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Impact of industrial effluent on morphological characteristics of maize fodder

S Islam[1], MO Rahman[1], MD Hossain[1], MM Rahman[2] and MZU Kamal[3]

[1]Department of Animal Science and Nutrition, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706, Bangladesh; [2]Department of Dairy and Poultry Science, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706, Bangladesh; [3]Department of Soil Science, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706, Bangladesh.

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Correspondence:
Professor Dr. Shilpi Islam ✉: shilpi@bsmrau.edu.bd

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ABSTRACT

Industrial effluent (IE) is a serious threat to human, plant and aquatic lives. This study was carried out to assess the impact of IE on morphological characteristics of maize fodder at different stages of growth. The pot experiment was laid out in a Completely Randomized Design using five treatments with eight replications at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur and IE was collected from the discharge points of the nearest garments located at BSMRAU. The treatments were $T_{1,}$ 100% FW (fresh water); $T_{2,}$ 75% FW + 25% IE; $T_{3,}$ 50% FW + 50% IE; $T_{4,}$ 25% FW + 75% IE; $T_{5,}$ 100% IE. The results indicated that IE decreased plant height and plant dry weight for all stages. Leaves number was reduced at the maturity stage in the IE treatments. No influence was observed on leaf length by IE. Higher concentrations of IE also influenced smaller leaf width at the vegetative stage. Root length was reduced for the application of IE at the maturity and vegetative stage. Root dry weight was higher for T_1 and T_3 at the flowering stage and T_3 at the maturity stage. Hence, it may be concluded that IE had negative effect on the morphological characteristics of maize fodder.

Introduction

Livestock is emerging as an important and integral component of the agricultural economy of Bangladesh. Recently 567.34 lakh number of ruminants are available in Bangladesh (DLS, 2021). Among livestock, cattle share the highest relative importance of milk (98.0%), meat (60.0%) and hides (60.0%) production in our country (Sarker *et al*., 2021). About 70.69% of the total cultivated land is used for agricultural land and only 0.02% for fodder production in Bangladesh (BBS, 2019). The total annual production of dry matter (DM) is 69576 x1000 tons including green grasses and non-conventional crop residues. The present total demand in DM, crude protein (CP) and metabolizable energy (ME) is 60.40 million tons, 6.00 million tons and 545633 million MJ, respectively. Though, the fodder production gets momentum but at present, the country faces a net deficit more than 40% dry matter, 65% crude protein and 60% metabolizable energy (Sarker *et al*., 2021). Farmer's faced problem of both quantity and quality of roughage that fluctuates on cropping seasons and regions hinders dairy and fattening cattle production in the country. Moreover, the recent growth rate of

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livestock is not matching with the requirement of feeds and fodder in the country. Hence, health status of most of the cattle is poor and the productivity is far to meet the demand. In order to minimize the fodder shortage, it is necessary to improve fodder production per unit of land.

Maize (*Zea mays*) is one of the most important crops having wider adaptability to varied agro-climatic conditions. It is a basic staple food grain for major parts of the world and it is the main food energy source in different developing countries. Maize is an excellent crop in terms of biomass production also. Maize straw along with fodder has been used as animal fodder for a long. The green maize fodder is considered the best among non-legume forage crops. Maize is ideal forage because it grows quickly, produces high yields, palatable, rich in nutrients, and helps in increasing growth, productivity and milk yield and quality in cattle (Sattar *et al*., 1994). Maize is the most suitable for ensiling (Irlbeck *et al*., 1993) also. Maize ensilage has many advantages over other methods for the preservation of nutrients, particularly from forages. Maize is a high energy feed, better than most other tropical forage crops, of which the DM is often below 40% digestible. In the tropics, while grass forages must be harvested almost monthly, maize forage matures within three months, is harvested only once, and does not require much labour and high machinery costs (Brewbaker, 2003). Adequate soil fertility is an important factor for the growth and development of maize.

On the other hand, industrial effluent is a serious threat to human, plant and aquatic lives (Hossain *et. al*., 2015). In Bangladesh, different industries have emerged in the last decade producing huge amounts of effluents, particularly the textile and composite industries (Saha, 2007). The Gazipur district is one of the major industrially developed areas of Bangladesh, where effluents are directly discharged to the environment without treatment which may cause the environmental and soil pollutions. The impact of land degradation that occurs is a decrease in the quality and quantity of agricultural products. Industrial effluent can cause damage to maize fodder which is being extensively used by farmers and livestock entrepreneurs in other region of the country. However, no research has not been found how industrial effluent affecting on morphological characteristics of maize fodder. Therefore, the present study was under taken to investigate the industrial effluent effects on Maize fodder.

Materials and Methods

Location, experimental layout and treatment

To assess the effect of industrial effluent (IE) on morphological characteristics in maize fodder an experiment was carried out at Livestock and Poultry farm, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur-1706. The experimental plastic pot was filled with 12 kg of fresh air-dried soil and IE was collected from discharge points of the nearest garments factories located at BSMRAU. The experiment was laid out in a Completely Randomized Design using five treatments with four replications, employing a popular variety of maize (BARI Hybrid Maize-9). The treatments were $T_{1,}$ 100% FW (fresh water), $T_{2,}$ 75% FW + 25% IE, $T_{3,}$ 50% FW + 50% IE, $T_{4,}$ 25% FW + 75% IE, $T_{5,}$ 100% IE.

Soil collection, pot preparation and seed sowing of seeds

The experimental soil sample was collected from 0 to 15 cm depth from the research field of the BSMRAU, Gazipur. The BSMRAU campus has a sub-topical humid climate and is characterized by high temperature accompanied with moderately high rainfall from April to September and low temperature from October to March. The soil samples were air-dried at room temperature. The dried samples were ground to a small particle size with mortar and pestle. The size of the individual cylindrical plastic pot was 25 cm in diameter and 30 cm in depth and each of the pots was filled with 12 kg of air-dried soil. The soil of each plastic pot was fertilized with 12, 3.5, 4.2, 7.2, 0.4 and 0.4 g of urea, triple super phosphate, muriate of potash, gypsum, zinc and boron, respectively just two weeks before the seed sown. The soil of the pots was moistened by fresh tap water. After two weeks 5-7 seeds were used for the seed sown. Just after 6-10 days all seeds germinated. For proper growth, healthy two plants were selected for trial and other plants were thinned. After that, effluent treatments were applied as needed to maintain the water level required for the growth of maize.

Collection of industrial effluent

Industrial effluent was collected from discharge points of the nearest garments factories at BSMRAU campus. During the irrigation time industrial effluent was collect from the same place of local drain which was situated near the livestock and poultry farm, BSMRAU and applied it directly for the irrigation. The collected industrial effluent was properly mixed and then used as irrigation water at five different concentrations (0, 25%, 50%, 75% and 100%) for different treatments. Every week irrigated water samples (industrial effluent and fresh water) were collected, preserved in the plastic containers and stored at 4ºC for chemical analysis.

Intercultural operations

Weeding was done manually by hand whenever deemed necessary. The same rate of irrigation water was applied for all treatments and no extra irrigation was done. No insecticide was applied during the experimental period. Plants were also protected from rainfall water by using a transparent plastic sheet and maintaining sufficient ventilation.

Harvesting and processing

Maize fodder was harvested manually at three different stages and morphological characteristics was determined from each pot. Firstly, it was harvested after 50 days (vegetative stage), then after 65 days (flowering stage) and lastly 108 days during the maturity stage.

Parameter studied and statistical analysis

Data were recorded on plant height at 20 and 40 days (growth phase) after plantation of all plants; then at 50, 65 and 108 days (vegetative, flowering maturity stage, respectively). After harvest, plant height, total number of leaves per plant, leaf length, leaf width, roots length, root weight and plant weight were recorded. Plant and root dry weight were also recorded after drying in an oven at 65º C up to constant weight. Fresh water and industrial effluent samples were collected and stored in plastic bottles. The chemical properties of fresh water and industrial effluent are presented in Table 1. All data were analyzed using the statistical program (SPSS 2016) to compute analysis of variance (ANOVA) for a Completely Randomized Design (CRD) and Duncan's Multiple Range Test (DMRT) was done to differentiate the treatment means at a 5% level of significance.

Results and Discussion

Growth phase

The effect of industrial effluent on plant height of maize fodder at growth phase are presented in Figure 2. The results showed that the plant height of maize fodder decreased significantly ($P<0.05$) with the increased application rate of industrial effluent at 20 days and 40 days, respectively. Chaves *et al*., (2011) reported that heavy metal (Cd and Zn) had a negative effect on sunflower plant height which was similar with this study.

Vegetative stage

The effect of industrial effluent on the morphological characteristics of maize fodder at vegetative stage are presented in Table 2. The plant height of the vegetative stage was 214.00, 207.33, 201.00, 195.00 and 188.00 cm for T_1, T_2, T_3, T_4 and T_5; respectively which indicated that the height of maize plants decreased significantly ($P<0.05$) with the increased application of industrial effluent (Table 2). A significantly lower value was observed for T_5 as compared to others because of higher concentration of IE. However, no significant ($P>0.05$) difference was observed on leaves number but there was a tendency to higher ($P<0.1$) leaves number for T_1 and T_2 treatments compared to the other IE treatments. Industrial effluent had no significant ($P>0.05$) effect on leaf length at the vegetative stage (Table 2). The leaf width at vegetative stage was 8.38, 7.72, 5.77, 6.95 and 7.41 cm for T_1, T_2, T_3, T_4 and T5, respectively which showed a significant ($P<0.01$) difference among the treatments (Table 2). Though, the value was higher in treatment T_1 and the lower value was observed in T_3. That it can be deduced from this study that the industrial effluent reduced leaf width. Industrial effluent had a significant ($P<0.05$) influenced on root length at vegetative stage for (Table 2). The lowest root length was observed in T_5 followed by T_4 and T_3 which was lowest as compared to T_1 and T_2. In the study, Chukwuka *et al*. (2014) reported that increasing concentration of industrial effluent (sewage) gives rise to gradual increase in the root length of maize. The result of this study disagreed with their assertion. The plant dry weight at vegetative stage was 154.44, 149.91, 141.53, 132.77 and 121.87 g for T_1, T_2, T_3, T_4 and T_5; respectively (Table 2). Plant dry weight was significantly ($P<0.01$) decreased with the increase of industrial effluent concentration (Table 2). Though, the value was higher in treatment T_1 and the lower value was observed in T_5 group. Chukwuka *et al*., (2014) also stated that the application of various concentrations of the industrial effluents positively increased maize plant dry weight. This statement was dissimilar with the present study because the effect of heavy metal toxicity on the growth and development of plants differs according to the particular heavy metal for that process. Root dry weight was not significantly (P>0.05) differed among the treatments.

Flowering stage

The effect of industrial effluent on morphological characteristics of maize fodder at flowering stage are presented in Table 3. Maize fodder height was significantly (P<0.05) decreased with the application of higher concentration of industrial effluent at flowering stage also. The lower value was observed for T_5 compare to T_1 treatment. Qasim *et al*. (2000) stated that increase in sewage water concentration resulted in maize plant height increase which was dissimilar with this study.

Table 1: Chemical properties of fresh water and industrial effluent used for irrigation

Properties	pH	EC (dS m-1)	Na+ (mg L-1)	K+ (mg L-1)	Ca2+ (mg L-1)	Mg2+ (mg L-1)	TN (mg L-1)	Zn2+ (mg L-1)	Cu2+ (mg L-1)	Pb (mg L-1)	Cd2+ (mg L-1)	Ni (mg L-1)
FW	7.34	0.38	9.05	5.14	23.02	11.15	22.17	0.06	0.04	0.03	0.02	0.06
IE	8.97	7.41	187.59	182.47	208.9	112.56	95.4	18.88	4.09	18.27	3.12	14.57

FW, fresh water; IE, industrial effluent; EC, Electrical Conductivity; dS m^{-1}, Deci-Siemens per metre; mg L^{-1}, milligrams per litre; *Na, Sodium; K, Potassium; Ca, Calcium; Mg, Magnesium; TN, total nitrogen; Zn, Zinc; Cu, copper; Pb, Lead; Cd, Cadmium; Ni, Nickel.*

Table 2: Effect of industrial effluents on morphological characteristics of maize fodder at vegetative stage

T	Plant height (cm)	Number of leaves	Leaf length (cm)	Leaf width (cm)	Root length (cm)	Plant dry weight (g)	Root dry weight (g)
T_1	214.00 ± 6.08^{a}	14.33±0.58	91.64±13.07	8.38 ± 0.96^{a}	48.67 ± 9.50^{a}	154.44 ± 6.41^{a}	33.11±6.22
T_2	207.33 ± 2.31^{ab}	14.33±0.58	87.13±13.23	7.72 ± 0.82^{ab}	48.50 ± 9.50^{a}	149.91 ± 7.04^{ab}	28.08±6.79
T_3	201.00 ± 9.64^{abc}	13.33±0.58	86.51±18.13	5.77 ± 1.33^{c}	36.00 ± 2.00^{b}	141.53 ± 6.77^{bc}	36.94±6.32
T_4	195.00 ± 7.00^{bc}	13.33±0.58	84.68±22.13	6.95 ± 1.33^{b}	36.00 ± 2.00^{b}	132.77 ± 8.52^{cd}	28.83±10.88
T_5	188.00 ± 10.00^{c}	13.33±0.58	81.38±22.67	7.41 ± 1.65^{b}	33.50 ± 1.50^{b}	121.87 ± 4.15^{d}	37.48±7.72
SEM	4.55	0.24	1.68	0.44	3.32	5.87	1.96
***P*-value**	0.014	0.092	0.674	0.000	0.027	0.001	0.473

T, Treatment; FW, fresh water; IF, industrial effluent; SEM, standard error mean; T_1, 100% FW; T_2, 75% FW + 25% IF; T_3, 50% FW + 50% IF; T_4, 25% FW + 75% IF; T_5, 100% IF. Different letters indicate significant difference among the treatments (at 5% level).

Table 3: Effect of industrial effluents on morphological characteristics of maize fodder at flowering stage

T	Plant height (cm)	Number of leaves	Leaf length (cm)	Leaf width (cm)	Root length (cm)	Plant dry weight (g)	Root dry weight (g)
T_1	220.00 ± 6.23^{a}	12.67±0.58	65.91±15.34	5.93±2.05	47.67 ± 9.50^{b}	161.97 ± 6.83^{a}	48.00 ± 9.73^{a}
T_2	214.00 ± 6.00^{ab}	13.33±0.58	67.56±17.57	6.45±1.39	39.67 ± 1.53^{b}	158.77 ± 8.08^{a}	28.66 ± 4.72^{b}
T_3	208.00 ± 2.00^{bc}	12.67±0.58	77.70±17.15	5.80±0.79	47.17 ± 4.01^{b}	148.96 ± 8.99^{ab}	58.73 ± 6.23^{a}
T_4	205.00 ± 5.00^{bc}	12.00±1.00	81.15±11.08	7.08±1.51	61.33 ± 6.03^{a}	140.64 ± 1.80^{bc}	27.72 ± 6.59^{b}
T_5	200.50 ± 6.73^{c}	12.33±0.58	75.14±14.87	7.23±1.03	41.33 ± 3.06^{b}	129.43 ± 9.06^{c}	26.68 ± 6.53^{b}
SEM	3.42	0.22	2.93	0.29	3.81	5.96	6.52
***P*-value**	0.011	0.256	0.109	0.099	0.006	0.002	0.001

T, Treatment; FW, fresh water; IF, industrial effluent; SEM, standard error mean; T_1, 100% FW; T_2, 75% FW + 25% IF; T_3, 50% FW + 50% IF; T_4, 25% FW + 75% IF; T_5, 100% IF. Different letters indicate significant difference among the treatments (at 5% level).

However, Chaves *et al*., (2011) reported that Cadmium is a nonessential element and exert hazardous effects on plant height of plants while, Zn is an essential element for plant growth but its excess amount exerts toxic effects on plant height. May be this was the reason of lower plant height in this experiment. However, no significant (P>0.05) effect was found among the treatments for leaves number, leaf length, leaf width and root dry weight at flowering stage (Table 3) due to industrial effluent application. There was a significant (P<0.05) variation among the treatments for root length at flowering stage (Table 3). Though, the value was higher in treatment T_4 and the lower value was observed in T_2 group. The plant dry weight at flowering stage was 161.97, 158.77, 148.96, 140.64 and 129.43 g for T_1, T_2, T_3, T_4 and T_5, respectively (Table 3). From this result it was found that plant dry weight decreased significantly with the increase of industrial effluent. Chukwuka *et al*., (2014) stated that the application of various concentrations of the industrial effluents positively affected maize plant dry weight which was dissimilar with this stage also.

Maturity stage

The effect of industrial effluent on morphological characteristics of maize fodder at maturity stage are shown in Table 4. The results showed that there was a tendency to a lower value for the plant height with the increased application of industrial effluent (P<0.1). Leaves number was significantly (P<0.05) decreased in higher concentration of industrial effluent application also for treatment T_4 and T_5. However, Vaca *et al*. (2011) reported that the addition of organic municipality waste (sewage

Table 4: Effect of industrial effluents on morphological characteristics of maize fodder at maturity stage

T	Plant height (cm)	Number of leaves	Leaf length (cm)	Leaf width	Root length (cm)	Plant dry weight (g)	Root dry weight (g)
T_1	213.00±8.72^{a}	7.67±0.58^{ab}	48.27±12.07	4.92±1.51	55.00±4.58^{a}	100.07±3.75^{a}	43.68±2.16^{bc}
T_2	206.50±3.91^{ab}	8.67±0.58^{a}	52.82±14.69	4.75±1.22	33.00±3.61^{b}	92.07±4.86^{b}	49.57±3.49^{ab}
T_3	204.00±4.58^{ab}	8.67±1.53^{a}	56.88±15.35	5.42±1.08	37.50±2.29^{b}	77.03±5.22^{c}	53.20±3.65^{a}
T_4	201.00±6.56^{ab}	6.00±1.00^{bc}	54.50±14.74	4.42±1.24	38.50±1.32^{b}	57.13±2.77^{d}	44.00±8.41^{bc}
T_5	194.00±8.72^{b}	5.67±0.58^{c}	46.64±16.43	4.27±0.96	34.50±6.06^{b}	52.67±3.96^{d}	38.13±2.32^{c}
SEM	3.13	0.64	1.91	0.20	3.95	9.32	2.60
***P*-value**	0.063	0.006	0.455	0.172	0.000	0.000	0.02

T, Treatment; FW, fresh water; IF, industrial effluent; SEM, standard error mean; T_1, 100% FW; T_2, 75% FW + 25% IF; T_3, 50% FW + 50% IF; T_4, 25% FW + 75% IF; T_5, 100% IF. Different letters indicate significant difference among the treatments (at 5% level).

Vegetative stage **Flowring stage** **Maturity stage**

Figure 1: Different stage of Maize fodder

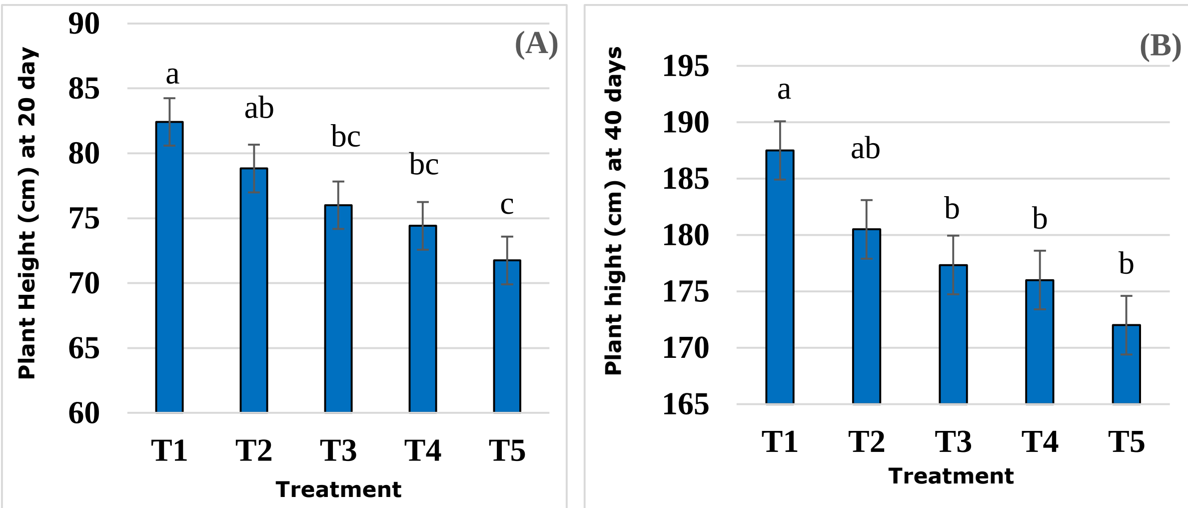

Figure 2: Plant height of maize fodder at 20 days (A) and 40 days (B)

sludge and sewage sludge compost) to soil had no negative effect on number of leaves and corn cobs per plant. No significant (P>0.05) effect was found among the treatments for leaf length and leaf width at maturity stage also (Table 4) due to industrial effluent. Root length and maize plant dry weight were significantly (P<0.05) higher for fresh water irrigation treatment (T_1) compared to industrial effluent irrigation treatments. Umebese and Onasanya (2007) and Chukwuka *et al*., (2014) stated that increasing concentration of industrial effluents gives rise to gradual increase in the root length and maize plant dry weight, however, this finding is fully disagreed with those findings. Grigorou *et al*. (1987) also reported that using of sewage water for irrigation improved root length. Root dry weight was significantly (P<0.05) differed among the treatments; however, higher root dry weight was observed in T_3 compared to others. Asati *et al*., (2016) reported that heavy metals such as Pb, Cd, Hg, and As which do not play any beneficial role in plant growth, adverse effects have been recorded at very low concentrations of these metals in the growth medium which statement was fully agreed with study. Most of the reduction in morphological characteristics of plants growing on polluted soils can be attributed to reduced photosynthetic activities, plant mineral nutrition, and reduced activity of some enzymes (Kabata-Pendias, 2001).

Conclusion

The results of the study indicated that the application of industrial effluent with different concentrations decrease the maize plant height at all stages (growth phase, vegetative stage, flowering stage and maturity stage). Plant dry weight was also reduced in vegetative stage, flowering stage and maturity stage with the irrigation of higher concentration of industrial effluent. Leaves number was reduced in maturity stage for the industrial effluent treatments. No influence was observed on leaf length by industrial effluent. Higher concentration of industrial effluent also influenced smaller leaf width at vegetative stage, however, no effect was observed for other stages. Root length was reduced for the application of industrial effluent at maturity and vegetative stage. Root dry weight was higher for fresh water irrigation treatment at flowering stage and 50% industrial effluent with 50 % fresh water treatment at maturity stage. According to the results, it is concluded that industrial effluent had negative effect on morphological characteristics of maize fodder.

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Authors' contributions

Dr. Shilpi Islam: prepared proposal from the idea initiated and securing fund executed the research; Md. Obydur Rahman conducted the experiment and prepared the manuscript data; Md. Delowar Hossain: data analysis and reviewed the manuscript; Md. Morshedur Rahman: conceptualized the research and reviewed the manuscript; Mohammed Zia Uddin Kamal: involved with the research and lab analysis.

Conflict of interest statement

We declared that there are no competing interests between us for publication of this manuscript.

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Data availability

The data used in this research would be available for any scientific purposes but need proper authentication from the authors and the journal as well.

Consent to participate

All the authors agreed to participate and would be happy for any further clarification needed from this paper.

Consent for publication

All the authors agreed and provide their consent for the publication of this manuscript in the Bangladesh Journal of Animal Science.

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