

Original Research Article

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## Effect of Beverage Industry Effluent Irrigation Growth, Yield and Quality of Sunflower

T.S. Punith Raj<sup>1\*</sup>, C.A. Srinivasamurthy<sup>2</sup>, S. Bhaskar<sup>3</sup>, S. S. Prakash<sup>4</sup>,  
and Prabhudev Dhumgond<sup>4</sup>

<sup>1</sup>CGWB, Ministry of Water Resources, Govt. of India, Bhubaneswar, Orissa-751030, India

<sup>2</sup>Central Agricultural University, Imphal, India

<sup>3</sup>Agronomy, Agro-Forestry and Climate change, ICAR, New Delhi, India

<sup>4</sup>Department of Soil Science and Agricultural Chemistry, CoA, Mandya, India

*\*Corresponding author*

### ABSTRACT

A field experiment was conducted in the premises of Pepsico Pvt. Ltd., near Bengaluru during 2013-14 to study the effect of beverage industry effluent on growth, yield and quality of sunflower with ten treatments replicated thrice using RCBD design. The beverage industry effluent was neutral in reaction, medium in electrical conductivity ( $1.59 \text{ dSm}^{-1}$ ), BOD ( $42.2 \text{ mg L}^{-1}$ ) and COD ( $143 \text{ mg L}^{-1}$ ) but low in plant nutrients content. Among the treatments, growth parameters like plant height, head diameter and number of leaves (184.5, 16.1 cm and 32.1, respectively) were significantly higher in treatment T<sub>10</sub> at 60 DAS. Significantly higher dry matter production in leaf, stem, ear head and TDM were observed in T<sub>10</sub>. Significant increase in yield attributes such as total dry matter, head weight, kernel weight per head, number of grains per head, grain filling per cent, test weight and volume weight were observed in T<sub>10</sub>. Oil content and oil yield of sunflower crop varied significantly due to treatments. Fatty acids such as palmitic, stearic, oleic and linoleic acid did not differ significantly due to beverage industry effluent irrigation. Treatment T<sub>10</sub> recorded significantly higher grain ( $3.43 \text{ t ha}^{-1}$ ) and stalk yield ( $4.99 \text{ t ha}^{-1}$ ) compared to other treatments. Significantly lower grain ( $1.83 \text{ t ha}^{-1}$ ) and stalk yield ( $2.67 \text{ t ha}^{-1}$ ) were recorded in T<sub>2</sub>.

#### Keywords

Beverage industry,  
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### 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 overexploitation of available resources, leading to pollution of land, air and water. By 2020 AD in India 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.

The Pepsico beverage industry is one of the largest users of water. Even though substantial technological improvements have been made, beverage industry has been producing approximately 650-700 KLD (Kilo litres per day) of effluent. These effluents are produced during different process such as RO reject (135-150 KLD), equipment sanitation (130-150 KLD), final bottle washing (70-80 KLD), floor cleaning (40-50 KLD), filter backwash (120-130 KLD) and domestic activities (15-25 KLD).

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.

Sunflower globally ranks second to soybean among annual field crops grown for edible

oil. The quantity of sunflower oil represents about 15 per cent of the total world production of the major vegetable oils. In India, it occupies an area of 1.81 m ha with a production of 1.16 mt and productivity of 639 kg ha<sup>-1</sup> (Anon., 2012). In Karnataka, it is grown over an area of 1 m ha with a production of 0.49 m t and the average productivity is 496 kg ha<sup>-1</sup> (Anon., 2010). Karnataka stands first with respect to area and production of sunflower in India. But the average productivity is below the national average.

The characteristics of industrial effluents profoundly vary and are determined by type of product, nature of inputs involved, effluent treatment processes and capacity of industrial unit. Reuse of this water is always associated with advantages and disadvantages.

Apart from supplying water, its organic and inorganic constituents could meet nutrients requirement of crops, decrease the fertilizer/manure requirement, improve soil fertility and simultaneously enhances the chances of contaminating soil, water and producing degraded quality crops (Qadir and Schubert, 2002). Use of effluent successfully involves questions concerning safe protocol of its use for crops, impact of its use on growth, yield of crops and soil properties. So, the research on successful and productive use of beverage industry effluent on crops is scanty. Hence, this study was taken up to standardize the practices of its safe usage in agriculture.

## **Materials and Methods**

Nelamangala is located in Bangalore rural district of Eastern Dry Zone, Karnataka and situated at 12° 11' North latitude 76° 69' East longitude with an altitude of 610 meters above mean sea level. A field experiment was carried out during 2013-14 with 10 different

treatments as given in table 1, to know the effect of beverage industry effluent on growth, yield and quality of sunflower. Sunflower crop was grown in plots of 3.6×3 m<sup>2</sup> size with 3 replications using RCBD design. Beverage industry effluent was collected at 60 days interval from Pepsico 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 average values are presented in table 2. The calculated quantities of nutrients were added as per recommendations.

The quantity of gypsum was calculated on the equivalent basis of sodium (Na<sup>+</sup>) content of beverage industry effluent (10.3 m.eq L<sup>-1</sup>) and fresh irrigation water (3.35 m.eq L<sup>-1</sup>). It was applied as basal dose to the treatments T<sub>6</sub> to T<sub>10</sub> to study the possibilities of overcoming the adverse effect of sodium present in effluent on soil properties. The experiment received 50 per cent of the gypsum required. Based on the irrigation requirement of sunflower (≈ 5 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 imposed with the irrigation treatments as detailed in table 1. The standard analytical procedures were adopted for soil analysis. The initial soil properties of the experimental site are pH (7.95), EC (0.53 dS/m), OC (4.6 g/kg), avail-N (189.6 kg/ha), P (26.9 kg/ha) and K (218.8 kg/ha).

## Results and Discussion

### Growth parameters

The results revealed that growth and yield parameters of sunflower crop differed significantly due to irrigation with beverage industry effluent and gypsum (Table 3).

**Plant height:** Significantly higher plant height during 30, 60 and 90 DAS and at harvest (84.4, 184.5 224.7 and 227.9 cm, respectively) was observed with cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF + gypsum (T<sub>10</sub>) compared to all other treatments followed by irrigation with beverage industry effluent + RDF + gypsum (T<sub>7</sub>) (83, 183.2, 223.4 and 225.8 cm, respectively) and irrigation with fresh water + RDF with gypsum (T<sub>6</sub>) (82, 182.2, 222.4 and 226.7 cm, respectively). The treatments T<sub>3</sub>, T<sub>1</sub> (73.3, 173.4, 213.5, 215.9 cm and 76.2, 176.3, 216, 221.4 cm, respectively) and T<sub>8</sub>, T<sub>9</sub> (78.3, 178.6, 218.8, 223.1 cm and 79.4, 179.7, 219.6, 225.3 cm, respectively) were found to be on par with each other. However, significantly lower plant height during all the stages of crop growth (61.2, 161.4, 201.6 and 205.6 cm, respectively) was observed in the treatment T<sub>2</sub> receiving irrigation with beverage industry effluent + RDF without gypsum.

### Number of leaves

During different growth stages (30, 60, 90 DAS and at harvest) of sunflower, significant difference with respect to number of leaves due to beverage industry effluent irrigation was observed. Significantly higher number of leaves was observed with cycle of irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF + gypsum (T<sub>10</sub>) compared to all other treatments. Significantly lower number of leaves during

all the stages of crop growth (4.2, 21.9, 12.1 and 8.6, respectively) was observed in the treatment T<sub>2</sub> receiving irrigation with beverage industry effluent + RDF without gypsum.

### **Head diameter**

Significantly higher head diameter was observed during 60, 90 DAS and at harvest (16.1, 26.4 and 31.6 cm, respectively) with cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF + gypsum (T<sub>10</sub>) compared to all other treatments followed by irrigation with beverage industry effluent + RDF + gypsum (T<sub>7</sub>) (186.2 and 252.2, respectively) and irrigation with fresh water + RDF with gypsum (T<sub>6</sub>) (15.6, 24.7 and 30.2 cm, respectively). The treatments T<sub>3</sub>, T<sub>4</sub> (11, 21.1, 21.6 cm and 11.1, 21.1, 22.5, respectively) and T<sub>8</sub>, T<sub>9</sub> (13.1, 23.1, 26.8 cm and 13, 23.1, 24 cm, respectively) were found to be on par with each other. However, significantly lower head diameter at 60, 90 DAS and at harvest (8.1, 18.2 and 19.2 cm, respectively) was observed in the treatment T<sub>2</sub> receiving irrigation with beverage industry effluent + RDF without gypsum.

### **Total dry matter accumulation**

The data on total dry matter accumulation and yield parameters such as head weight, kernel weight per head, number of grains per head, grain filling per cent, test weight and volume weight varied significantly due to beverage industry effluent irrigation at harvest. Significantly higher total dry matter production was observed in the treatment receiving cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF + gypsum (T<sub>10</sub>: 180.2 g plant<sup>-1</sup>) compared to all the other treatments followed by irrigation with fresh water + RDF + gypsum (T<sub>6</sub>: 177.4 g plant<sup>-1</sup>) and was on par with T<sub>7</sub>. Significantly lower total dry matter

production was observed in the treatment with irrigation of beverage industry effluent + RDF without gypsum (T<sub>2</sub>: 105.2 g plant<sup>-1</sup>).

### **Yield and yield parameters**

The data pertaining to yield parameters such as head weight, kernel weight per head, number of grains per head, grain filling percent, test weight and volume weight of sunflower crop as influenced by beverage industry effluent irrigation are presented in table 4.

Different irrigation treatments with gypsum and without gypsum showed a profound effect in increasing the head weight and kernel weight per head. Maximum head and kernel weight was recorded in the treatment which received cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF + gypsum (1.73 kg and 72.3 g, respectively) followed by irrigation with beverage industry effluent + RDF + gypsum (T<sub>7</sub>: 1.61 kg and 67.4 g, respectively) and irrigation with fresh water + RDF with gypsum (T<sub>6</sub>: 1.55 kg and 64.7 g, respectively) and significantly superior over the treatment with irrigation of beverage industry effluent + RDF without gypsum (T<sub>2</sub>: 0.92 kg and 38.4 g, respectively).

Number of grains per head and grain filling percent increased significantly with cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF + gypsum (T<sub>10</sub>: 1320 and 95.3 %, respectively) compared to all other treatments. Significantly lower number of grains and grain filling percent was recorded in the treatment which received irrigation of beverage industry effluent + RDF without gypsum (T<sub>2</sub>: 696 and 83.1 %, respectively).

Treatments differed significantly due to irrigation with fresh water, beverage industry effluent and application of gypsum.

Significantly higher test weight and volume weight was observed in the treatment receiving cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF + gypsum ( $T_{10}$ : 6.75 and 66.4 g) followed by irrigation with beverage industry effluent + RDF + gypsum ( $T_7$ : 6.3 and 61.8 g, respectively) and was on par with  $T_6$  (6.24 and 59.4 g, respectively). However, significantly lower test weight and volume weight were recorded in the treatment  $T_2$  which received irrigation of beverage industry effluent + RDF without gypsum (3.59 and 35.2 g, respectively).

The data pertaining to grain yield, stalk yield, oil content and oil yield of sunflower crop as influenced by beverage industry effluent irrigation are presented in table 5.

Cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF + gypsum ( $T_{10}$ ) recorded significantly higher grain and stalk yield (3.43 and 4.99 t ha<sup>-1</sup>, respectively) compared to all other treatments followed by the irrigation with beverage industry effluent + RDF + gypsum ( $T_7$ ) (3.2 and 4.7 t ha<sup>-1</sup>, respectively) and irrigation with fresh water + RDF with gypsum ( $T_6$ ) (3.08 and 4.51 t ha<sup>-1</sup>, respectively). The treatments  $T_3$  and  $T_5$  (2.14, 3.14 t ha<sup>-1</sup> and 2.0, 2.92 t ha<sup>-1</sup>, respectively) were found to be on par with each other. Significantly lower grain and straw yield (1.83 and 2.67 t ha<sup>-1</sup>, respectively) was recorded in the treatment receiving irrigation with beverage industry effluent + RDF without gypsum ( $T_2$ ).

Oil content and oil yield of sunflower crop varied significantly due to treatments. Significantly higher oil content (40.8 %) was recorded in the treatment  $T_9$  receiving cycle of 2 irrigations with fresh water + 1 irrigation with beverage industry effluent + RDF + gypsum followed by  $T_7$  and  $T_{10}$  (40.3 and

40.2%, respectively) and were on par with each other (Table 5). Maximum oil yield was observed in the treatment  $T_{10}$  which received cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF + gypsum (1377.3 Kg ha<sup>-1</sup>) followed by  $T_7$  and  $T_6$  (1288.4 and 1200.7 Kg ha<sup>-1</sup>, respectively). However, lowest oil content and oil yield was observed in the treatment  $T_2$  receiving irrigation with beverage industry effluent + RDF without gypsum (704.6 Kg ha<sup>-1</sup>, respectively).

### **Fatty acid profile**

The data pertaining to different fatty acids content of sunflower oil as influenced by beverage industry effluent irrigation are presented in table 6. Fatty acids such as palmitic, stearic, oleic and linoleic acid did not differ significantly due to beverage industry effluent irrigation. However, higher per cent of palmitic acid was recorded in the treatment  $T_{10}$  (6.79 %) and lower value was in treatment  $T_7$  (5.39 %). Further, stearic acid content was highest in the treatment  $T_7$  (3.62 %) and was lowest in the treatment  $T_{10}$  (2.97 %). Oleic and linoleic acid content was higher in the treatment  $T_8$  and  $T_3$  (50.4 and 52.7 %) but the lower content was recorded in the treatment  $T_3$  and  $T_8$  (37.8 and 40.8 %).

### **Growth, yield parameters and yield of sunflower**

The results revealed that growth, yield parameters and yield of sunflower crop differed significantly due to irrigation with beverage industry effluent and gypsum (Table 3 to 5). However, significantly higher plant height, number of leaves and head diameter was observed in the treatment  $T_{10}$  compared to all other treatments followed by  $T_7$  and  $T_6$ . 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. This increased plant growth attributes may be due to plant growth influencing material such as auxin, amino acids, vitamins that are influenced by S application (Imayavaramban *et al.*, 2002 and Ahmad and Jabeen, 2009).

Significant increase in yield attributes such as total dry matter, head weight, kernel weight per head, number of grains per head, grain filling per cent, test weight and volume weight were observed in T<sub>10</sub> compared to all other treatments followed by T<sub>7</sub> and T<sub>6</sub>. This could be due to addition of small amount of nutrients through effluent and gypsum, full exposure of head encouraged better photosynthesis, better pollination by the insects, better utilization of more photosynthates from protein and less fat synthesis coupled with FYM and S application (Vaiyapuri *et al.*, 2004).

Significant increase in grain and stalk yield of sunflower in treatment T<sub>10</sub> (3.43 and 4.99 t ha<sup>-1</sup>, respectively) compared to all other treatments followed by T<sub>7</sub>(3.2 and 4.7 t ha<sup>-1</sup>, respectively) and T<sub>6</sub> (3.08 and 4.51 t ha<sup>-1</sup>, respectively). Similar results were recorded by Dhananjaya (2005), Vijay Krishna (2005) and Basavalingaiah *et al.*, (2009a) who found that alternate irrigation with fresh water and lime treated coffee pulp effluent recorded higher fodder yield (35.2 t ha<sup>-1</sup>), which was on par with 2:1 cycles of lime treated coffee pulp effluent and fresh water (33.3 t ha<sup>-1</sup>). The enhanced values of yield attributing characters were witnessed due to tendency of nutrients in accelerating growth, photosynthetic activity and translocation efficiency of photosynthates towards the reproductive sink (Ujjinaiah *et al.*, 1995, Reddy and Kumar, 1996 and Yadav *et al.*, 2010).

**Table.1** Treatment details

|                       |   |
|-----------------------|---|
| <b>T<sub>1</sub></b>  | Irrigation with fresh water + RDF without gypsum  |
| <b>T<sub>2</sub></b>  | Irrigation with beverage industry effluent + RDF without gypsum   |
| <b>T<sub>3</sub></b>  | Alternate irrigation with fresh water and beverage industry effluent + RDF without gypsum                   |
| <b>T<sub>4</sub></b>  | Cycle of 2 irrigations with fresh water + 1 irrigation with beverage industry effluent + RDF without gypsum |
| <b>T<sub>5</sub></b>  | Cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF without gypsum |
| <b>T<sub>6</sub></b>  | Irrigation with fresh water + RDF + gypsum  |
| <b>T<sub>7</sub></b>  | Alternate irrigation with fresh water and beverage industry effluent + RDF + gypsum                         |
| <b>T<sub>8</sub></b>  | Cycle of 2 irrigations with fresh water + 1 irrigation with beverage industry effluent + RDF + gypsum       |
| <b>T<sub>9</sub></b>  | Irrigation with beverage industry effluent + RDF + gypsum   |
| <b>T<sub>10</sub></b> | Cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF + gypsum       |

**Table.2** Physico-chemical properties of effluent samples

| Parameters  | Sample-1 | Sample-2 | Sample-3 | Sample-4 | Sample-5 | Sample-6 | Sample-7 | Sample-8 | Sample-9 | Sample-10 | Average         |
|---|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|-----------------|
| pH  | 7.55     | 7.49     | 7.60     | 7.35     | 7.65     | 7.42     | 7.71     | 7.58     | 7.68     | 7.49      | <b>7.55±0.1</b> |
| EC (dS m <sup>-1</sup> )                                  | 1.52     | 1.50     | 1.62     | 1.58     | 1.68     | 1.48     | 1.76     | 1.54     | 1.69     | 1.53      | <b>1.59±0.1</b> |
| BOD (mg L <sup>-1</sup> )                                 | 46       | 42       | 50       | 39       | 35       | 45       | 36       | 49       | 47       | 33        | <b>42.2±6.1</b> |
| COD (mg L <sup>-1</sup> )                                 | 146      | 149      | 156      | 140      | 145      | 138      | 132      | 150      | 138      | 136       | <b>143±7.4</b>  |
| DS (g L <sup>-1</sup> )                                   | 1.75     | 1.91     | 2.0      | 1.86     | 1.95     | 1.72     | 2.10     | 1.92     | 1.95     | 1.98      | <b>1.91±0.1</b> |
| TSS (g L <sup>-1</sup> )                                  | 1.57     | 1.56     | 1.52     | 1.63     | 1.45     | 1.50     | 1.64     | 1.70     | 1.63     | 1.60      | <b>1.5±0.1</b>  |
| TS (g L <sup>-1</sup> )                                   | 3.26     | 3.39     | 3.3      | 3.48     | 3.31     | 3.25     | 3.81     | 3.70     | 3.56     | 3.58      | <b>3.46±0.2</b> |
| Na (m.eq L <sup>-1</sup> )                                | 9.6      | 10.4     | 10.3     | 9.4      | 10.8     | 9.5      | 10.5     | 9.8      | 11.6     | 10.9      | <b>10.3±0.7</b> |
| CO <sub>3</sub> (m.eq L <sup>-1</sup> )                   | nil      | nil      | nil      | nil      | nil      | nil      | nil      | nil      | nil      | Nil       | <b>Nil</b>      |
| HCO <sub>3</sub> (m.eq L <sup>-1</sup> )                  | 6.9      | 6.4      | 6.6      | 6.8      | 6.7      | 6.7      | 7.1      | 7.0      | 7.2      | 6.9       | <b>6.8±0.2</b>  |
| Total-N (mg L <sup>-1</sup> )                             | *        | *        | *        | *        | *        | *        | *        | *        | *        | *         | <b>*</b>        |
| Total-P (mg L <sup>-1</sup> )                             | 2        | 1.8      | 2.3      | 1.6      | 1.7      | 1.5      | 1.9      | 2.1      | 2.3      | 2.8       | <b>2.0±0.4</b>  |
| Total-K (mg L <sup>-1</sup> )                             | 30       | 31       | 34       | 28       | 35       | 30       | 34       | 25       | 38       | 45        | <b>33±5.6</b>   |
| Total-S (mg L <sup>-1</sup> )                             | 150      | 152      | 135      | 146      | 132      | 140      | 155      | 138      | 163      | 159       | <b>147±10.5</b> |
| Ca (m.eq L <sup>-1</sup> )                                | 3.70     | 3.40     | 3.45     | 3.63     | 3.56     | 3.82     | 3.78     | 3.94     | 3.95     | 3.45      | <b>3.67±0.2</b> |
| Mg (m.eq L <sup>-1</sup> )                                | 2.60     | 2.50     | 2.68     | 2.62     | 2.52     | 2.35     | 2.78     | 2.60     | 2.30     | 2.10      | <b>2.51±0.2</b> |
| Cl (m.eq L <sup>-1</sup> )                                | 7.7      | 7.5      | 7.6      | 7.3      | 7.0      | 7.2      | 7.4      | 7.5      | 8.9      | 7.8       | <b>7.5±0.5</b>  |
| Fe (mg L <sup>-1</sup> )                                  | nil      | nil      | nil      | nil      | nil      | nil      | nil      | nil      | nil      | nil       | <b>Nil</b>      |
| Cu (mg L <sup>-1</sup> )                                  | nil      | nil      | nil      | nil      | nil      | nil      | nil      | nil      | nil      | nil       | <b>Nil</b>      |
| Mn (mg L <sup>-1</sup> )                                  | nil      | nil      | nil      | nil      | nil      | nil      | nil      | nil      | nil      | nil       | <b>Nil</b>      |
| Zn (mg L <sup>-1</sup> )                                  | nil      | nil      | nil      | nil      | nil      | nil      | nil      | nil      | nil      | nil       | <b>Nil</b>      |
| B (mg L <sup>-1</sup> )                                   | nil      | nil      | nil      | nil      | nil      | nil      | nil      | nil      | nil      | nil       | <b>Nil</b>      |
| SAR   | 5.6      | 6.2      | 6.1      | 5.2      | 6.3      | 5.6      | 5.8      | 5.4      | 6.8      | 6.8       | <b>6.0±0.6</b>  |
| RSC (m.eq L <sup>-1</sup> )                               | 0.60     | 0.50     | 0.47     | 0.55     | 0.64     | 0.53     | 0.54     | 0.46     | 0.95     | 1.35      | <b>0.66±0.3</b> |
| Note: * indicates traces found that could not be detected |          |          |          |          |          |          |          |          |          |           |                 |
| <b>Sodium content of fresh water</b>                      |          |          |          |          |          |          |          |          |          |           |                 |
| Na (m.eq L <sup>-1</sup> )                                | 3.3      | 3.5      | 3.0      | 3.2      | 3.5      | 3.1      | 3.7      | 3.4      | 3.3      | 3.0       | <b>3.3±0.2</b>  |

**Table.3** Effect of beverage industry effluent irrigation on plant height, number of leaves and head diameter of sunflower

| Treatments            | Plant height (cm) |             |             |             | Number of leaves |             |             |             | Head diameter (cm) |             |             |
|-----------------------|-------------------|-------------|-------------|-------------|------------------|-------------|-------------|-------------|--------------------|-------------|-------------|
|                       | 30 DAS            | 60 DAS      | 90 DAS      | At harvest  | 30 DAS           | 60 DAS      | 90 DAS      | At harvest  | 60 DAS             | 90 DAS      | At harvest  |
| <b>T<sub>1</sub></b>  | 76.2              | 176.3       | 216.0       | 221.4       | 7.3              | 28.1        | 18.1        | 11.5        | 12.2               | 22.3        | 25.0        |
| <b>T<sub>2</sub></b>  | 61.2              | 161.4       | 201.6       | 205.6       | 4.2              | 21.9        | 12.1        | 8.6         | 8.1                | 18.2        | 19.2        |
| <b>T<sub>3</sub></b>  | 73.3              | 173.4       | 213.5       | 215.9       | 6.2              | 27.9        | 17.9        | 11.8        | 11.0               | 21.1        | 21.6        |
| <b>T<sub>4</sub></b>  | 70.3              | 169.9       | 210.5       | 216.5       | 6.1              | 27.2        | 17.2        | 12.4        | 11.1               | 21.1        | 22.5        |
| <b>T<sub>5</sub></b>  | 66.4              | 166.6       | 207.0       | 212.2       | 5.0              | 25.0        | 14.8        | 9.7         | 10.1               | 20.2        | 20.8        |
| <b>T<sub>6</sub></b>  | 82.0              | 182.2       | 222.4       | 226.7       | 8.9              | 30.1        | 20.1        | 13.3        | 14.0               | 24.1        | 29.0        |
| <b>T<sub>7</sub></b>  | 83.0              | 183.2       | 223.4       | 225.8       | 10.0             | 30.9        | 19.6        | 12.5        | 15.6               | 24.7        | 30.2        |
| <b>T<sub>8</sub></b>  | 78.3              | 178.6       | 218.8       | 223.1       | 8.1              | 29.1        | 19.7        | 13.4        | 13.1               | 23.1        | 26.8        |
| <b>T<sub>9</sub></b>  | 79.4              | 179.7       | 219.6       | 225.3       | 8.5              | 29.1        | 19.8        | 12.9        | 13.0               | 23.1        | 24.0        |
| <b>T<sub>10</sub></b> | 84.4              | 184.5       | 224.7       | 227.9       | 11.8             | 32.1        | 21.1        | 13.1        | 16.1               | 26.4        | 31.6        |
| <b>S. Em±</b>         | <b>2.27</b>       | <b>3.81</b> | <b>4.70</b> | <b>4.60</b> | <b>0.30</b>      | <b>0.86</b> | <b>0.72</b> | <b>0.25</b> | <b>0.50</b>        | <b>0.68</b> | <b>0.86</b> |
| <b>C. D. at 5%</b>    | <b>6.7</b>        | <b>11.3</b> | <b>14.2</b> | <b>13.5</b> | <b>0.91</b>      | <b>2.5</b>  | <b>2.2</b>  | <b>0.67</b> | <b>1.5</b>         | <b>2.0</b>  | <b>2.6</b>  |
| <b>CV (%)</b>         | <b>5.2</b>        | <b>3.8</b>  | <b>3.8</b>  | <b>4.2</b>  | <b>7.0</b>       | <b>5.3</b>  | <b>7.0</b>  | <b>6.2</b>  | <b>7.0</b>         | <b>5.3</b>  | <b>6.0</b>  |

**Legend:**

T<sub>1</sub>: Irrigation with fresh water + RDF without gypsum

T<sub>2</sub>: Irrigation with beverage industry effluent + RDF without gypsum

T<sub>3</sub>: Alternate irrigation with fresh water and beverage industry effluent + RDF without gypsum

T<sub>4</sub>: Cycle of 2 irrigations with fresh water + 1 irrigation with beverage industry effluent + RDF without gypsum

T<sub>5</sub>: Cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF without gypsum

FYM @ 7.5 t ha<sup>-1</sup> and borax @ 10 kg ha<sup>-1</sup> common for all the treatments

T<sub>6</sub>: Irrigation with fresh water + RDF + gypsum

T<sub>7</sub>: Irrigation with beverage industry effluent + RDF + gypsum

T<sub>8</sub>: Alternate irrigation with fresh water and beverage industry effluent + RDF + gypsum

T<sub>9</sub>: Cycle of 2 irrigations with fresh water + 1 irrigation with beverage industry effluent + RDF + gypsum

T<sub>10</sub>: Cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF + gypsum



**Table.4** Effect of beverage industry effluent irrigation on total dry matter production, head weight, kernel weight per head, number of grains per head, grain filling per cent, test weight and volume weight of sunflower

| Treatments            | TDM (g plant <sup>-1</sup> ) | Head weight (kg) | Kernel weight per head (g) | Number of grains per head | Grain filling per cent | Test weight (g) | Volume weight (g) |
|-----------------------|------------------------------|------------------|----------------------------|---------------------------|------------------------|-----------------|-------------------|
| <b>T<sub>1</sub></b>  | 152.9                        | 1.33             | 55.9                       | 1012                      | 91.4                   | 5.21            | 51.4              |
| <b>T<sub>2</sub></b>  | 105.2                        | 0.92             | 38.4                       | 696                       | 83.1                   | 3.59            | 35.2              |
| <b>T<sub>3</sub></b>  | 123.6                        | 1.07             | 45.1                       | 818                       | 87.2                   | 4.21            | 41.4              |
| <b>T<sub>4</sub></b>  | 133.6                        | 1.18             | 50.4                       | 898                       | 89.2                   | 4.63            | 45.5              |
| <b>T<sub>5</sub></b>  | 115.0                        | 1.00             | 42.0                       | 761                       | 85.6                   | 3.92            | 38.5              |
| <b>T<sub>6</sub></b>  | 177.4                        | 1.55             | 64.7                       | 1174                      | 93.8                   | 6.24            | 59.4              |
| <b>T<sub>7</sub></b>  | 176.7                        | 1.61             | 67.4                       | 1223                      | 94.4                   | 6.30            | 61.8              |
| <b>T<sub>8</sub></b>  | 163.9                        | 1.43             | 59.9                       | 1084                      | 92.6                   | 5.58            | 54.9              |
| <b>T<sub>9</sub></b>  | 146.8                        | 1.26             | 53.6                       | 971                       | 91.0                   | 5.00            | 49.2              |
| <b>T<sub>10</sub></b> | 180.2                        | 1.73             | 72.3                       | 1320                      | 95.3                   | 6.75            | 66.4              |
| <b>S. Em±</b>         | <b>3.3</b>                   | <b>0.046</b>     | <b>1.25</b>                | <b>30.7</b>               | <b>3.2</b>             | <b>0.10</b>     | <b>0.59</b>       |
| <b>C. D. at 5%</b>    | <b>9.8</b>                   | <b>0.138</b>     | <b>3.7</b>                 | <b>91.3</b>               | <b>9.6</b>             | <b>0.30</b>     | <b>1.75</b>       |
| <b>CV (%)</b>         | <b>3.9</b>                   | <b>6.2</b>       | <b>4.0</b>                 | <b>5.3</b>                | <b>6.2</b>             | <b>3.5</b>      | <b>2.0</b>        |

**Legend:**

T<sub>1</sub>: Irrigation with fresh water + RDF without gypsum

T<sub>2</sub>: Irrigation with beverage industry effluent + RDF without gypsum

T<sub>3</sub>: Alternate irrigation with fresh water and beverage industry effluent + RDF without gypsum

T<sub>4</sub>: Cycle of 2 irrigations with fresh water + 1 irrigation with beverage industry effluent + RDF without gypsum

T<sub>5</sub>: Cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF without gypsum

FYM @ 7.5 t ha<sup>-1</sup> and borax @ 10 kg ha<sup>-1</sup> common for all the treatments

T<sub>6</sub>: Irrigation with fresh water + RDF + gypsum

T<sub>7</sub>: Irrigation with beverage industry effluent + RDF + gypsum

T<sub>8</sub>: Alternate irrigation with fresh water and beverage industry effluent + RDF + gypsum

T<sub>9</sub>: Cycle of 2 irrigations with fresh water + 1 irrigation with beverage industry effluent + RDF + gypsum

T<sub>10</sub>: Cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF + gypsum

**Table.5** Effect of beverage industry effluent irrigation on grain yield, stalk yield, oil content and oil yield of sunflower

| Treatments            | Yield (t ha <sup>-1</sup> ) |             | Oil content (%) | Oil yield (kg ha <sup>-1</sup> ) |
|-----------------------|-----------------------------|-------------|-----------------|----------------------------------|
|                       | Grain yield                 | Stalk yield |                 |                                  |
| <b>T<sub>1</sub></b>  | 2.65                        | 3.89        | 39.2            | 1039.4                           |
| <b>T<sub>2</sub></b>  | 1.83                        | 2.67        | 38.6            | 704.6                            |
| <b>T<sub>3</sub></b>  | 2.14                        | 3.14        | 38.8            | 829.9                            |
| <b>T<sub>4</sub></b>  | 2.36                        | 3.45        | 38.8            | 913.2                            |
| <b>T<sub>5</sub></b>  | 2.00                        | 2.92        | 39.6            | 788.7                            |
| <b>T<sub>6</sub></b>  | 3.08                        | 4.51        | 39.0            | 1200.7                           |
| <b>T<sub>7</sub></b>  | 3.20                        | 4.70        | 40.3            | 1288.4                           |
| <b>T<sub>8</sub></b>  | 2.84                        | 4.17        | 39.7            | 1127.7                           |
| <b>T<sub>9</sub></b>  | 2.54                        | 3.73        | 40.8            | 1037.8                           |
| <b>T<sub>10</sub></b> | 3.43                        | 4.99        | 40.2            | 1377.3                           |
| <b>S. Em±</b>         | <b>0.08</b>                 | <b>0.15</b> | <b>0.432</b>    | <b>31.83</b>                     |
| <b>C. D. at 5%</b>    | <b>0.23</b>                 | <b>0.44</b> | <b>1.3</b>      | <b>94.6</b>                      |
| <b>CV (%)</b>         | <b>5.3</b>                  | <b>6.8</b>  | <b>1.9</b>      | <b>5.3</b>                       |

**Legend:**

T<sub>1</sub>: Irrigation with fresh water + RDF without gypsum

T<sub>2</sub>: Irrigation with beverage industry effluent + RDF without gypsum

T<sub>3</sub>: Alternate irrigation with fresh water and beverage industry effluent + RDF without gypsum

T<sub>4</sub>: Cycle of 2 irrigations with fresh water + 1 irrigation with beverage industry effluent + RDF without gypsum

T<sub>5</sub>: Cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF without gypsum

FYM @ 7.5 t ha<sup>-1</sup> and borax @ 10 kg ha<sup>-1</sup> common for all the treatments

T<sub>6</sub>: Irrigation with fresh water + RDF + gypsum

T<sub>7</sub>: Irrigation with beverage industry effluent + RDF + gypsum

T<sub>8</sub>: Alternate irrigation with fresh water and beverage industry effluent + RDF + gypsum

T<sub>9</sub>: Cycle of 2 irrigations with fresh water + 1 irrigation with beverage industry effluent + RDF + gypsum

T<sub>10</sub>: Cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF + gypsum

**Table.6** Effect of beverage industry effluent irrigation on different fatty acid content of sunflower oil

| Treatments            | Palmitic acid | Stearic acid | Oleic acid  | Linoleic acid |
|-----------------------|---------------|--------------|-------------|---------------|
|                       | (%)           |              |             |               |
| <b>T<sub>1</sub></b>  | 5.68          | 3.11         | 44.7        | 46.5          |
| <b>T<sub>2</sub></b>  | 5.98          | 3.43         | 44.5        | 46.1          |
| <b>T<sub>3</sub></b>  | 6.02          | 3.48         | 37.8        | 52.7          |
| <b>T<sub>4</sub></b>  | 6.33          | 2.88         | 39.8        | 50.7          |
| <b>T<sub>5</sub></b>  | 5.66          | 2.98         | 46.3        | 45.1          |
| <b>T<sub>6</sub></b>  | 5.52          | 3.12         | 48.3        | 43.1          |
| <b>T<sub>7</sub></b>  | 5.39          | 3.62         | 47.8        | 43.2          |
| <b>T<sub>8</sub></b>  | 5.45          | 3.31         | 50.4        | 40.8          |
| <b>T<sub>9</sub></b>  | 5.93          | 3.02         | 44.0        | 47.0          |
| <b>T<sub>10</sub></b> | 6.79          | 2.97         | 42.0        | 48.3          |
| <b>S. Em±</b>         | <b>0.29</b>   | <b>0.19</b>  | <b>3.5</b>  | <b>3.3</b>    |
| <b>C. D. at 5%</b>    | <b>NS</b>     | <b>NS</b>    | <b>NS</b>   | <b>NS</b>     |
| <b>CV (%)</b>         | <b>8.5</b>    | <b>10.3</b>  | <b>13.5</b> | <b>12.4</b>   |

**Legend:**

T<sub>1</sub>: Irrigation with fresh water + RDF without gypsum

T<sub>2</sub>: Irrigation with beverage industry effluent + RDF without gypsum

T<sub>3</sub>: Alternate irrigation with fresh water and beverage industry effluent + RDF without gypsum

T<sub>4</sub>: Cycle of 2 irrigations with fresh water + 1 irrigation with beverage industry effluent + RDF without gypsum

T<sub>5</sub>: Cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF without gypsum

FYM @ 7.5 t ha<sup>-1</sup> and borax @ 10 kg ha<sup>-1</sup> common for all the treatments

T<sub>6</sub>: Irrigation with fresh water + RDF + gypsum

T<sub>7</sub>: Irrigation with beverage industry effluent + RDF + gypsum

T<sub>8</sub>: Alternate irrigation with fresh water and beverage industry effluent + RDF + gypsum

T<sub>9</sub>: Cycle of 2 irrigations with fresh water + 1 irrigation with beverage industry effluent + RDF + gypsum

T<sub>10</sub>: Cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF + gypsum

Higher grain and stalk yield in sunflower 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 total dry matter, head weight, kernel weight per head, number of grains per head, grain filling per cent, test weight and volume weight. These results are in conformity with the findings of Parameswari (2009). Gypsum had significant effect in increasing the yield of the crop by reducing the effect of sodium on crop growth

Significantly lower grain yield and stalk yield (1.83 and 2.67 t ha<sup>-1</sup>, respectively) was recorded in the treatment receiving irrigation with beverage industry effluent + RDF without gypsum (T<sub>2</sub>) 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. These results are in agreement with findings of Mohamedin *et al.*, (2006) and Parameswari (2009).

### Quality of sunflower crop

Oil content and oil yield increased with increase in seed yield and increased S application rates. This might be attributed to the application sulphur which helped in conversion of carbohydrates to oil (Chopra and Kanwar, 1966) and it also played an important role in fatty acid synthesis by converting acetyl Co-A to malonyl Co-A. This might be one of the reasons for increased the oil content of sunflower with sulphur application (Padma *et al.*, 2001).

Fatty acids such as palmitic, stearic, oleic and linoleic acid did not differ significantly due to beverage industry effluent irrigation. There was no deleterious effect of the beverage industry effluent on the quality of sunflower oil due to beverage industry effluent. Day *et al.*, (1982) reported that wheat grain quality

was not affected by sewage effluent irrigation. Similar observations were reported by Mohan Singh *et al.*, (1993), Babu *et al.*, (1996) and Sharma *et al.*, (2011).

In conclusion, based on the results of field trial, it can be concluded that, sunflower crop performed well under beverage industry effluent irrigation in presence of gypsum. The continuous use of beverage industry effluent for several years may lead to a salinity buildup, as well as contribute to the deterioration of soil quality and results in lower growth, yield and quality of crops. But in Begur, Nelamangala region due to the even distribution of rain, one season crop might be under rainfed condition which might dilute the pollutants and be utilized during the next cropping season. 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 confirmatory results on this regard.

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