IMPACT OF TREATED WASTE WATER FROM FOOD PROCESSING INDUSTRIES IN AGRICULTURE THROUGH DRIP IRRIGATION SYSTEM

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ABSTRACT

Water is the essential basis for all forms of life. The present experiment was conducted in Jain Irrigation System Ltd. Jalgaon (India), to check the feasibility of treated waste water from food processing industry in agriculture. The experiment was laid out in split plot design for maize crop (Zea mays, DeKalb pinnacles) with three treatments viz., treated fruit waste water (M1), treated onion waste water (M2) and bore well fresh water (M3). Two emitter were selected viz., Model B2.0 (Non pressure compensating – S2) and Model C2.0 (Pressure compensating and compensating non leakage – S1). The different observations on each treatment were taken such as uniformity coefficient, plant height, yield, protein content and fat content. The results showed that the highest uniformity coefficient (96.07 %) M1 (01 DAS), plant height (267.82 cm) M1, yield (9.92 t ha^{-1}) M3, protein (7.82 %) M1 and fat (3.21%) M2. In conclusion, treated fruit waste water can be used as an alternative source of irrigation after fresh water source, as it has positive effect on crop growth, yield and quality parameters, also less maintenance while operating drip system as compared with treated onion waste water.

Keywords: waste water, uniformity coefficient, treated fruit waste water, treated onion waste water, maize.

1. INTRODUCTION

Agricultural use of water accounts for nearly 70 per cent of the water used throughout the world, and the majority of this water is used for irrigation. The sources of irrigation water are limited and demand for agricultural products is increasing. Inadequate access to water is one of the biggest problems faced the world. India is one such nation where demand of water has continuously overlapped its supply. The total water demand in the country in 2003 was close to 465 BCM which has been increased to 634 BCM in 2013 (www.snpinfrasol.com,2014).The wastewater from industries varies greatly in both flow and pollutional strength. Industrial wastewater may contain suspended, colloidal and dissolved (mineral and organic) solids. These wastes may contain inert, organic or toxic materials and possibly pathogenic bacteria. It is necessary to pre-treat the wastes water prior to release to the agriculture or municipal system. Jain Irrigation has food processing facilities for dehydration of onion, vegetables and production of fruit purees, concentrates and pulp. The annual average availability of treated waste water generated from fruit processing is 200000 cubic meters and from onion dehydration plant is about 150000 cubic meters (Anonymous, 2012). Maize (*Zea mays*) is the world's third most cereal crop after rice and wheat. It is referred as miracle crop and Queen of cereals due to its high productivity (Anon., 2011). It is a nutrients supplement for humans and animals, serves as a basic raw materials for the production of starch oil and protein, alcoholic beverages, and more, recently as potential fuel. In India maize growing areas are Andra Pradesh, Karnataka, Bihar, Rajasthan and Madhya Pradesh (Anon., 2011). However, major maize cultivation area is spread in rainfed condition contributing around 80-82 per cent of annual production in *kharif*, whereas left over production come from *Rabi* and summer season under irrigated conditions. The maize crop cultivation in India increased from 6611.30 – 8553.80 Mha (22.70 per cent) during the period of 2001–11 (Zhang *et al.,* 2012).

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2. MATERIAL AND METHODS

Field experiment was conducted during 30th January 2014 to 30th May 2014 in Rabi season. The experiment was located at Jain irrigation Systems Ltd. Jalgaon, India. The climate is semi-arid and the average annual rainfall is 690 mm. The maximum and minimum temperature and ET during the cropping period was 44 °C and 12 mm day $^{-1}$ and the minimum was 9.5 °C and 3.8 mm day^{-1} respectively. Soil texture of the experimental conducted site is sandy clay-loam. The total experimental area was about 1500 m^2 in the vicinity of food processing plant. The experiment was laid out in split plot design with 3 main treatments, 2 sub treatments with 5 replications are presented in the Plate 1. The raised beds of 1.2 m x 10 m were prepared for sowing maize seeds by maintaining plant and row spacing (30 cm x 40 cm). There were five replications for each treatment; each replication was having area about 100 m^2. Variety- DeKalb Pinacle (Hybrid Maize) was used for sowing. The irrigation system consists of 5000 litre storage tank, 2.5 hp pump, 63 mm water meter, 25 m^3/hr sand and disc filter, 40 mm control valves, 40 mm main line, 32 mm sub main lines, 16 inline laterals and other necessary details of treatment and sub treatments are explained below and depicted in plate1;

1. Main treatments (irrigation sources)
   - M1 - Treated fruit waste water (TFWW)
   - M2 - Treated onion waste water (TOWW)
   - M3 - Bore well fresh water (BWFW)
2. Sub treatment (emitter types – discharge 2 lph, emitter spacing 30 cm)
   - S1 - Pressure compensating, compensating non leakage emitter (Model C2.0)
   - S2 - Non pressure compensating emitter (Model B2.0)

Plate.1. Drip System and experimental maize crop layout

2.1 DETERMINATION OF PEAK WATER REQUIREMENT

Amount of irrigation water applied to drip treatments were based on daily pan evaporation readings. The water requirement of the crop was calculated based on the following equation mentioned in Jain Irrigation Systems Manual (Anonymous, 2008).

$$Q = A \times B \times C \times D$$

Where,

Q = Quantity of water required, lpd

A= Gross area per plant, m^2

B = Amount of area covered with foliage, fraction

C = Crop Coefficient, Fraction

D = Kp x Epan

Kp = Pan Coefficient

Epan = Evaporation from Class A open pan Evaporimeter, mm

2.2 DETERMINATION OF UNIFORMITY COEFFICIENT (UC)

To determine the uniformity coefficient in drip irrigation the depth of water in the formula was replaced by discharge rate of drip as suggested by Wu and Gitlin (1974). The discharge of emitter was measured by volumetric method for three minutes. The uniformity coefficient was calculated using equation by Keller and Karmeli (1974).

$$\text{UC, per cent} = 100\left[1 - \frac{D}{M}\right]$$

Where,
D = Average absolute deviation from the mean discharge rate, lph.
M = Mean discharge rate, lph.
Periodically observations on each treatment were taken for uniformity coefficient, plant height, yield, protein and fat content.

3. RESULT AND DISCUSSION

3.1 Water analysis

Treated waste water analysis revealed that all studied parameters were within permissible limit as declared by Maharashtra Pollution Control Board. Water analysis result should that the treated waste water from both fruit as well as onion processing industries was adding macro and micro nutrient in the water. Average value of waste water analysis is given in Table 1.

Table1. Quality of treated waste water and fresh water used for experiment

Parameters	Units	MPCB Norms	Different water treatments		
			TFWW	TOWW	BWFW
TDS	ppm	2100	810.67	1030.00	788.30
pH		6.5 to 9.0	7.27	7.63	6.73
BOD	ppm	30	8.83	15.17	0.56
COD	ppm	250	78.03	105.36	0.93
Cl	ppm	600	141.67	104.23	0.00
S	ppm	1000	47.67	40.53	0.00
EC	dS/m		1.22	1.60	1.10
N	ppm		2.23	0.61	0.48
P	ppm		0.65	6.26	1.48
K	ppm		44.23	45.09	50.94
Na	ppm		175.67	98.79	23.36
Ca	ppm		88.00	123.66	95.65
Mg	ppm		53.67	65.45	34.35

3.2 Uniformity coefficient

The data pertaining to uniformity coefficient of drip irrigation system at different stages (01, 30, 60, 90 and 120 DAS) of crop growth as influenced by different irrigation treatments and different emitter types as well as their interactions are presented in the Fig.1. There was significant effect of different irrigation treatments on the uniformity coefficient throughout the experiment, except at the end of experiment i.e. 120 DAS, there was not much difference in the uniformity under each treatment due to maintenance of drip system. The highest uniformity coefficient about was 96.07 per cent (01 DAS) was observed under TFWW. On the contrary, lowest uniformity coefficient of 90.07 per cent (90 DAS) was observed under TOWW. There was no any significant effect among the different emitter types, hence the highest uniformity coefficient of 96.04 per cent was observed under Model C2.0 type emitter (01 DAS). On the contrary, lowest uniformity coefficient of 88.60 per cent (90 DAS) was observed under Model B2.0 type emitter. Uniformity coefficient of emitters was within permissible limit throughout the experiment due to regular maintenance of all the components of drip system. The special care was taken to increase the clogging resistance of emitters by regular chlorine and acid treatment. The similar results were observed by Capra and Scicolone (2004).

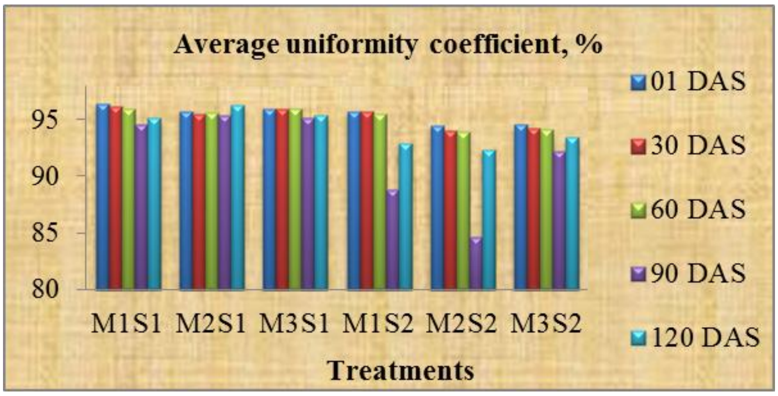

Fig.1. Effect of different irrigation treatments on uniformity coefficient

3.3 Plant height

The data pertaining to plant height at different stages 15, 30, 60, 90 and 120 DAS of crop growth was not influenced by different irrigation treatments and different emitter types as well as their interactions are presented in the Fig.2. There was no significant effect of different irrigation treatments and emitter types on plant height during all stages of plant growth except at 120 days. Under BWFW, plants have significantly more height (267.82 cm) than TOWW but it was statistically at par with TFWW. In different emitter type treatment final plant height varied between 262.51 cm to 265.51 cm. The interaction effects due to different irrigation treatments and emitter types on plant height during all stages of plant growth were found to be non-significant except TFWW at 15 DAS in Model B2.0 type emitter was showing significant growth in plant height. As a result of this may be due to the nitrogen, potassium nutrient increase the plant height. Higher nitrogen and potassium uptake in sandy clay loam soil is an evidence for this. Similar results were found by Adewoye *et al.* (2010).

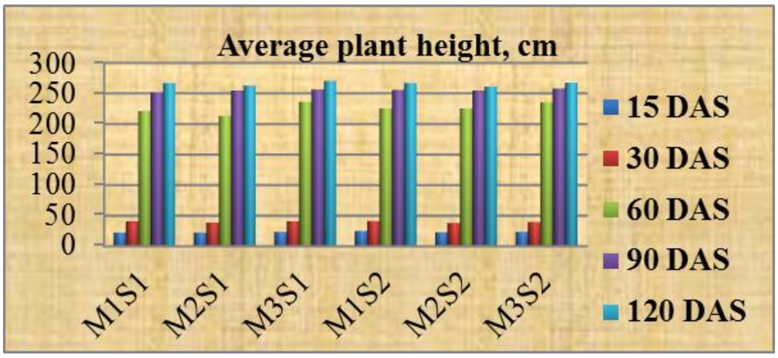

Fig.2. Effect of different irrigation treatments on maize plant height

3.4 Grain yield

The data pertaining to grain yield influenced by different irrigation treatments and different emitter types as well as their interactions are presented in the Fig 3. Significantly highest grain yield was observed under BWFW was about 9.92 t ha^{-1}. On the contrary, lowest grain yield 7.15 t ha^{-1} was observed under TOWW but among treated waste water TFWW (8.34 t ha^{-1}) has significant effect on grain yield. Among the different emitter types, significantly highest grain yield of 9.04 t ha^{-1} was observed under Model C2.0 type emitter. On the contrary, lowest grain yield was 7.15 t ha^{-1} in Model B2.0 type emitter. Interaction effects due to different irrigation treatments and emitter types on grain yield were found to be significant. The more difference in the grain yield was observed in the BWFW followed by TFWW and TOWW. The maximum grains yield was observed in the Model C2.0 type emitter (10.56 t ha^{-1}) in BWFW and minimum in Model B2.0 type emitter (6.62 t ha^{-1}) in TOWW. This may be due the treated waste water was carrying impurities were affecting the emitter performance and still the pressure compensating emitter were better than non-pressure compensating emitter in case of uniformity. Also the treated waste water was adding macro as well as micro nutrient to the soil and which was available during its growth period. Similar findings was observed by Hassanli *et al.* (2010)

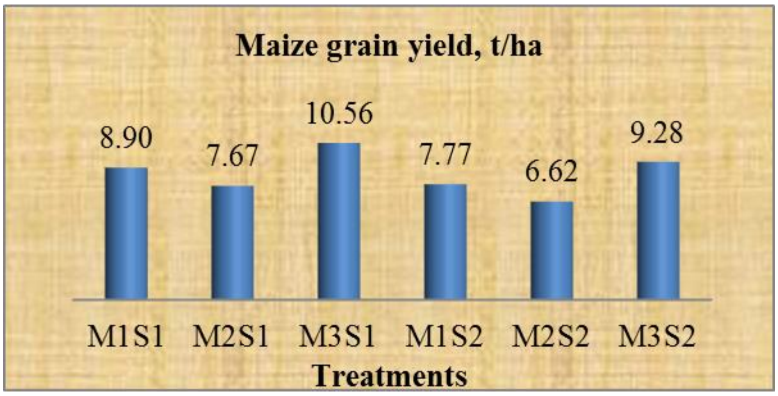

Fig.3. Effect of different irrigation treatments on maize grain yield

3.5 Quality parameters

Quality of maize depends on amount of protein and fat content within it. TFWW is containing maximum amount of protein (7.82 %) and TOWW is containing maximum amount of fat (3.21%) which is presented in Fig.4. This may be due to the essential micro nutrient present in the treated waste water from fruit and onion processing plant was available during growing period. The similar finding were observed by Pacco *et al*. (2009)

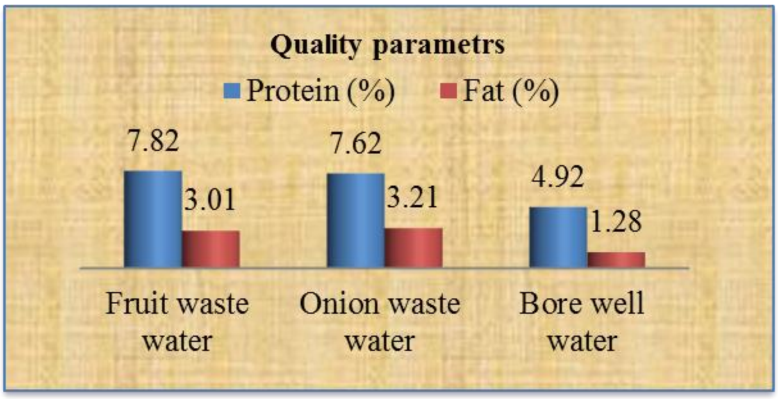

Fig.4. Effect of different irrigation treatments on protein and fat content of maize

4. CONCLUSION

- Model C2.0 type of emitter was having better performance throughout the experiment than Model B2.0 type emitter. It was observed that UC were more than 90 per cent for Model C2.0 type of emitter under TFWW, TOWW and BWFW. Performance of drip system was within the permissible limit for TFWW, TOWW due to chlorine and acid treatment for BWFW.
- The yield obtained under TFWW was 8.90 t ha^{-1} under Model C2.0 type emitter and 7.77 t ha^{-1} Model B2.0 type emitter, TOWW was 7.67 t ha^{-1} under Model C2.0 type emitter and 6.61 t ha^{-1} Model B2.0 type emitter and BWFW 10.55 t ha^{-1} under Model C2.0 type emitter and 9.27 t ha^{-1} Model B2.0 type emitter.
- Maximum yield was obtained under Model C2.0 type emitter in BWFW; whereas minimum yield was obtained under Model B2.0 type emitter in TOWW.
- Percentage protein and fat content in the maize was increased under treated fruit waste water and treated onion waste water.

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