



Effect of industrial effluent (IE) on growth and yield of chilli (*Capsicum annum* L.) in semi-arid region

Mimansa Pandey¹, Jagannath Pathak^{1,*}, Amit Mishra⁴, Prashant Kumar¹, J.K. Tiwari¹, A.H. Kalhapure² and Monika Jain³

¹Department of Soil Science and Agricultural Chemistry, BUAT, Banda-210001, Uttar Pradesh, India

²Department of Agronomy, BUAT, Banda-210001, Uttar Pradesh, India

³Department of Natural resource Management, BUAT, Banda-210001, Uttar Pradesh, India

⁴School of NRM college of PGS, CAU-Imphal, Umam, Meghalaya, India

Corresponding author email: jagannathpathak@yahoo.in

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ABSTRACT

The research was carried out during the rabi season of 2024-2025 at Green shed net house, Banda University of Agriculture and Technology, Banda, to investigate the effect of industrial effluent on growth and yield of chilli (*Capsicum annum* L.) in semi-arid region. The experiment was laid out in Completely Randomized Design with seven treatments and four replications. Nursery was raised in plastic bags after three weeks it was transplanted into plastic pots containing 10kg soil. The growth and yield parameters were collected and data assessed. After study it was observed that the plants exhibited a considerable increase in growth and yield attributes such as plant height, leaf length, number of branches, number of flowers, number of fruits, fruit weight, fruit girth with lower concentrations of effluent. Quality attributes such as capsaicin content and dry matter also increased significantly after irrigation with lower concentrations of effluent. Thus, it may be resolved that wastewater serve as an alternate source of fresh water for irrigation and it may be used for the cultivation of chilli.

Keywords: Industrial effluent, Chilli (*Capsicum annum* L.), Crop growth, Wastewater, Concentration

INTRODUCTION

Water is characterized as a tasteless, colourless, and odourless chemical substance comprised two hydrogen & one oxygen. It serves as a basis for survival and development of all living's beings on earth. It serves has been used for various purposes such as irrigation, drinking, washing, fishing and industries by humans (Hassan *et al.*, 2022). About one-fourth of the world's population exists in water-scarce areas which will experience a 40% deficit amid forecast demand and the quantity of accessible water. Estimates disclose that world's population will range 9.2 billion by 2050 and global water use is probable to rise about 21% (Rosegrant *et al.*, 2009). Despite being a renewable resource, it considered non-renewable due to its fixed or constant quantity. The continued dependence on rainfed

agriculture or crop irrigation using conservative water sources such as rivers, streams, lakes, groundwater, springs and so on may not be sustainable, as in recent years, there have been progressively frequent and protracted droughts in some Mediterranean nations, along with substantial imbalances between the supply and demand of fresh water. Due to water scarcity in semi-urban parts of India, farmers are looking for simply available and less expensive water sources such as industrial and municipal waste-water (Mohanty and Das, 2023).

For some lack of sufficient amount of fresh water for human consumption & agriculture utilization, wastewater become an alternative source for crop irrigation (Ali *et al.*, 2019). It contains almost 99% water and 1% suspended, colloidal or dissolved particles (Ain *et al.*, 2019). About 70% population of

India depend on agriculture for their livelihood. Consumption of vegetables become a significant component of balanced diet. In addition, being inexpensive vegetables are good source of minerals, nutrient, fibres and folic acid (Aftab *et al.*, 2023).

Chilli (*Capsicum annum*) is referred as one of the most vital commercial vegetable and spices in the world. It belongs to Solanaceae family's genus capsicum. India is the major producer and consumer of chilli and contributes 36% of world chilli production followed by China which share 24% (Babu *et al.*, 2018). Major chilli growing states of India are as fallow- Andhra Pradesh (49%), Karnataka (15%), Maharashtra (6%) and Tamilnadu (3%), accounts 75% of total area under chilli cultivation in India (Jagtap *et al.*, 2012). According to the 3rd advance estimate, in the year 2021-2022 chilli production of India was 15.78 lakh tonnes (Department of Agriculture and Farmers Welfare). In the year 2019-2020, Uttar Pradesh contributes 43% (8.05 lakh tonnes) of country's total chilli production. It is an essential component of life and most people's meals are incomplete unless chilli is combined in them or provided on the side as a condiment (Akram *et al.*, 2021). It has a great nutritional value and its 100 grams of dried pods produced about 160 calories, contain, 18 grams of proteins, 36 grams of carbohydrates, 480 mg of calcium, 16 grams of fat and 640 I.U. of vitamin "A" and 40 mg of vitamin "C" (Okanume *et al.*, 2023). Being cultivated over a large area it is contributed as major crop in India that utilize huge amount of water. The study aimed (1) To assess the effects of industrial effluents on growth attributes of Chilli; (2) To estimate the effects of industrial effluents on yield and yield attributes of chilli; (3) To evaluate the effect of industrial effluent on quality attributes of chilli.

MATERIALS AND METHODS

The experimental Soil was collected from five different points within a field situated at agriculture research farm after required analysis. Collected soil mixed together and made a composite sample. Soil sample from the composite soil was analysed for different chemical parameters (Table 1). The untreated effluent for experimentation was collected after monsoon from the direct discharge point of the tannery industry, situated at industrial area of Jajmau, Kanpur (Uttar Pradesh), India. Pots were filled using soil mixture comprising of 10 kg per pot

Table 1. Chemical characteristics of experimental soil (pre-analysis)

S. No.	Parameters of soil	Values
1.	Soil pH	8.11
2.	Electrical conductivity	0.19 dSm ⁻¹
3.	Organic carbon	0.34%
4.	Available nitrogen	107.98 mg kg ⁻¹ soil
5.	Available phosphorus	9.54 mg kg ⁻¹ soil
6.	Exchangeable potassium	136.48 mg kg ⁻¹ soil
7.	Available sulphur	10.15 mg kg ⁻¹ soil

(9kg soil + 1 kg vermicompost) @ 3 to 4week-old seedling plants of chilli were transplanted in each pot. The plant was irrigated primarily over a week with fresh water until establishment.

Pot soil was analysed before and after harvesting for different parameters. The pH and electrical conductivity (EC) of soil was determined using a pH meter and conductivity meter respectively. The available N & P in soil was calculated by using alkaline KMnO₄ method proposed by (Subbiah and Asija, 1956) and sodium bicarbonate (NaHCO₃) extraction method proposed by Olsen *et al.* (1954). Exchangeable K was measured using flame photometer (Hanway, 1952). Available S content was determined spectro-photometrically using the 1.5% CaCl₂ extractant (Williams and Steinberg's, 1969). Through the growth period, the various growth parameters such as plant height, leaf length, number of branches and number of flowers were measured after 30 & 60 days of transplanting and at harvest. At harvest all yield (fruit girth, fruit weight, number of fruits, dry matter content) and quality parameter including (Capsaicin content) were measured carefully.

Statistical analysis

All experimental data were examined statistically through completely randomized design (CRD) as per method described by Cochran and Cox (1963) with four replication and seven treatments.

RESULTS AND DISCUSSION

Effluent characteristics

The physico-chemical characteristics of the industrial effluent which were used for the irrigation is presented in Table 2. The used industrial wastewater had brick red colour with slightly

Table 2. Physico-chemical characteristics of industrial effluent

S. No.	Parameters of wastewater	Values	Permissible limits
1.	Temperature	25°C	-
2.	Colour	Brick red colour	-
3.	Odour	Slightly pleasant	-
4.	Turbidity	85 NTU	10
5.	pH	11.58	6.5
6.	EC (dSm ⁻¹)	8.89	2
7.	Total suspended solids (mg L ⁻¹)	1230	100
8.	Total dissolved solids (mg L ⁻¹)	1580	1300
9.	Total solids (mg L ⁻¹)	2590	2,000
10.	Hardness (mg L ⁻¹)	1900.80	600
11.	BOD (mg/l)	750.0	20
12.	COD (mg L ⁻¹)	1697.4	250
13.	Nitrate (mg L ⁻¹)	78.02	45
14.	Phosphate (mg L ⁻¹)	20.23	0.3
15.	Potassium (mg L ⁻¹)	29.02	12
16.	Sulphate (mg L ⁻¹)	861.01	400

unpleasant odour, moderately to high turbidity, total soluble solids, rich in chemical oxygen demand (COD) and biological oxygen demand (BOD). It has. It has considerable amount of total N, P, K and S. The concentration of the total solids, BOD, COD, nitrate, phosphate, potassium, sulphate of studied industrial wastewater were higher than the permissible limits of Indian irrigation standard (BIS, 1991).

Growth attributes

The data relating to plant height presented in Table 3. Highest plant height was recorded at treatment T₇ (20% Industrial effluent + 80% Tap water) which was statistically higher than the T₁ and T₂. Whereas, lowest plant height was observed with 100% effluent application. The data relating to leaf

length per plant is presented in Table 3. Highest leaf length was recorded in T₇. Whereas, the lowest leaf length was recorded at T₂ followed by T₃ (80% Industrial effluent + 20 % Tap water) and T₄ (60% Industrial effluent + 40 Tap water).

The data pertaining to number of branches and number of flowers per plant is presented in Table 3. 100% effluent concentration significantly lower mean number of branches compared to T₇ and T₆ while 20% effluent concentration had a suggestively higher mean number of branches. Table 3. shows the effect of various concentration of industrial effluent on number of flowers. There was a significant reduction in number of flowers with increased concentration of effluent. Maximum and minimum number of flowers were recorded in T₇ and T₂ respectively.

Yield and Yield Attributes

Application of industrial effluent exhibited positive response for yield and all yield attributes. The mean number of fruits were decreased with increased concentration of effluent and data tabulated in Table 4. Maximum number of fruits were recorded in T₇ where plant was irrigated with 20% effluent while minimum number of flowers were recorded 100% effluent irrigation.

Data related with fruit girth and fruit weight presented in Table 4. Highest fruit girth and fruit weight were recorded in T₇ followed by T₆ while the lowest fruit girth and fruit weight were recorded in T₂ followed by T₃ and T₄. Yield was statistically increased at successive growth stages under the lower dose of industrials effluent application (Fig. 1). However, the higher application of textile effluent (T₂) had antagonistic effect on yield of chilli. Maximum and minimum yield was recorded in T₇ which is at par with T₆ and T₂ followed by T₃.

Table 3. Effect of different effluent concentrations on various growth attributes of *Capsicum annuum*

	Growth attributes			
	Plant height (cm)	Leaf length (cm)	No. of branches plant ⁻¹	No. of flowers plant ⁻¹
T ₁	44.08	5.08	12.25	13.75
T ₂	38.05	4.03	8.50	11.00
T ₃	38.35	4.43	8.75	11.50
T ₄	39.28	4.53	10.25	12.00
T ₅	40.87	4.93	11.75	12.75
T ₆	44.25	5.43	13.00	14.50
T ₇	47.63	5.85	14.25	16.25

Table 4. Effect of different effluent concentrations on the number of fruits, fruit girth, fruit weight and yield of *Capsicum annuum*

	No. of fruits plant ⁻¹	Fruit girth (cm)	Fruit weight (g fruit ⁻¹)	Yield (g plant ⁻¹)
T ₁	27.75	0.70	3.12	86.58
T ₂	25.75	0.60	3.10	79.82
T ₃	26.25	0.60	3.12	81.83
T ₄	26.75	0.63	3.14	83.94
T ₅	27.25	0.66	3.15	85.84
T ₆	28.50	0.70	3.16	89.99
T ₇	29.25	0.73	3.18	92.95

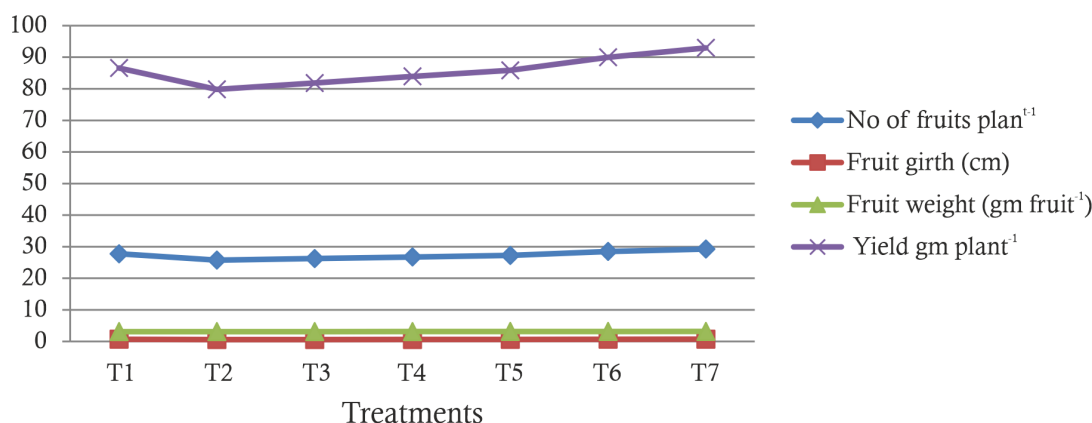


Fig. 1. Effect of industrial effluent on number of fruits, fruit girth, fruit weight and yield of *Capsicum annuum*.

Table 5. Effect of different effluent concentrations on the Capsaicin content and Dry matter *Capsicum annuum*

Treatment	Dry matter of fruits (gm/plant ⁻¹)	Capsaicin content (µg/g ⁻¹)
T ₁	43.54	562.75
T ₂	39.91	535.75
T ₃	41.42	536.75
T ₄	42.47	538.75
T ₅	43.42	563.00
T ₆	45.25	574.75
T ₇	47.01	590.00

Quality Attributes

Capsaicin content accelerated significantly at all industrial effluent concentrations (Table 5). Plant irrigated with by 20% Industrial effluent + 80% Tap water (T₇) exhibited maximum content of Capsaicin as compared to T₂ where plants irrigated with 100% Industrial effluent. Dry matter was affected positively by effluent irrigation of the present experiment (Fig. 2). Dry matter content observed maximum in T₇ order of the increase was T₇ > T₆ > T₁ > T₅ and the minimum dry matter was recorded in T₂ which was at par with T₃.

DISCUSSION

Industrial effluent has a vital role in producing large amounts of water pollution by characteristic toxicity of its discharge i.e., higher TDS, TSS, TS, Total hardness, COD and BOD. Though, considerable amount of mineral nutrients such as N, P, K and S is also present in the industrial effluent (Kaushik *et al.*, 2005; Singh *et al.*, 2015) making it a possible source of nutrient. Industrial effluent used in the present study was found to be rich in various nutrient required for the plant physiological activity (Yaseen *et al.*, 2017).

The present study showed positive effect of industrial effluent on plant height. Singh and Rathor (2018); Bhuiyan *et al.* (2016) also observed increase in plant height with lower concentration of industrial effluent, and a decrease in plant height with increase in the concentration of the effluent to be a result of accumulated toxic element which could hinder the uptake of essential nutrients, diminish root respiration, and suppress the growth of the plant. Leaf length and number of branches also increased in plants irrigated with lower concentration over

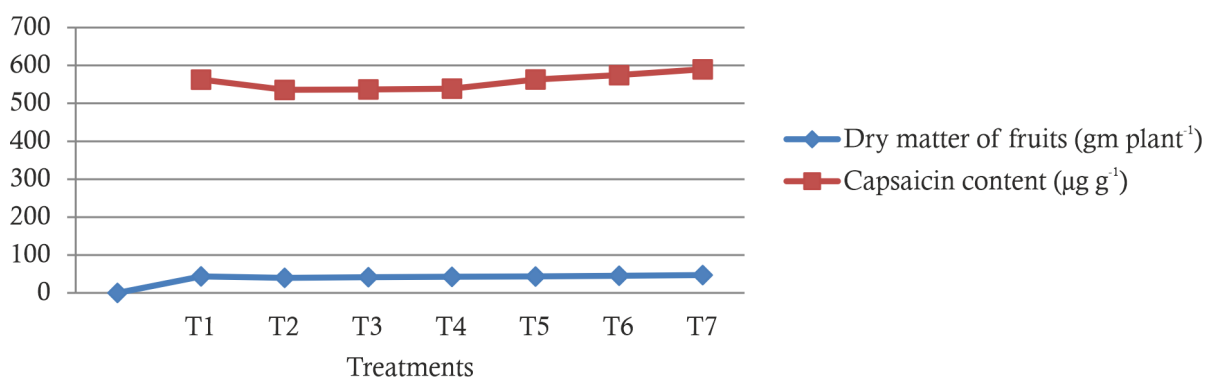


Fig. 2. Effect of different effluent concentrations on the Capsaicin content and Dry matter *Capsicum annuum*

100% T.W irrigated plants and provided more persistent results as compare to higher dose. Ogochukwu *et al.* (2023); Ajouri *et al.* (2004); Neelab *et al.* (2021) also demonstrated that the lower concentrations of industrial effluents enhance the leaf length and number of branches of chilli as compared to higher concentration, may be due to nutrient deficiency in soil or its unavailability that reduce the growth of plants. Neelab *et al.* (2021) reported significant increase in number of flowers after irrigation with 20% effluent concentration as compared to 100% effluent application. An increase in number of flowers may be due to a plant's capacity to absorb essential nutrients that are crucial to its growth and development.

The number of fruits were decreased with increased concentration of effluent have been reported by (Ogochukwu *et al.*, 2023) may be due to the existence of hazardous metals in industrial effluent might be responsible for this ongoing reduction in number of fruits. Akinyemi *et al.* (2015) supported the view that the increase in fruit girth and fruit weight at low of the effluent may be due to higher concentrations of effluent comprises destructive metals that can modify the metabolism of plants and other physiological functions. The yield of chilli reduced significantly by increased concentrations of chilli. The reduction in chilli with growing effluent concentrations had been stated by (Neelab *et al.*, 2021; Handa *et al.*, 2019; Chalkoo *et al.*, 2014). Quality attributes (capsaicin content and dry matter) showed similar trend as growth and yield attributes and increased with minimum irrigation with effluent may be expected due to the effluent can moderately replace fertilizers and sustaining pungency might be responsible for increasing capsaicin content among the various treatments (Iqbal *et al.*, 2017; Marofi *et al.*, 2013).

CONCLUSION

The research revealed that the industrial waste water can play a significant role in enhancing growth and yield when used in lower concentration. Industrial effluent frequently consists essential nutrients such as N, P, K and OC (Organic carbon) which improve soil nutrient status and indorse improved growth and leading to increase yield. Though, high concentration consists harmful or toxic pollutants, negatively affect different metabolic activities of plant by them the growth and

development caused the reduction of yield and also affect the soil health and food safety. Consequently, the application of lower concentration of industrial effluent with proper management provide the beneficial results.

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STATEMENT AND DECLARATION

Conflicts of Interest: The authors declare that there are no conflicts of interest to report regarding the present study.

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