield and quality of tomatoes (Murmu et al., 2012; Souri and Dehnavard, 2017). Adequate supply of nutrient and water will result in better resource utilization and to avoid stress situations (Souri and Hatamian, 2019) and control production (Raviv and Blom, 2001). In recent years, organic fertilization has attracted much attention due to healthier effect on food's quality (Naiji and Souri, 2018). Organic fertilizers increase the microbial activity, anion and cation exchange capacity, organic matter and carbon-content of soil. Poultry manure and cow dung are good sources of organic matter and play a vital role in soil fertility improvement as well as supplying primary, secondary and micronutrients for crop production (Zamil et al., 2015). The amount and type of nutrients supplied to tomato can influence not only its yield but also its nutrient content, taste and post-harvest storage quality (Sainju et al., 2003). Tomatoes require large amounts of water to grow well and are adversely affected by drought stress. Few studies have evaluated the physicochemical characteristics of commercial tomatoes grown under water stress conditions (Klunklin and Savage, 2017). Therefore, the aim of this research work was to investigate the yield and quality of cherry tomato under different organic fertilizer and irrigation intervals.

Materials and Methods

To study the effects of organic fertilizers and irrigation frequency on yield and qualities of cherry tomato, a field experiment was conducted at Agricultural Field Research Center of Bangladesh Open University, Gazipur, Bangladesh during winter season of 2018-19. Twelve treatment combinations comprising 6 fertilizer doses including control (no fertilizer), NPK fertilizer (urea at 300 kg, TSP 200 kg and MoP 250 kg), cow-dung at 5 t ha^{-1}, cow-dung at 10 t ha^{-1}, poultry litter at 5 t ha^{-1} and poultry litter at 10 t ha^{-1} with 2 levels of irrigation frequencies including alternate day irrigation and two day interval irrigation were investigated in a split plot design with three replications. Fertilizer was assigned in the main plot and irrigation in the subplot. In this experiment, cherry tomato cv. Houngli was used as the test crop. Primarily, seeds were collected from China in 2017 and multiplied subsequent year at Bangladesh Open University agricultural research farm. The land was ploughed with power tiller for four times and leveled by ladder. The weeds and stubbles were cleaned properly. The final land preparation was done on 10 December 2018. The unit plot size was 3m x 2m. Each plot received only the treatments doses of fertilizers. As per NPK fertilizer treatment (T_2) specific plots were fertilized at 300 kg of urea, 200 kg of TSP and 250 kg of MoP per hectare. All organic fertilizers, one third of N fertilizer and PK fertilizer with urea, TSP and MP were respectively applied at the final land preparation. Remaining nitrogen fertilizer was applied in two equal splits at 20 and 40 days after transplanting. Cultural practices were done when necessary. Healthy and uniform sized 30 day-old seedlings were taken separately from the seedbed and were transplanted on 10 December, 2018 in the experimental field maintaining spacing of 50 cm and 50 cm between the rows and plants, respectively. The treatments were applied per raised bed. In each plot, 20 plants were grown. The treatments on fertilizer management were applied prior to transplanting. On the other hand, scheduled irrigation was done using a watering dipper following the irrigation schedule treatments. One dipper, approximately 1 L of water, per plant was applied. The tomato seedlings were irrigated uniformly prior to treatments to ensure good stand establishment after which the different irrigation intervals were applied. Stalking was done by bamboo stick, both the sides of plants like as ‘A’ shape to overcome plants fall down on ground due to weak stem. Stacking facilitate management operations such as irrigation; inter tillage, pest control and harvesting. Ten plants from each plot were selected for data collection of data for plant height, fruits per plant, fruit yield per plant (g) and yield (t ha^{-1}). The plant height was measured from the soil level to the tip of the shoot and expressed in cm. Tomato fruit was harvested sequentially from the first week to the last week of March, 2019. Fruit yield was recorded on the whole plot basis. Plant height, yield data were measured at School of Agriculture and Rural Development laboratory of Bangladesh Open University. All biochemical parameters associated with this study (TSS%, pH, Vitamin C content) were analyzed at the Postharvest Technology Laboratory of Bangladesh Agricultural Research Institute (BARI) following standard procedure. Ripen fruit sample (200 g) of each treatment was sent to the relevant laboratory after harvesting for quality test. The recorded data were statistically analyzed by using ‘CropStat’ software (IRRI, 2007) to examine the significant variation of the results due to treatments. The treatment means were compared by Least Significance Difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

Results

The plant height (cm), fruits number per plant, yield (t ha^{-1}), TSS% and vitamin C content (mg 100 g^{-1}) of studied tomato variety were significantly influenced by organic fertilizers, irrigation intervals as well as their interaction. However, pH value of tomato fruits did not show significant variation by the application of organic fertilizers, irrigation frequencies and their interaction. The results are presented in Table 1-3.

Effect of fertilizers

Results showed significant differences for the plant height of cherry tomato due to fertilizer treatments irrespective of irrigation intervals. The plant height increased slowly up to 30 days after transplanting (DAT), increased rapidly up to 75 DAT and then remained almost constant. All the treatments followed the almost similar trends due to the application of different fertilizers. The plant height ranged from 119.40 to 179.38 cm at 90 DAT under different fertilizer treatments. The highest plant height (179.38 cm) was found in poultry litter at 10 t ha^{-1} and lowest plant height (119.40 cm) was observed in control treatment (no fertilizer). The number of fruits per plant was significantly influenced by the application of different levels of fertilizer and gradually increased up to 75 DAT. The highest number of fruit per plant (146.83) was recorded in poultry litter at 5 t ha^{-1} and the lowest number of fruits per plant (59.33) was observed under control treatment. The highest fruit yield per plant (846.33g) was recorded in poultry litter at 5 t ha^{-1} treatment and the lowest yield per plant (398.83g) was observed in control treatment. Addition of organic fertilizers significantly affected the TSS% and vitamin C content. Among the treatments maximum amount of TSS% (6.60) and vitamin C content (15.27 mg 100 g^{-1}) were recorded when poultry litter was applied at 5 t ha^{-1}. Minimum vitamin C content (12.77 mg 100 g^{-1}) was found in control plot (Table 1).

Effect of irrigation intervals

The significant variation was observed in plant height, fruit number per plant, yield per plant (g), yield (t ha^{-1}) and vitamin C content due to irrigation frequency. TSS% and pH values of tomato fruits did not differ significantly due to irrigation intervals (Table 2). Maximum plant height (165.26 cm) was observed under one day interval irrigation. The results revealed that the average number of fruit per plant for 1-day irrigation frequency was higher (97.11) than that of 2 day interval (93.94). Highest fruits yield per plant (678.61g), yield (27.14 t ha^{-1}) and vitamin C (14.33 mg 100 g^{-1}) was recorded under one day's interval irrigation irrespective of fertilizer treatments.

Table 1. Effect of organic fertilizers on the yield and quality of cherry tomato (cv. Houngli)

Fertilizers	Plant height (cm)	Fruit $plant^{-1}$	Yield $plant^{-1}$ (g)	Yield (t ha^{-1})	TSS (%)	pH	Vitamin C (mg 100 g^{-1})
F_1	119.40d	59.33e	398.83f	15.95f	5.18d	4.41a	12.77e
F_2	175.65b	81.83d	649.83e	25.99e	4.97e	4.41a	13.41d
F_3	164.17c	98.83b	743.50b	29.74b	6.20b	4.51a	13.97c
F_4	166.80c	87.17c	699.83d	27.99d	6.05bc	4.40a	14.44b
F_5	173.90b	146.83a	846.33a	33.85a	6.60a	4.48a	15.27a
F_6	179.38a	99.17b	708.00c	28.32c	5.93c	4.52a	15.14a

Mean values in the same column followed by different letters are significantly different in least significant difference (LSD) tests at $P<0.05$ level. [F_1- Control (no fertilizer), F_2- NPK fertilizer (urea at 300 kg, TSP 200 kg and MP 250 kg), F_3- cow-dung at 5 t ha^{-1}, F_4-cow-dung at 10 t ha^{-1}, F_5- poultry litter at 5 t ha^{-1} and F_6- poultry litter at 10 t ha^{-1}].

Table 2. Effect of irrigation intervals on the yield and quality of cherry tomato (cv. Houngli)

Irrigation	Plant height (cm)	Fruit $plant^{-1}$	Yield $plant^{-1}$ (g)	Yield (tha^{-1})	TSS (%)	pH	Vitamin C (mg 100 g^{-1})
I_1	165.26a	97.11a	678.61a	27.14a	5.78a	4.43a	14.33a
I_2	161.17b	93.94b	670.16b	26.80b	5.86a	4.48a	13.99b

Mean values in the same column followed by different letters are significantly different in least significant difference (LSD) tests at $P<0.05$ level. [I_1- Alternate day irrigation and I_2-two day's interval irrigation].

Interaction effect of fertilizer and irrigation interval

Highest plant height (181.77 cm) was obtained under interaction effect when plots were fertilized by poultry manure at 5 t ha^{-1} with one day irrigation interval (F_6I_1). The highest number of fruits per plant (148.66) was produced in poultry manure at 5 t ha^{-1} with one day interval irrigation treatment (F_5I_1) and it was statistically similar to F_5I_2. Whereas the lowest number of fruits (57.66) was found in control (No fertilizer) treatment with two day interval irrigation (F_1I_2) and it was statistically similar to F_1I_1. The highest fruit yield per plant (851.00g) was recorded in F_5I_1 treatment and the lowest yield per plant (395.00g) was observed in F_1I_2 treatment. The best performance of cherry tomato in terms of yield (34.04 t ha^{-1}) was observed when poultry manure was applied at 5 t ha^{-1} with one day interval irrigation (F_5I_1). Maximum TSS% (6.66) was recorded where poultry litter was applied at5 t ha^{-1} with two day irrigation interval (F_5I_2) that was statistically similar to F_5I_1 treatment. Among the treatments maximum amount of vitamin C content (15.49 mg 100 g^{-1}) was recorded where poultry litter was applied at 5 t ha^{-1} with one day interval irrigation treatment (F_5I_1) and it was statistically similar to F_5I_2, F_6I_1, F_6I_1 treatments. Minimum vitamin C content (12.73 mg 100 g^{-1}) was found in control plot with two days interval irrigation (F_1I_2) (Table 3).

Table 3. Interaction effect of fertilizers and irrigation on the yield and quality of cherry tomato (cv. Houngli)

Fertilizers X Irrigation	Plant height (cm)	Fruit plant^{-1}	Yield plant^{-1} (g)	Yield (tha^{-1})	TSS (%)	pH	Vitamin C (mg 100 g^{-1})
F_1 X I_1	120.17e	61.00d	402.66j	16.10i	5.13c	4.42a	12.80g
F_1X I_2	118.63e	57.66d	395.00k	15.80j	5.23c	4.41a	12.73f
F_2 x I_1	178.50ab	83.33c	655.33h	26.21g	5.03cd	4.38a	13.75d
F_2 x I_2	172.80c	80.33c	644.33i	25.77h	4.90d	4.45a	13.07e
F_3 x I_1	165.10d	101.00b	747.33c	29.89c	6.13b	4.49a	14.01d
F_3 x I_2	163.23d	96.66b	739.66d	29.58c	6.26b	4.53a	13.93b
F_4 x I_1	170.63c	88.00c	703.66f	28.14e	5.96b	4.39a	14.60b
F_4 X I_2	162.97d	86.33c	696.00g	27.84f	6.13b	4.42a	14.27c
F_5 x I_1	175.40b	148.66a	851.00a	34.04a	6.53a	4.45a	15.49a
F_5 x I_2	172.40c	145.00a	841.66b	33.66b	6.66a	4.52a	15.04a
F_6 x I_1	181.77a	100.66b	711.66e	28.46d	5.90b	4.49a	15.36a
F_6 x I_2	177.00b	97.66b	704.33	28.17e	5.96b	4.56a	14.91b

Mean values in the same column followed by different letters are significantly different in least significant difference (LSD) tests at $P<0.05$ level.[F_1- Control (no fertilizer), F_2- NPK fertilizer (urea at 300 kg, TSP 200 kg and MP 250 kg), F_3- cow-dung at 5 t ha^{-1}, F_4-cow-dung at 10 t ha^{-1}, F_5- poultry litter at 5 t ha^{-1} & F_6- poultry litter at 10 t ha^{-1}. I_1- Alternate day irrigation and I_2-two day's interval irrigation}.

Discussion

Effect of fertilizers

In the present study the tallest plants were found when poultry litter treatment was applied to cherry tomato plants, this might be due to the supply of more nutrient and nitrogen to the plants. These results are similar to those reported by Kalbani et al. *(*2016). Among the treatments, maximum tomato fruit yield was recorded under poultry manure when it was applied at 5 t ha^{-1}. This finding agreed with Akande and Adediran (2004) who reported that poultry manure at 5 t ha^{-1} significantly increased tomato yield due to more nutrient uptakes. The application of poultry manure is a good practice for the fruit yield of tomato. The reasons of obtaining comparatively higher flower clusters and fruits might be due to the contribution of poultry manure. No fertilizers treatment provided the lowest yield of tomato might be due to shortage of nutrients throughout the growing period. Maximum amount of TSS% and vitamin C content was recorded where poultry litter was applied at 5 t ha^{-1}. Minimum vitamin C content was found in control plot. Rajya et al. (2015) reported that increase in quality parameters might be due to increased availability of macro nutrients as well as micro nutrients especially nitrogen and potassium, as they play a vital role in enhancing the fruit vitamin C content of tomato and minimum might be due to lack of availability of sufficient nutrients. Poultry manure is the most influential organic manure due to the high content of nitrogen compared to the others (Kalbani et al., 2016). It has also been reported that poultry manure can increase soil pH (Ullah et al., 2008). The nutrients composition of tomato fruit is affected by the levels of manure application either organic or inorganic manure. Organic manure increases some of the nutrients component better than the inorganic fertilizers as reported byn Abolusoro et al. (2017).

Effect of irrigation intervals

The variation was small in fruit number per plant, yield per plant (g), yield (t ha^{-1}) and vitamin C content due to irrigation interval. The results revealed that the average number of fruit per plant for 1-day irrigation interval was higher than that of 2 day interval. Highest fruits yield per plant, yield (t ha^{-1}) and vitamin C content was recorded under one day interval irrigation treatment irrespective of fertilizer treatments. The 2 day irrigation interval saved irrigation water but one day interval irrigation performed better for the yield and quality of cherry tomato. Optimal irrigation scheduling is very important to save water, while efficient use of water by irrigation is becoming increasingly important. Ismail et al. (2007) reported that the dry weight is decreased by an increase in irrigation interval. They also found that the shoots and roots dry weight for 1-day irrigation frequency are higher than 3 and 5 days frequencies.

Interaction effect of fertilizer and irrigation intervals

The better performance of cherry tomato in terms of yield and quality was observed as a result of poultry manure application at 5 t ha^{-1} with one day interval irrigation (F_5I_1). This result agreed with Kalbani et al. (2016), who showed that poultry manure is good for the overall quality of the fruits. Superior physical fruit quality might be due to the effect of poultry manure applied with one day interval irrigation, which enhanced the nutrients availability and improved the plant capability of more nutrients uptake from the surrounding soil. Manure applications increased plant height, number of branches, root length, number and weight of fruits. Poultry manure decomposed more rapidly in the soil and released more available nitrogen and phosphorus than the others. Cow dung releases nutrient slowly as reported by Zamil et al. (2015). Poultry manure increased soil organic matter, nitrogen and phosphorus (Ewulo et al., 2008).

Conclusion

From the results obtained from present study, it can be concluded that fertilizer and irrigation intervals alone and in combination with together can influence the yield and quality contributing characters of cherry tomato. Poultry litter at 5 t ha^{-1} when applied at one day interval on cherry tomato gave the highest yield and quality.

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Conflict of interest

The authors declare no conflict of interest for this work.

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