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Effect of treated effluent from beverage industry irrigation on growth and yield of Maize (*Zea mays* L.)

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Abstract
A field experiment was conducted in the premises of coca cola Pvt. Ltd., near Bidadi, Ramanagara district of Karnataka during 2017-18 to study the effect of beverage industry effluent on soil properties, growth and yield of maize with ten treatments replicated thrice using RCBD design. The beverage industry effluent was slightly alkaline in pH (8.21 ±0.20). Electrical conductivity was medium (1.75± 0.14 dS m^{-1}), BOD (5.23± 0.36 mg L^{-1}) and COD (20.44 ± 1.07 mg L^{-1}) and TSS (152.90 ± 0.21 mg L^{-1}) but low in plant nutrient content. Among the plant parameters in maize crop heigher plant height (207.44 cm), number of leaves (16.43), kernel and Stover yield (6818.25 kg $ha^{-1}$and 8011.63 kg ha^{-1}, respectively) were significantly higher in the treatment receiving irrigation with beverage industry effluent + RDF + gypsum (T_7) compared to all other treatments. Significantly lower plant height (177.61 cm), number of leaves (11.35), kernel and stover yield (6932.56 kg ha^{-1} and 8145.94 kg ha^{-1}, respectively) were recorded in treatment received irrigation with beverage industry effluent + RDF without gypsum (T_2).

Keywords: Treated, effluent, beverage, industry, Maize, *Zea mays* L.

Introduction
Water and nutrients are the most important natural resources for crop production and their management is more challenging due to their scarcity and high cost. Their efficient use is indispensable for the sustainable agriculture in view of shrinking land and water resources and increasing prices of fertilizer, haunting energy crisis, wide spread pollution and fast depletion of natural resources. The rapid increase in population and demand for industrial establishments to meet human requirements has created problems such as over exploitation of available resources, leading to pollution of land, air and water. By 2020 AD in India it is required to produce about 300 mt of food grains to feed the ever growing population. Population growth with increasing urbanization and industrialization is encroaching upon the share of agricultural water and is leading to production of huge quantities of waste water, which are beyond the capacity of natural systems to assimilate. Majority of the industries in India consume large volume of fresh water and discharge the entire quantity of water as effluent loaded with pollutants. Pollution of soil and water bodies is a serious problem ever since man started disposing sewage and industrial effluents into water bodies and on land. Indiscriminate discharge of this waste water on soil and into water bodies may create serious problems of pollution. Thus, there is a need to develop eco-friendly measures to exploit the liquid wastes profitably (Punith Raj *et al.* 2017) [15].
Agricultural use of treated waste water, therefore, might represent a unique opportunity to solve both the problems of water supply for irrigation and disposal of treated waste water at the same time. In developing countries, non-utilization of these effluents has its impact on economic growth and development and there is increased recognition for this potential. Due to increasing environmental concerns and regulations, there have been attempts to utilize this beverage industry effluent in an eco-friendly manner.
Maize (*Zea mays* L.) is one of the most versatile emerging crop having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. It is cultivated on nearly 190 m ha in about 165 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 39 per cent in the global grain production. The United States of America (USA) is the largest producer of maize contributes nearly 36 per cent of the total production America (USA) is the largest producer of maize contributes nearly 36 percent of

the total production in the world and maize is the driver of the US economy. In India, Maize is grown throughout the year. It is predominantly a kharif crop with 85 per cent of the area under cultivation in the season (APEDA, 2019) [4]. Maize is the third most important cereal crop in India after rice and wheat. It accounts for around 10 per cent of total food grain production in the country. In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc.

Irrigation with treated industrial waste water increased growth, yield and yield components of maize due to available nutrients. Maximum growth rate and yield of maize were obtained in irrigation with well water and treated industrial waste water integrating, than the irrigation with well water and waste water during whole growing period. Treated industrial waste water can have a positive influence on yield and growth of maize at all stages due to rich nutrients and organic matter. There is an increasing trend in the area, production and productivity of maize in Karnataka. Maize is grown in all the three seasons in an area of 9,36,000 ha, with an annual production of 2,73,000 tonnes and productivity of 2.9 tonnes ha^{-1} (APEDA, 2019) [4].

Materials and Methods

Bidadi industrial area is located in Ramanagara district which comes under Eastern Dry Zone (zone V), of Karnataka and situated at 12° 47' North latitude 77° 25' East longitude with an altitude of 746 meters above mean sea level. A field experiment was carried out during 2017-18 with 10 different treatments as given in table 1, to know the effect of beverage industry effluent on growth and yield of maize. Maize crop was grown in plots of 4.5 × 4.2 m^2 size with 3 replications using RCBD design. Treated effluent from beverage industry was collected at 10 days interval from coca cola Pvt. Ltd., and the samples were analyzed for pH, electrical conductivity, BOD, COD, total solids, total suspended solids, total dissolved solids, total nitrogen, phosphorus, potassium, sodium, calcium, magnesium, chlorides, sulphates and micronutrients (Zn, Cu, Fe, Mn and B) content by following standard procedures and The analysis of the samples revealed that the pH value of beverage effluent was slightly alkaline in pH (8.21±0.20). Electrical conductivity was medium (1.75+0.14 dS m^{-1}). The BOD and COD, dissolved salts, total suspended solids and total solids of the effluent sample were 5.23± 0.36 mg L^{-1}, 20.44 ± 1.07 mg L^{-1}, 1.91± 0.1 g L^{-1}, 152.90 ± 3.38 g L^{-1}, and 3.46 ± 0.20 g L^{-1} respectively. The effluent has trace quantities of nitrogen that could not be detected using standard procedure. However, the total P, K and sulphur contents were 2.0 ± 0.4, 33 ± 5.6 and 147 ± 10.5 mg L^{-1}, respectively. The Na, Ca and Mg concentrations were 14.23 ± 0.21, 3.52 ± 0.27 and 2.54 ± 0.16 m.eq L^{-1}, respectively. Chloride content of the effluent was high (7.64 ± 0.21 m.eq L^{-1}). Carbonates and bicarbonate content was 4.34 ± 0.22 m.eq L^{-1}, 2.57 ± 0.22 m.eq L^{-1}. The Sodium absorption ratio of the effluent sample varied from 8.24 ± 0.24 and residual sodium carbonate varies from 0.81 ± 0.02. The analysis of the samples revealed that the sodium content of fresh water varied from 3.30 ± 0.20 m.eq L^{-1}. The calculated quantities of nutrients were added as per recommendations.

The quantity of gypsum was calculated on the equivalent basis of sodium (Na^+) content of beverage industry effluent (14.23± 0.21 m.eq L^{-1}) and fresh irrigation water (3.45± m.eq L^{-1}). Gypsum was applied as basal dose to the treatments T_6 to T_{10} to study the possibilities of overcoming the adverse effect of sodium present in effluent on soil properties. The treatment received 50 per cent of the gypsum required. Based on the irrigation requirement of maize (≈8 irrigations @ 5 cm/irrigation) the treatments received cycles of irrigation with fresh water and beverage industry effluent.

The crop was irrigated with fresh water for first 15 days after sowing to avoid the deleterious effect if any of high sodium content of the beverage industry effluent on initial establishment of plants. After 15 days, the crops were sown with the irrigation treatments as detailed in table 3. The standard analytical procedures were adopted for soil analysis. The initial soil properties of the experimental site were pH (7.70), EC (1.8 dS m^{-1}), OC (0.68 g kg^{-1}), avail-N (255 kg ha^{-1}), P_2O_5 (30.5 kg ha^{-1}) and K_2O (148 kg ha^{-1}).

Table 1: Treatment details

T_1	**Irrigation with fresh water + RDF without gypsum**
T_2	Irrigation with beverage industry effluent + RDF without gypsum
T_3	Alternate irrigation with fresh water and beverage industry effluent + RDF without gypsum
T_4	Cycle of 2 irrigations with fresh water + 1 irrigation with beverage industry effluent + RDF without gypsum
T_5	Cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF without gypsum
T_6	Irrigation with fresh water + RDF + gypsum
T_7	Alternate irrigation with fresh water and beverage industry effluent + RDF + gypsum
T_8	Cycle of 2 irrigations with fresh water + 1 irrigation with beverage industry effluent + RDF + gypsum
T_9	Irrigation with beverage industry effluent + RDF + gypsum
T_{10}	Cycle of 1irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF + gypsum

Table 2: Physico chemical and biological properties of treated effluent from beverage industry

Parameters	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Average
pH	8.12	8.15	8.16	8.41	8.56	7.87	8.14	8.43	8.16	8.13	8.21±0.20
EC (dS m^{-1})	1.78	1.87	1.71	1.89	1.52	1.68	1.98	1.65	1.62	1.75	1.75±0.14
BOD (mg L^{-1})	5.3	5.21	5.32	5.4	5.10	4.32	5.65	5.41	5.12	5.47	5.23±0.36
COD (mg L^{-1})	20.2	20.31	20.14	21.30	20.36	21.03	20.17	20.16	20.14	20.54	20.44±1.07
DS (g L^{-1})	1.75	1.91	2.0	1.86	1.95	1.72	2.10	1.92	1.95	1.98	1.91±0.1
TSS (g L^{-1})	151	146	152	154	153	152	154	152	156	159	152.90±3.38
TS (g L^{-1})	3.26	3.39	3.3	3.48	3.31	3.25	3.81	3.70	3.56	3.58	3.46±0.2
Na (m.eq L^{-1})	14.4	14.5	14.6	14.3	14.2	14.5	14.8	14.6	14.2	14.2	14.23±0.21
CO_3 (m.eq L^{-1})	4.30	4.23	4.21	4.56	4.21	4.74	4.14	4.65	4.21	4.13	4.34±0.22

HCO_3 (m.eq L^{-1})	2.70	2.41	2.14	2.65	2.45	2.61	2.97	2.45	2.70	2.57	2.57±0.22
Total-N (mg L^{-1})	nil	nil	Nil	nil	nil	nil	nil	nil	nil	nil	nil
Total-P (mg L^{-1})	2	1.8	2.3	1.6	1.7	1.5	1.9	2.1	2.3	2.8	2.0±0.4
Total-K (mg L^{-1})	30	31	34	28	35	30	34	25	38	45	33±5.6
Total-S (mg L^{-1})	150	152	135	146	132	140	155	138	163	159	147±10.5
Ca (m.eq L^{-1})	3.80	3.28	3.45	3.27	3.87	3.45	3.65	3.90	3.14	3.45	3.52±0.27
Mg (m.eq L^{-1})	2.40	2.65	2.41	2.46	2.35	2.65	2.47	2.54	2.67	2.87	2.54±0.16
Cl (m.eq L^{-1})	7.60	7.89	7.45	7.98	7.45	7.65	7.86	7.45	7.65	7.42	7.64±0.21
Fe (mg L^{-1})	nil	nil	Nil	nil	nil	nil	nil	nil	nil	nil	nil
Cu (mg L^{-1})	nil	nil	Nil	nil	nil	nil	nil	nil	nil	nil	nil
Mn (mg L^{-1})	nil	nil	Nil	nil	nil	nil	nil	nil	nil	nil	nil
Zn (mg L^{-1})	nil	nil	Nil	nil	nil	nil	nil	nil	nil	nil	nil
B (mg L^{-1})	nil	nil	Nil	nil	nil	nil	nil	nil	nil	nil	nil
SAR	8.18	8.21	8.14	8.45	8.74	8.12	8.61	7.92	7.89	8.14	8.24±0.24
RSC (m.eq $100g^{-1}$)	0.80	0.79	0.76	0.81	0.83	0.83	0.84	0.81	0.82	0.83	0.81±0.02
Sodium content of fresh water											
Na (m.eq L^{-1})	3.3	3.5	3.0	3.2	3.5	3.1	3.7	3.4	3.3	3.0	3.3±0.2

Table 3: Initial physico-chemical and biological properties of soil of the experimental site

Sl. No.	Properties/Parameters		Values
Physical analysis			
1	Particle size distribution	Sand (%)	49.34
		Silt (%)	16.40
		Clay (%)	34.26
		Texture	Sandy clay
2	Bulk density (Mg m^{-3})		1.25
3	Porosity (%)		49.66
4	Maximum water holding capacity (%)		35.9
Chemical analysis			
5	pH		7.70
6	EC (dS m^{-1})		1.8
7	Organic carbon (%)		0.68
8	Available Nitrogen (kg ha^{-1})		255
9	Available Phosphorus (kg ha^{-1})		30.53
10	Available Potassium (kg ha^{-1})		148
11	Exchangeable Calcium [c mol (p+) kg^{-1}]		3.65
12	Exchangeable Magnesium [c mol (p+) kg^{-1}]		1.50
13	Available Sulphur (mg kg^{-1})		17.96
14	DTPA-Zinc (mg kg^{-1})		1.23
15	DTPA-Iron (mg kg^{-1})		5.90
16	DTPA-Copper (mg kg^{-1})		0.88
17	DTPA-Manganese (mg kg^{-1})		8.08
18	Boron (mg kg^{-1})		0.65
Biological analysis			
19	Urease activity (µg NH_4 N g^{-1} soil h^{-1})		433.59
20	Dehydrogenase activity (µg TPF g^{-1} soil h^{-1})		330.21
21	Alkaline phosphatase activity (µg TPF g^{-1} soil h^{-1})		6.37

Statistical analysis
The data collected were analysed statistically following the procedure as described by Panse and Sukhatme (1967). The level of significance used in 'F' and 't' test was P=0.05. Critical differences were calculated using the 't' test wherever 'F' test was significant.

Results and Discussion
Plant height
Increasing trend in plant height was observed over crop growth stages in all treatments (table 4). At 30 DAS, significantly higher plant height (58.33cm) was recorded in treatment which received RDF + gypsum + Cycle of 2 irrigations with fresh water + 1 irrigation with treated effluent from beverage industry (T_7) and which was on par with the treatment (T_6) (57.38 cm) which received RDF + Alternate irrigation with fresh water and treated effluent from beverage industry. Whereas, lower plant height was recorded (49.94 cm) in the treatments applied with RDF + Irrigation with treated effluent from beverage industry (T_2). But at 60 DAS the treatment received RDF + gypsum + Irrigation with treated effluent from beverage industry (T_7) recorded significantly higher plant height (167.68 cm) whereas, the lower plant height was recorded (143.56 cm) in the treatment with application of RDF + Irrigation with treated effluent from beverage industry (T_2). Significantly higher plant height at 90 DAS and at harvest (200.13 and 207.44 cm, respectively) were recorded with the application of RDF + gypsum + Irrigation with treated effluent from beverage industry (T_7) and was on par with treatments (T_6) RDF + gypsum + Irrigation with fresh water (196.88 and 204.07 cm, respectively) and (T_1) RDF + Irrigation with fresh water (191.66 cm and 198.66 cm, respectively). The lower plant heights at 90 DAS and at harvest (171.35 cm and 177.61 cm, respectively) were recorded in the treatment (T_2) RDF + Irrigation with treated effluent from beverage industry

Table 4: Effect of treated effluent from beverage industry for irrigation on plant height (cm) and number of leaves of maize crop in maize-cowpea cropping sequence at 30 DAS, 60 DAS, 90 DAS, and at harvest

Treatment	Plant height (cm)				Number of leaves			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1	55.86	160.58	191.66	198.66	5.86	12.29	16.98	14.94
T_2	49.94	143.56	171.35	177.61	4.34	9.10	12.56	11.35
T_3	53.22	152.99	182.60	189.27	4.69	9.83	13.58	12.25
T_4	54.21	155.84	186.00	192.79	5.16	10.82	14.94	13.14
T_5	50.20	144.31	172.24	178.53	4.51	9.47	13.07	10.61
T_6	57.38	164.95	196.88	204.07	6.15	12.91	17.83	15.68
T_7	58.33	167.68	200.13	207.44	6.45	13.52	18.67	16.43
T_8	53.51	153.82	183.60	190.30	5.68	11.92	16.47	14.49
T_9	55.40	159.26	190.08	197.02	5.45	11.43	15.79	13.89
T_{10}	52.13	149.86	178.86	185.39	5.57	11.68	16.13	14.19
S. Em±	0.08	0.23	0.28	0.29	0.02	0.06	0.04	0.03
C. D. @ 5%	0.24	0.69	0.83	0.86	0.07	0.19	0.11	0.10

Legend

T_1: RDF + Irrigation with fresh water
T_2: RDF + Irrigation with treated effluent from beverage industry
T_3: RDF + Alternate irrigation with fresh water and treated effluent from beverage industry
T_4: RDF + Cycle of 2 irrigations with fresh water + 1 irrigation treated effluent from beverage industry
T_5: RDF + Cycle of 1 irrigation with fresh water + 2 irrigations with treated effluent from beverage industry
T_6: RDF + Gypsum + Irrigation with fresh water
T_7: RDF + Gypsum + Irrigation with treated effluent from beverage industry
T_8: RDF + Gypsum + Alternate irrigation with fresh water and treated effluent from beverage industry
T_9: RDF + Gypsum + Cycle of 2 irrigations with fresh water + 1 irrigation with treated effluent from beverage industry
T_{10}: RDF + Gypsum + Cycle of 1 irrigation with fresh water + 2 irrigations with treated effluent from beverage industry

Number of leaves

The results on the effect of irrigation with treated effluent from beverage industry on number of leaves of maize crop in a field experiment were showed in table 4. Significantly higher number of leaves per plant in maize crop at different growth stages i.e. 30, 60, 90 DAS and at harvest (6.45, 13.52, 18.67 and 16.43, respectively) was recorded with the application of RDF + gypsum + Irrigation with treated effluent from beverage industry (T_7). However, significantly lower number of leaves (4.34, 9.10, 12.56 and 11.35 at 30, 60, 90 DAS and at harvest, respectively) were recorded in treatment which received RDF + Irrigation with treated effluent from beverage industry (T_2).

Yield

With the application of treated effluent from the beverage industry recorded (table 5) significantly higher kernel yield (6932.56 kg ha^{-1}) was recorded in the treatment (T_7) which received RDF + gypsum + Irrigation with treated effluent from beverage industry, whereas, lower kernel yield (5935.40 kg ha^{-1}) was in the treatment which received RDF + Irrigation with treated effluent from beverage industry (T_2). The application of treated effluent from beverage industry significantly increased the stover yield wherein higher stover yield (8145.94 kg ha^{-1}) was recorded in the treatment receiving RDF + gypsum + Irrigation with treated effluent from beverage industry (T_7) and was on par with the treatment (T_6) applied with RDF + gypsum + Irrigation with fresh water. Whereas, significantly lower value (6974.26 kg ha^{-1}) was recorded with the application of RDF + Irrigation with treated effluent from beverage industry (T_2) (table 10). The test weight of maize was found to be non-significant, the test weight was increased with the application of treated beverage effluent when applied as a source of irrigation where significantly higher test weight (32.09g) was recorded with the application of RDF + gypsum + Irrigation with treated effluent from beverage industry (T_7) and lower test weight (31.27g) was recorded in treatment receiving RDF + Irrigation with treated effluent from beverage industry (T_2).

Table 5: Effect of treated effluent from beverage industry for irrigation on kernel, Stover yield and test weight of maize in maize-cowpea cropping sequence

Treatment	Kernel yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Test weight (g)
T_1	6639.00	7801.00	31.85
T_2	5935.40	6974.26	31.27
T_3	6325.23	7432.32	31.70
T_4	6442.90	7570.57	31.76
T_5	5966.31	7010.57	31.45
T_6	6819.65	8013.27	31.95
T_7	6932.56	8145.94	32.09
T_8	6359.70	7472.82	31.46
T_9	6584.33	7736.76	31.79
T_{10}	6195.69	7280.10	31.78
S. Em±	96.30	113.20	0.46
C. D. @ 5%	286.10	336.20	NS

Legend

T_1: RDF + Irrigation with fresh water
T_2: RDF + Irrigation with treated effluent from beverage industry

T_3: RDF + Alternate irrigation with fresh water and treated effluent from beverage industry
T_4: RDF + Cycle of 2 irrigations with fresh water + 1 irrigation treated effluent from beverage industry
T_5: RDF + Cycle of 1 irrigation with fresh water + 2 irrigations with treated effluent from beverage industry
T_6: RDF + Gypsum + Irrigation with fresh water
T_7: RDF + Gypsum + Irrigation with treated effluent from beverage industry
T_8: RDF + Gypsum + Alternate irrigation with fresh water and treated effluent from beverage industry
T_9: RDF + Gypsum + Cycle of 2 irrigations with fresh water + 1 irrigation with treated effluent from beverage industry
T_{10}: RDF + Gypsum + Cycle of 1 irrigation with fresh water + 2 irrigations with treated effluent from beverage industry

In the present study, the results revealed that growth and yield parameters of maize differed significantly due to beverage industry effluent and gypsum. Significantly higher growth and yield parameters were observed with irrigation with beverage industry effluent + RDF + gypsum (T_7) compared to all other treatments, except the test weight. Significantly lower growth and yield parameters were observed in the treatment T_2 receiving irrigation with beverage industry effluent + RDF without gypsum. This might be due to addition of small amount of nutrients from beverage industry effluent and gypsum as an amendment which are required for plant growth and development. Positive effect on growth and yield p arameters due to combined use of effluent irrigation and amendments on cucumber, napier grass, maize and sunflower were reported by Parameswari (2009) [13]. Similar results were reported by Anoop *et al.*, (2002) and Vanitha (2010) [3].
Increase in grain yield of maize (Kernel yield 6818.25 kg ha^{-1} and Stover yield 8011.63 kg ha^{-1}) was observed with irrigation with beverage industry effluent + RDF + gypsum (T_7). Similar results were observed by Anon (2008) [1] who reported that among coffee pulp effluent irrigated treatments, irrigation with 2:1 cycles of lime treated coffee pulp effluent and fresh water recorded significantly higher baby corn yield (98.2 q ha^{-1} and 26.67 t ha^{-1}) which was on par with alternate irrigation with fresh water and lime treated coffee pulp effluent (77.6 q ha^{-1}) during 2006. Whereas, in 2007, alternate irrigation fresh water and lime treated coffee pulp effluent recorded significantly higher baby corn yield (102.9 q ha^{-1}) over other effluent irrigated treatments. This was mainly due to higher plant height, number of leaves and test weight observed in this treatment. These results are in conformity with the findings of Pandey (2006) [12], Efstathios *et al.*, (2009) [6], Moazzam *et al.*, (2010) and Nwoko (2010) [9, 11] who reported increased yields due to more growth parameters and yield parameters with application of waste water to field crops. Devarajan and Oblisamy (1995) [5] recorded the highest cane yield of 182.8 t ha^{-1} due to irrigation with distillery effluent diluted 50 times. Best results were obtained when 50 times diluted vinasse was applied at 16 t ha^{-1} (Ghugare and Magar, 1995) [7]. Pujar (1995) [14] recorded highest grain yield of wheat at 50 times and maize at 10 times dilution of effluent irrigation. Twelve pre-sowing irrigations with the distillery effluent had no adverse effect on the germination of maize but improved the growth and yield (Singh and Raj Bahadur, 1998) [16]. Pujar (1995) [14] registered highest sugar cane yield with 10 times dilution when distillery effluent was amended along with pressmud.
Higher grain and straw yield of maize was observed with irrigation with beverage industry effluent + RDF + gypsum (T_7) in present study could be attributed to better total uptake of essential nutrients and its translocation to economic parts as well as improvement in yield attributing characters like number of leaves, leaf area and length of leaf. These results are in conformity with the findings of Parameswari (2009) [13]. Significantly lower growth and yield of barley was recorded in treatment which received irrigation with beverage industry effluent + RDF without gypsum which may be attributed to accumulation of salts in the root zone and the presence of sodium and chlorides in irrigation water which are absorbed by plants and accumulate in the leaves. However, lower yield of maize (3.05 and 4.35 t ha^{-1} grain and straw yield, respectively) was observed in the treatment which received only beverage industry effluent + RDF, without gypsum when compared to others. These effects might be due to the salinity through brewery waste water irrigation which generally inhibited the growth, yield attributes and yield through reduced water absorption, reduced metabolic activities due to Na^+ and Cl^- toxicity and nutrients deficiency caused by ionic interference. These results are in agreement with findings of Leth and Burrow (2002) [8], Mohamedin *et al.*, (2006) and Parameswari (2009) [10, 13].

Yield parameters of maize

The results indicated that all the yield parameters were statistically significant (table 6) where significantly higher number of grains per row, grain weight per cob, cob weight, cob girth, cob length and number of rows per cob (42.11 g, 208.71 g, 196.52 g, 9.00 cm, 18.80 cm and 17.13, respectively) was recorded in the treatment which received RDF + gypsum + Irrigation with treated effluent from beverage industry (T_7) and was on par with the treatment which received RDF + gypsum + Irrigation with fresh water (T_6) (41.43 g, 205.31 g, 193.32 g, 8.85 cm, 18.49 cm and 16.85 cm, respectively). However, significantly lower number of grains per row, grain weight per cob, cob weight, cob girth, cob length and number of rows per cob (36.06 cm, 178.69 g, 168.25 g, 7.71 cm, 16.09 cm and 14.66, respectively) was recorded with the application of RDF + Irrigation with treated effluent from beverage industry (T_2).

Table 6: Effect of treated effluent from beverage industry for irrigation on yield parameters of maize in maize- cowpea cropping sequence

Treatment	No. of grains row^{-1}	Grain weight cob^{-1} (g)	Cob weight (g)	Cob girth (cm)	Cob length (cm)	No, of rows cob^{-1}
T_1	40.33	199.87	188.20	8.62	18.00	16.40
T_2	36.06	178.69	168.25	7.71	16.09	14.66
T_3	38.42	190.42	179.31	8.21	17.15	15.62
T_4	39.14	193.97	182.64	8.37	17.47	15.92
T_5	36.24	179.62	169.13	7.75	16.18	14.74
T_6	41.43	205.31	193.32	8.85	18.49	16.85
T_7	42.11	208.71	196.52	9.00	18.80	17.13
T_8	38.63	191.46	180.28	8.26	17.24	15.71
T_9	40.00	198.22	186.65	8.55	17.85	16.26

T_{10}	37.64	186.52	175.63	8.04	16.80	15.30
S. Em±	0.06	0.29	0.27	0.01	0.03	0.02
C. D. @ 5%	0.17	0.86	0.81	0.04	0.08	0.07

Legend

T_1: RDF + Irrigation with fresh water
T_2: RDF + Irrigation with treated effluent from beverage industry
T_3: RDF + Alternate irrigation with fresh water and treated effluent from beverage industry
T_4: RDF + Cycle of 2 irrigations with fresh water + 1 irrigation treated effluent from beverage industry
T_5: RDF + Cycle of 1 irrigation with fresh water + 2 irrigations with treated effluent from beverage industry
T_6: RDF + Gypsum + Irrigation with fresh water
T_7: RDF + Gypsum + Irrigation with treated effluent from beverage industry
T_8: RDF + Gypsum + Alternate irrigation with fresh water and treated effluent from beverage industry
T_9: RDF + Gypsum + Cycle of 2 irrigations with fresh water + 1 irrigation with treated effluent from beverage industry
T_{10}: RDF + Gypsum + Cycle of 1 irrigation with fresh water + 2 irrigations with treated effluent from beverage industry

Among the treatments, higher number of grains per row, grain weight per cob, cob weight, cob girth, cob length and number of rows per cob was recorded in the treatment which received RDF + gypsum + Irrigation with treated effluent from beverage industry (T_7). This could be due to gypsum had significant effect in increasing the yield of the crop by reducing the effect of sodium on crop growth. Higher kernel and stover yield and yield parameters in maize could be attributed to better total uptake of essential nutrients and its translocation to economic parts as well as improvement in yield attributing characters like grains per row, grain weight per cob, cob weight, cob girth, cob length and number of rows per cob and test weight, and these results are in conformity with the findings of Parameswari (2009) [13], Pandey (2006) [12], Efstathios *et al*. (2009) [6], Moazzam *et al*. (2010) and Nwoko (2010) [9, 11] who reported increased yields due to more growth parameters and yield parameters with application of waste water to field crops.

Conclusion

Based on the results of field trial, it can be concluded that, maize crop performed well under beverage industry effluent irrigation in presence of gypsum, continuous use of beverage industry effluent for several years may lead to a salinity build-up, as well as contribute to the deterioration of soil quality and results in lower growth and yield of crops. This problem could be effectively managed by the use of gypsum. However, long term field experiments in different agro-climatic zones involving use of different amendments are needed for conclusion in this regard.

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