



RESEARCH ARTICLE

Assessing the Phytotoxicity of Sugar Industry Effluents on Tomato (*Lycopersicon esculentum* Mill. Var. S-22): Morphological Alterations in Leaf Dimensions

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ABSTRACT

This study investigates the detrimental effects of sugar industry effluents on the growth and development of tomato plants (*Lycopersicon esculentum* Mill. Var. S-22), focusing specifically on lamina length and breadth. The experiment involved exposing plants to varying concentrations i.e. 20%, 40%, 60%, 80% and 100 % of sugar industry effluents. The results showed significant reductions in lamina length and breadth with increasing 80% and 100% per cent effluent concentrations. Compared to controls, plants treated with 100% effluent exhibited a 5.67 % decrease in lamina length and a 0.82 % decrease in lamina breadth. The findings suggest that sugar industry effluents induce phytotoxicity, leading to stunted growth and altered leaf morphology in tomato plants. These results have implications for agricultural practices near sugar industrial sites, highlighting the need for efficient wastewater management strategies to mitigate environmental pollution and ensure sustainable crop production.

Keywords: Sugar industry effluents, Phytotoxicity, *Lycopersicon esculentum*, Leaf morphology, Environmental pollution, Wastewater management.

INTRODUCTION

Tomato is one of the most popular and most consumable vegetable in the form of different ways such as salad with other leafy vegetables, in sandwiches, and stewed, fried and baked singly or with combination with other vegetables. It is also rich in nutrients and calories. It is good source of Fe and vitamin A, B, and C (Table-1). A 230 gm of tomato consumption can supply about 60 % of the recommended daily requirement of vitamin C in adults and 85% in children (USDA Agricultural handbook No. 7, 1963). The mineral composition of tomatoes is largely determined by the type and quantity of nutrients they absorb from their growth medium, whether it be soil, hydroponic solutions, or other artificial substrates. Essential nutrients such as Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), and various micronutrients play a crucial role in plant development, affecting fruit quality, yield, and nutritional value. The availability of these nutrients depends on soil properties, including pH, organic matter content, microbial activity, and moisture levels, as well as external inputs like fertilizers and soil amendments.

However, rapid industrialization has led to severe environmental pollution, significantly impacting both the hydrosphere (water bodies) and atmosphere. Industrial activities release a variety of pollutants, including heavy metals, chemical compounds, and toxic gases, which degrade air and water quality. This pollution not only affects ecosystems but also disrupts agricultural productivity.

One of the most pressing concerns is the discharge of untreated industrial and domestic wastewater into the environment. Wastewater often contains hazardous substances such as heavy metals (lead, mercury, cadmium), organic pollutants, and pathogenic microorganisms. When released into water bodies, these pollutants alter water chemistry, reduce oxygen levels, and harm aquatic life. Additionally, when contaminated water is used for irrigation, harmful substances accumulate in the soil, leading to nutrient imbalances and toxicity. This can degrade soil fertility, reduce microbial biodiversity, and negatively impact crop growth.

For tomatoes specifically, the uptake of contaminants from polluted soil and water can alter their mineral composition, leading to potential health risks for consumers. Heavy metals, for instance, can accumulate in plant tissues and pose serious health hazards when ingested. Moreover, excessive industrial pollutants can lead to soil acidification or salinization, further limiting nutrient availability and affecting overall plant health.

To mitigate these challenges, sustainable agricultural practices, proper wastewater treatment, and stringent environmental regulations are necessary. Strategies such as phytoremediation (using plants to clean up contaminants), biochar application (to improve soil quality), and controlled irrigation techniques can help reduce the impact of pollution on tomato cultivation and ensure food safety. The effect of various industrial effluents on seed germination, growth and yield of crop plants have captivated the attention of many workers (Ozoh and Oladimeji, 1984; Rahman *et al.* 2002; Street *et al.* 2007).

REVIEW OF LITERATURE

The disposal of industrial effluent is one of the world's most critical problems (Islam MR *et al.* 2020). Sugar mills, thermal power plants, paper mills, textile mills, distilleries, fertilizer units, electroplating plants, tannery industries, sago factories, oil refineries, pesticide and herbicide industry are the most prominent effluent generating industries. Heavy metal-containing industrial effluents constitute a significant threat to the ecology (Helal Uddin *et al.*, 2011).

Sugar mills release a considerable volume of wastewater because they use a large amount of water throughout the manufacturing process. Different chemicals utilized during processing were incorporated with the produced effluents (Sanjay KS *et al.* 2005). The discharge of effluent from sugar mills into surface water bodies with high TDS has a negative impact on aquatic life. During the sugar producing period in November-April, the irrigation water for most of the Rabi-crop had insufficient water near the sugar mill areas (ETPI-Environmental Technology Program for Industry, 2001).

Vegetables play significant role in our life as protective food and most beneficial for the health maintenance and disease prevention. Vegetables have valuable food ingredients that can be easily utilized to build up and repair the body (Bakhru. H.K *et al.* 1990). Tomato is one of the major vegetable crops of our country.

Tomatoes are high in health-promoting chemicals and can be easily incorporated into a balanced diet (Martí, R *et al.* 2016). Plant growing conditions determine tomato fruit quality and metabolite biosynthesis (Diouf, I. A *et al.* 2018). Tomato production is affected by several of problems, including water limitation, soil salinization, and other abiotic factors (Fahad, S. *et al.* 2017 Gharbi, E *et al.* 2017 & Zhou, R *et al.* 2019).

Table-1.
Vitamin and mineral content of tomato of 100 gm
edible portion (Nonneck, I.N. 1989)

Description	Green	Ripe
Ca (mg)	13	13
P (mg)	27	27
Fe (mg)	0.5	0.5
Na (mg)	3	3
K (mg)	244	244
Vitamin A(I.U.)	270	900
Thiamine (mg)	0.06	0.06
Riboflavin(mg)	0.04	0.04
Niacin (mg)	0.5	0.7
Ascorbic acid (mg)	20	23

MATERIAL AND METHOD

The field experiments on two varieties of *Lycopersicon esculentum* Var. S- 22 were carried out on “Rabi” (winter) season in the Botanical research field at Shibli National College, Azamgarh. The experiments were conducted in factorial randomized block design. The area was ploughed thoroughly to break up the soil's surface layer and maintain optimal soil aeration, which aids in root penetration, organic matter mixing, and nutrient distribution throughout the soil. For each treatment, 1 X 1 sq. m plots were created and moderately irrigated before sowing to preserve moisture and promote proper germination. Standard agricultural procedures were used to grow the crop of *Lycopersicon esculentum* Var. S- 22.

Seed Materials

The seeds of *Lycopersicon esculentum* Mill. Var. S- 22 was obtained from agricultural office, sidhari Azamgarh. The viability of the healthy seeds of uniform size was determined. Seeds were surface sterilized with a 0.1 percent mercuric chloride solution.

Collection of Sugar mill effluent

The effluent was collected from “The Kisan Sahkari Chini Mill. Ltd”. Sathiyaon, Azamgarh (UP). Sugar industry effluent contains some important nutrients along with several toxic substances. The elements present in the effluent of sugar industry are nitrogen, phosphorus, potassium, magnesium, iron, chromium, boron, zinc, etc. It also contains Sulphur in the form of sulphate and sulphite. Toxic element includes oil and grease, chloride, phosphate, phenol, cyanide, pesticides, borax, arsenic, barium, sodium, cadmium, copper, lead, chromium, mercury, nickel, silver, zinc, chloroform, reducing sugar, non-fermented sugar etc.

The chemical composition of the effluent obtained from chemical cell of sugar Mill, Sathiyaon, Azamgarh”.

Growth Analysis

The data collected in the study was analyzed using standard statistical procedures, such as ANOVA to determine CD (critical difference) for each character by (Panse and Sukhatme, 1967).

RESULTS AND DISCUSSION

Statistical comparison between the mean values of the length of lamina of *Lycopersicon esculentum* Mill. Var. S -22 and the population irrigated with different concentration of sugar industry effluent has been made and critical difference was calculated at 5 per cent level of probability. The data represented in (Table-2). It was observed that the length of lamina was affected with the irrigation of different concentration of sugar industry effluent. Twenty (T₁) per cent concentration of sugar industry effluent significantly increase in the length of the lamina by 9.98 per cent as compared to control. Irrigation with 40 per cent concentration of sugar industry effluent (T₂) increases the length of lamina by 32.30 per cent as compared to control. The length of lamina was increased in T₃ treatments by 38.09 per cent where plants were received 60 per cent concentration of sugar industry effluent. This is the maximum increase in the length of lamina. Treatments T₄ and T₅ where plant irrigated with 80 per cent & 100 per cent concentration of sugar industry effluent respectively showed adverse effect on the length of lamina. T₄ treatment decreases the length of lamina 3.38 per cent and T₅ treatment decrease 5.67 per cent as compared to control (Table-2).

Table-2

Statistical comparison between the mean values of the length of lamina in *Lycopersicon esculentum* Mill. Var. S-22 irrigated with different concentration of sugar industry effluent

Treat ments	Replicates					Mean	Total
	R1	R2	R3	R4	R5		
T0	5.51	5.65	5.63	5.80	5.70	5.66	28.29
T1	6.08	6.10	6.06	6.37	6.50	6.22	31.12
T2	7.52	7.53	7.38	7.50	7.50	7.49	37.43
T3	7.52	7.53	7.38	7.50	7.50	7.49	37.43
T4	5.51	5.60	5.49	5.35	5.39	5.47	27.34
T5	5.42	5.35	5.40	5.30	5.22	5.34	26.69
Total	37.56	37.76	37.36	37.80	37.82		

M.SS between treatment= 7.1625

M.SS between replicates= 0.0049

M.SS Error=0.01485

C.D. =0.147

Lycopersicon esculentum Mill. Var. S -22 when irrigated with 20 per cent concentration of sugar industry effluent, it showed a little increase of only 9.98 per cent as compared to control and this was significant, but when the concentration of sugar industry effluent increased by 20 per cent i.e. T₂ treatment it showed an increase in the length of lamina by 20.30 per cent as compared to T₁ treatment. Further addition of 20 per cent concentration of sugar industry effluent i.e. T₃ treatment showed no increase in the length of lamina by 4.370 per cent (Table-2). Further increase of 20 per cent concentration i.e. T₄ treatment showed the adverse effect on the length of lamina in *Lycopersicon esculentum* Mill. Var. S -22 and it was decrease significantly by 26.97 per cent as compared to T₃ treatment. Hundred percent concentration of sugar industry effluents found to be toxic for the length of lamina was decreases by 2.37% compare to the T₄ treatment (Table 2).

Statistical comparison between the mean values of the breadth of lamina of *Lycopersicon esculentum* Mill. Var. S -22 and the population irrigated with different concentration of sugar industry effluent has been made and critical difference was calculated at 5 per cent level of probability. The data represented in (Table-3). It has been observed that the breadth of lamina affected with the different concentration of sugar industry effluent. Twenty (T₁) per cent concentration of sugar industry effluent (T₁) was found to increase in the breadth of lamina of the crop by 0.48 per cent as compared to control. Although this increase was not significant when the crop irrigated with 40 per cent concentration of sugar industry effluent (T₂) increases the breadth of lamina by 4.33 per cent. While maximum increase in the breadth of lamina was noted in T₃ treatments i.e. 60 per cent of sugar industry effluent by 8.41 per cent as compared to control. Statistical analysis showed that this was significant. T₄ and T₅ treatments showed toxic effect to the plant in respect to the breadth of lamina. In the case T₄ treatment the breadth of lamina decreases by 0.63 per cent while in T₅ treatment it was decreases 0.82 per cent as compared to control although this decrease was not significant (Table-2).

Twenty per cent concentration of sugar industry effluent given to the crop of *Lycopersicon esculentum* Mill. Var. S -22, showed non-significant increase in the breadth of lamina by 0.48 per cent as compared to control. Further addition of 20 per cent concentration of sugar industry effluent (T₂ treatment) showed an increase in the breadth of lamina by 3.83 per cent as compared to T₁ treatment. When the T₂ treatment i.e. another addition of 20 per cent concentration of sugar industry effluent, i.e. T₃ treatment showed an increase in the breadth of lamina by 3.91 per cent as compared to T₂ treatment. In T₄ treatment, it means further

addition of 20 per cent concentration of sugar industry effluent showed decrease in the breadth of lamina by 8.35 per cent as compared to T₃ treatment. While in T₅ treatment, the plant showed decrease the breadth of lamina by 0.1836 per cent as compared to T₄ treatment (Table-3).

Table-3

Statistical comparison between the mean values of the breadth of lamina in *Lycopersicon esculentum* Mill. Var. S-22 irrigated with different concentration of sugar industry effluent

Treatments	Replicates					Mean	Total
	R1	R2	R3	R4	R5		
T0	3.36	3.33	3.62	3.58	3.63	3.50	17.54
T1	3.49	3.47	3.41	3.65	3.58	3.52	17.62
T2	3.55	3.52	3.73	3.72	3.77	3.66	18.30
T3	3.96	3.50	3.76	3.85	3.92	3.80	19.01
T4	3.41	3.63	3.32	3.36	3.69	3.48	17.42
T5	3.44	3.32	3.61	3.47	3.54	3.47	17.39
Total	21.23	20.80	21.48	21.65	22.16		

M.SS between treatment=0.08344

M.SS between replicates=0.043125

M.SS Error=0.01528

C.D. =0.1489

CONCLUSION

Tomato (*Lycopersicon esculentum* Mill.) is a member of Solanaceae that is the second most important fruit or vegetable crop after potato (*Solanum tuberosum*). It's grown both for fresh fruit and manufacturing products. Tomatoes are rich in vitamins and minerals, carotenoids, and phenolic compounds, all of these are beneficial to health. Tomatoes have become the model for the research of fleshy fruit growth, in addition to their economic and nutritional value. Tomatoes are climacteric fruits, meaning they go through substantial metabolic changes as they grow.

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