International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(6): 3099-3104
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Received: 04-09-2020
Accepted: 10-10-2020

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Effect of treated effluent from beverage industry irrigation on growth and yield of cowpea [*Vigna unguiculata* (L.)] in maize: Cowpea cropping sequence

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DOI: https://doi.org/10.22271/chemi.2020.v8.i6aq.11896

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 residual cowpea crop higher plant height (45.44 cm), No of branches $plant^{-1}$ (10.00), seed and haulm yield (1023.33 kg $ha^{-1}$and 2411.86 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 (38.91 cm), No of branches $plant^{-1}$ (8.56), seed and haulm yield (876.14 kg $ha^{-1}$and 2064.95 kg ha^{-1}, respectively) were recorded in treatment received irrigation with beverage industry effluent + RDF without gypsum (T_2).

Keywords: Cucumber, boron, yield, quality, Konkan

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) [16, 17].

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. Finger maize-residual cowpea is a major cereal-pulse based cropping system followed in southern dry zone of Karnataka.

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 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*. Residual cowpea (*Vigna unguiculata* (L.) Walp.) is a legume mainly grown in tropical and subtropical regions in the world for vegetable and grains and to lesser extent as a fodder crop. It also serves as cover crop and improves soil fertility by fixing atmospheric nitrogen.

Irrigation with treated industrial waste water increased growth, yield and yield components of maize and residual cowpea due to available nutrients. Maximum growth rate and yield of maize and residual cowpea 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 and residual cowpea 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]. In view of this effect of treated effluent irrigation on maize cowpea cropping sequence was carried out.

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.

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

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 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

Growth parameters of cowpea: Significantly higher plant height (table 4) during 30, 60 and at harvest (20.24, 39.99 and 45.44 cm, respectively) was observed in the treatment which received RDF + Gypsum + Irrigation with treated effluent from beverage industry (T7) compared to all other treatments followed by (RDF + gypsum + irrigation with fresh water (T6) (19.91, 39.34 and 44.70 cm, respectively) Significantly lower plant height during all the stages of crop growth (17.33, 34.24 and 38.91 cm, respectively) was observed in the treatment (T2) RDF + Irrigation with treated effluent from beverage industry.

During different growth stages (30, 60 DAS and at harvest) of residual cowpea, significant difference with respect to number of branches per plant was observed due to treated effluent from beverage industry effluent irrigation. Significantly higher number of branch was observed in the treatment which received RDF + Gypsum + Irrigation with treated effluent from beverage industry (T7) (2.30, 6.24 and 10.00 cm) compared to all other treatments. Significantly lower number of leaves during all the stages of crop growth (1.97, 5.35 and 8.56cm, respectively) was observed in the treatment (T_2) received RDF + Irrigation with treated effluent from beverage industry.

Table 4: Residual effect of treated effluent from beverage industry for irrigation on plant height (cm) and number of branches per plant by residual cowpea in maize-residual cowpea cropping sequence at 30 DAS, 60 DAS and at harvest

Treatment	30 DAS		60 DAS		At harvest	
	Plant height	No. of branches plant^{-1}	Plant height	No. of branches plant^{-1}	Plant height	No. of branches plant^{-1}
T_1	19.38	2.20	38.30	5.98	43.52	9.58
T_2	17.33	1.97	34.24	5.35	38.91	8.56
T_3	18.46	2.10	36.49	5.70	41.46	9.13
T_4	18.81	2.14	37.17	5.80	42.23	9.30
T_5	17.42	1.98	34.42	5.37	39.11	8.61
T_6	19.91	2.26	39.34	6.14	44.70	9.84
T_7	20.24	2.30	39.99	6.24	45.44	10.00
T_8	18.56	2.11	36.69	5.73	41.69	9.18
T_9	19.22	2.18	37.98	5.93	43.16	9.50
T_{10}	18.09	2.05	35.74	5.58	40.61	8.94
S. Em±	0.03	0.00	0.06	0.01	0.06	0.01
C. D. @ 5%	0.08	0.01	0.17	0.03	0.19	0.04

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

The plant height and number of branch per plant were increased with increase in the rate of gypsum application along with different combination of fresh water with treated effluent from beverage industry. In the present study, the results revealed that significantly higher number of branch per plant was observed in the treatment which received RDF + Gypsum + Irrigation with treated effluent from beverage industry (T7). The reason for this could be attributed to the presence of relatively higher quantities of NPK in the soil before sowing of residual cowpea seeds. This might be due to addition of small amount of nutrients from beverage industry effluent in addition to RDF added to maize and gypsum as an amendment which are required for plant growth and development. Hence, the residual effect of the fertilizers applied to the previous crop did have a favorable effect on plant height of succeeding crop residual cowpea (Gabriel, 2010 and Punitha, 2016) [16, 17]. Maximum number of branches per plant was higher in treatment (T7), for growth of any plant NPK are the major mineral nutrients required for growth and development of plants. Adequate NPK might have helped in harvesting of solar energy as reflected by increased growth of succeeding crop residual cowpea, Punitha (2016) [16, 17]. 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, residual cowpea, maize and sunflower were reported by Parameswari (2009) [14]. Similar results were reported by Anoop *et al.*, (2002) and Vanitha (2010) [3].

Yield and yield attributes of cowpea

Among the different irrigation treatments with gypsum and without gypsum showed a profound effect (table5) in increasing the pods per plant. Maximum number of pod per plant at 60 DAS and at harvest was recorded in the treatment which received RDF + Gypsum + Irrigation with treated effluent from beverage industry (T7) (10.12 and 16.54, respectively) followed by RDF + gypsum + irrigation with fresh water (T6) (9.95 and 16.27 respectively) and significantly low number of pods per plant were observed in the treatment which received RDF + Irrigation with treated effluent from beverage industry (T2) (8.66 and 14.16, respectively). Among the different irrigation treatments with gypsum and without gypsum showed a profound effect in increasing in the pod length. Maximum pod length at 60 DAS and at harvest was recorded in the treatment which received RDF + Gypsum + Irrigation with treated effluent from beverage industry (T7) (19.54 cm) followed by RDF + gypsum + irrigation with fresh water (T6) (19.27 cm) and significantly lower pod length was observed in the treatment which received RDF + Irrigation with treated effluent from beverage industry (T2) (17.16 cm). Among the different irrigation treatments with gypsum and without gypsum showed a profound effect in increasing in the pods per plant. Maximum number of seeds pod^{-1} at harvest was recorded in the treatment which received RDF + Gypsum + Irrigation with treated effluent from beverage industry (T_7) (9.75) followed by RDF + gypsum + irrigation with fresh water (T_6) (9.59) and significantly low number of pods^{-1} (8.35) were observed in the treatment which received RDF + Irrigation with treated effluent from beverage industry (T_2). The data pertaining to test weight of residual cowpea crop as influenced by beverage industry effluent for irrigation treatments differed significantly due to irrigation with fresh water, beverage industry effluent and application of gypsum. Significantly higher test weight was observed in the treatment which received RDF + Gypsum + Irrigation with treated effluent from beverage industry (T7) (9.93 g) followed by RDF + Gypsum + Irrigation with fresh water (T6) (9.90 g). However, significantly lower test weight was recorded in the treatment (T2) which received RDF + Irrigation with treated effluent from beverage industry (8.62 g).

Table 5: Residual effect of treated effluent from beverage industry for irrigation on yield and yield parameters of residual cowpea in maize-residual cowpea cropping sequence

Treatment	Pods plant^{-1} at 60 DAS	Pods plant^{-1} at Harvest	Pod length (cm)	Number of seeds pod $^{-1}$	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (HI)	Test weight (g)
T_1	9.69	15.84	18.84	9.34	980.00	2309.73	0.295	9.64
T_2	8.66	14.16	17.16	8.35	876.14	2064.95	0.276	8.62
T_3	9.23	15.09	18.09	8.90	933.68	2200.57	0.287	9.18
T_4	9.40	15.37	18.37	9.06	951.05	2241.50	0.284	9.36
T_5	8.71	14.24	17.24	8.39	880.70	2075.70	0.280	8.66
T_6	9.95	16.27	19.27	9.59	1006.67	2372.58	0.302	9.90
T_7	10.12	16.54	19.54	9.75	1023.33	2411.86	0.308	9.93
T_8	9.28	15.17	18.17	8.95	938.77	2212.56	0.301	9.23
T_9	9.61	15.71	18.71	9.26	971.93	2290.71	0.296	9.56
T_{10}	9.04	14.78	17.78	8.72	914.56	2155.50	0.287	9.00
S. Em±	0.01	0.02	0.02	0.01	1.42	3.35	0.03	0.50
C. D. at 5%	0.04	0.07	0.07	0.04	0.07	9.95	0.09	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

The data pertaining to seed yield and haulm yield of residual cowpea crop as influenced by beverage industry effluent irrigation are presented in Table 5.RDF + Gypsum + Irrigation with treated effluent from beverage industry (T7) recorded significantly higher seed and haulm yield (1023.33 and 2411.86 kg ha^{-1}, respectively) compared to all other treatments followed by the RDF + gypsum + irrigation with fresh water (T6) (1006.67 and 2372.58 kg ha^{-1}, respectively) and significantly lower seed and haulm yield (876.14 and 2064.95 kg ha^{-1}, respectively) was recorded in the treatment which received RDF + Irrigation with treated effluent from beverage industry (T2).

In the present the results revealed that significantly higher harvest index (HI) was observed in the treatment which received RDF + Gypsum + Irrigation with treated effluent from beverage industry (T7). RDF + Gypsum + Irrigation with treated effluent from beverage industry (T7) (0.302) recorded significantly higher harvest index compared to all other treatments followed by the RDF + gypsum + irrigation with fresh water (T6) (0.300) and harvest index (0.276) was recorded in the treatment which received RDF + Irrigation with treated effluent from beverage industry (T2).

This might be due to adequate supply of nutrients in the early stages of a plant is considered very important in promoting rapid vegetative growth and in increasing sink in terms of flowering and seed setting and including their development. Thus, overall improved growth coupled with increased net photosynthesis on one hand and greater mobilization of photosynthates towards reproductive structures on the other hand, might have improved the seed and haulm yield (Abayomi *et al*., 2008). The positive response recorded on both seed yield and haulm yield of succeeding crop of residual cowpea could be due to mineralization of nutrients, as a result of which better growth was achieved. Higher vegetative production in crop means higher interception of light and, therefore, more assimilate production resulted in increased yield (Babaji *et al*., 2011). This might be due to addition of small amount of nutrients from beverage industry effluent in addition to RDF applied for the maize crop and gypsum as an amendment which are required for plant growth and development. Similar results were observed by Anon (2008) [1, 2] 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) [13], Efstathios *et al.* (2009) [6], Moazzam *et al.* (2010) and Nwoko (2010) [10] 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) [8]. Pujar (1995) [15] 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) [18]. Pujar (1995) [15] registered highest sugar cane yield with 10 times dilution when distillery effluent was amended along with pressmud.
Higher seed and haulm yield of residual cowpea 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) [14].
Significantly lower growth and yield of residual cowpea 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) [9], Mohamedin *et al.*, (2006) [11] and Parameswari (2009) [14].

Conclusion
Based on the results of field trial, it can be concluded that, residual cowpea 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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