Effect of Industrial Coconut Oil Effluent Irrigation on Germination, Growth and Yield of *Talinum fruticosum* L.

Abstract

The increase in food production has been the major concern to developing countries. Due to high demand for certain crops especially vegetables, farmers resort to the use of wastewater to cultivate these crops during dry season. The aim of this research work was to investigate the effects of industrial coconut oil effluent (ICE) on the germination, growth and yield of *Talinum fruticosum*. The physicochemical composition of the effluent was determined using standard analytical methods. Germination and vegetative growth (the plant height, number of leaves, leaf area and fresh weight) were studied on *T. fruticosum.* The plants were subjected to irrigation with 20%, 40%, 60%, 80%, 100% and 0% (control) concentrations of ICE. The experiment on the vegetative growth studies was carried out in a Completely Randomized Design (CRD). The data were collected every two weeks, subjected to Analysis of Variance (ANOVA) and means compared by using Duncan's new multiple range test (DNMRT) at $P < 0.05$.The results of physicochemical analysis of ICE showed that most parameters were above FEPA standard limits except lead. Results from germination and vegetative studies revealed that mean values from treatment 0% (control) were significantly higher at $P<0.05$ and that the germination of seeds and seedling growth gradually declined as the concentration of effluent increased. Therefore, adequate dilution of the effluent is required before disposal and reuse of ICE for irrigation purposes.

Key words: Seedlings, Vegetable production, Wastewater reuse. Water leaf.

INTRODUCTION

The increase in food production has been a major concern to Nigeria and many other tropical countries. Leafy vegetable is one of the foods obtained from plant sources and stand out as the most popular, being used in the preparation of most dishes eaten by man (Schippers, 2000). Nutritionally, *Talinum fruticosum* (water leaf) is high in crude- protein (22.1%), ash (33.95%) and crude fibre (11-12%); rich source of vitamins A and C, lipids, proteins, β-carotene and minerals such as calcium, potassium and magnesium (Ezekwe *et al.*, 2001) which are essential for maintenance of human health (Bolaji *et al.*, 2007; Osuagwu, 2008; Nya and Eka 2008). The consumption of vegetables in diet has been reported to protect the human body from degenerative diseases and their main protective action had been attributed to their antioxidants content (Swarna *et al.,* 2013). The continuous demand for water leaf has increased the need to cultivate it all year round. The use of effluent or wastewater is an important alternative source of water for irrigation especially during the dry season and in regions where water is scarce to meet up with the rising demand for fresh vegetables (Uaboi-Egbenni *et al*., 2009; Ogunkunle *et al*., 2013). The use of industrial effluents irrigation in the production of leafy vegetables is not a new concept and has been practised in many developed and developing countries (Nweze and Eji, 2005; Nzekwe *et al*., 2009).

Coconut fruit (*Cocos nucifera* L.) is of domestic and industrial importance because of the oil obtained from the solid endosperm (meaty part of coconut fruit). The industrial process of producing coconut oil generates huge quantities of wastes. During the extraction process, about 80% of the water results into coconut oil wastewater. Most times, the wastewater is discharged into the environment without proper treatment while some urban farmers divert effluents to farmlands to irrigate their vegetable farms for adequate output (Fatoba *et al*., 2011). Many investigators reported that effluents from distilleries, sugar industry, pulp and paper mills and textile industries cause gradual decline of seed germination and seedling growth with increasing concentration of the effluent. However, rate of inhibition was different for different seeds. Studies suggested that industrial effluents could be used safely for agricultural purposes with proper dilution (Uaboi-Egbenni *et al.*, 2009; Medhi *et al*., 2011; Narain *et al.*,2012)

Materials and methods

Study location

The planting was carried out in the Botanic Garden at the University of Nigeria, Nsukka (UNN) of 7^o $35^{'}00''$ E longitude and $6^o15^{'}$ $00''$ N latitude geographic co-ordinates. Nsukka is both commercial and agrarian town producing varieties of vegetable crops including *T. fruticosum.* The soil and plant samples were analyzed in the Department of Soil Science, and the Department of Crop Science respectively, of the University of Nigeria, Nsukka.

Collection of materials

Viable seeds of *Talinum fruticosum* were obtained from the Botanic Garden of the Department of Plant Science and Biotechnology, University of Nigeria Nsukka (UNN). Coconut oil effluent was collected from a coconut oil producing company in Nsukka and analysed at the Department of Biochemistry, UNN. The top soil and sandy soil were collected from the Botanic Garden of the Department of Plant Science and Biotechnology, UNN and poultry manure collected from the poultry farm at the Faculty of Agriculture, UNN.

Preparation of Soil Samples: The top garden soil, poultry manure and sandy soil were mixed in the ratio of 3:2:1 to formulate the amended soil. The sandy soil was added to facilitate drainage and easy uprooting of the seedlings for analyses. Two kilogram aliquots of amended garden soil were weighed using an electronic digital weighing balance (Furi, model: FEJ-600) and put into 180 polythene bags.

Preparation of Effluent: The various concentrations of coconut oil effluent used for the irrigation experiments were prepared as follows: 0% control (100 ml tap water), 20% concentration (20 ml effluent + 80 ml tap water), 40% concentration (40 ml effluent + 60 ml tap water), 60% concentration (60 ml effluent + 40 ml tap water), 80% concentration (80 ml effluent + 20 ml tap water), and 100% (100 ml effluent).

Nursery bed preparation

Two nursery baskets filled with amended soil were used. The seeds of *Talinum fruticosum* were nursed in the nursery baskets filled with amended soil samples and watered daily till the plants were ready for transplanting.

Plate 1: *T. fruticosum* growing in a nursery (4 weeks after planting).

Transplanting

The seedlings were transplanted four weeks after germination into 180 polythene bags each containing 2 kg of amended soil. Transplanting was done in the evening to avoid the effect of transpiration on the seedlings. The plants were watered with tap water at an interval of two days for two weeks for the seedlings to stabilize before application of effluent. Thereafter, 100 ml of the effluent concentrations of 0%, 20%, 40%, 60%, 80% and 100% respectively were applied on the seedlings. Irrigation was done at an interval of two days for 12 weeks.

Germination Studies

The germination studies were carried out in the Postgraduate Laboratory of the Department of Plant Science and Biotechnology, University of Nigeria Nsukka. Twenty seeds of *T. fruticosum* were sown in each of18sterilized Petri dishes lined with filter papers. Then, 2 ml of tap water (0%, control) and 2 ml each of effluent solution at 20%, 40%, 60%, 80% and 100% were respectively added in different labelled Petri dishes. One millilitre of tap water was added to the control and 1 ml effluent diluents was added to the various dilutions respectively at two - day intervals to keep the plates moist. The experiment was replicated three times. They were left to stand for seven days and the treatments were monitored after sowing to know the treatment that can retard or enhance germination. Records of the following were taken:

(i) Days of germination: The number of days it took the seeds to germinate was recorded.

(ii) Germination percentage: This was calculated for the various treatments respectively following the equationpresented by Omosun *et al.*, 2008

$$\text{Germination (\%)} = \frac{\text{total number of normal germinated seed}}{\text{total number of sown seeds}} \times 100.$$

Chemical Analysis of Industrial Coconut Oil Effluent

Some selected chemical properties such as nitrogen, Phosphorus, copper, lead, chromium, and exchangeable cations (K, Ca and Mg) were determined by leaching method (AOAC, 2002). The biological oxygen demand (BOD) and Chemical oxygen demand (COD) were determined following Winkler's method as described by Horvitz and Latimer (2006). The pH of the samples was measured with a glass electrode in 1:2 sample-water ratio suspensions using digital pH meter (Metrohm, Model: 872 Labo-maga symbol).

Experimental Design

The experiment was carried out in a Completely Randomized Design (CRD) comprising of six treatments. Each treatment was replicated eighteen times given a total of 180 experimental units.

Statistical Analysis

The data from each treatment were subjected to analysis of variance (ANOVA) and means were separated using Duncan's Multiple Range Test (DMRT) at $p < 0.05$ level of significance, using Statistical Package for Social Sciences (IBM SPSS) version 20.

Results

Chemical Composition of Industrial Coconut Oil Effluent (ICE)

The values of some chemical components of industrial coconut oil effluent (ICE) showed in Table 1 revealed that the data obtained from ICE (pH, BOD, COD, N, P, K, Cd, Cr) were above FEPA accepted standards for irrigation water, except lead that was within acceptable limits. Fats and oils contents were quite high and above and beyond the recommended standard for discharge on land. pH was acidic as well.

Table 1: Chemical analysis of industrial coconut oil effluent

Properties	ICE	FEPA(1991) for Irrigation Water
pH	4.0	6.5-9
DO(mg/L)	8.50	NA
BOD (mg/L)	8,200	4.0
COD(mg/L)	12,667	120
Fats &oil	20.34	10
Nitrogen (mg/L)	9.5	0.10
Phosphate (mg/L)	5.35	0.02
Potassium (mg/L)	4.63	0.2
Magnesium (mg/L)	33.40	0.50
Calcium (mg/L)	26.50	0.20
Lead (mg/L)	4.36	5.0
Cadmium (mg/L)	1.14	0.01
Chromium(mg/L)	0.82	0.10

Key: ICE = Indusial Coconut Effluent, FEPA= Federal Environmental Protection Agency, NA = Not Avaiable.

Seed Germination

The seed percentage germination gradually declined as the treatment increased (Table 1). The highest percentage germination (74%) was recorded for 0% (control) treatment, followed by treatment with 20% ICE (58%). Treatment with 100% ICE gave the least seed percentage germination of 8%.

Table 2: **Percentage seed germination with different Industrial Coconut Effluent (ICE) concentrations**

ICE Concentration	No. of Germinated Seeds	Percentage Germination
0% (control)	35	74%
20%	28	58%
40%	23	46%
60%	20	40%
80%	9	18%
100%	4	8%

Effect of Effluent on Plant Growth and Yield of *T. fruticosum*

The impact of coconut oil effluent irrigationon plant height, number of leaves, leaf area and fresh and dry weight are shown in Tables 3, 4, 5,6 and 7 respectively. From the 2nd to the 12th week after treatment (WAT) in all the treatments, 0% (control) treatment gave the highest ($P<0.05$) mean plant height followed 20% while 100% treatment had the lowest mean plant height (Table 3).

The control gave the highest number of leaves ($P<0.05$) from the 2nd to 12thWAT, while 100% treatment had the lowest number (Table 4). At 4, 8, and 10 WAT, 20%, 40%, 60% and 80% treatments were the same for each week. However, at 6 WAT, 60%, 80%, and 100%

treatments produced the same number of leaves which were significantly (P< 0.05) lower than the number of leaves produced by 20% and 40% treatments.

The highest mean leaf area was produced by the 0% (control) treatment from the 2nd to 12th WAT and this was significant at P<0.05 while 80% and 100% treatments gave low leaf area (Table 5).The highest leaf fresh and dry weight were obtained in 0% treatment (control) followed by 20% treatment while 100% ICE treatment had the least (Table 6).The plant height, number of leaves, leaf area, stem girth, root length and fresh and dry weight of *Talinum fruticosum* grown in the control (0%) treatment were significantly higher (P<0.05) than all the growth and yield parameters measured in ICE treated plants.

Table 3: Mean plant height (cm) of *T. fruticosum* irrigated with different concentrations of ICE.

ICE Treatments	**Week after Treatment (WAT)**					
	2	4	6	8	10	12
0% (control)	28.0 ± 1.16[a]	30.7 ± 1.45[a]	32.3 ± 1.45[a]	35.7 ± 2.33[a]	38.3 ± 2.40[a]	42.0 ± 1.53[a]
20%	26.0 ± 0.58[ab]	28.0 ± 1.53[ab]	29.3 ± 1.76[ab]	30.7 ± 1.20[b]	31.3 ± 1.20[b]	34.3 ± 1.20[b]
40%	25.0 ± 1.00[bc]	26.3 ± 1.86[bc]	26.7 ± 1.45[bc]	27.7 ± 1.45[bc]	28.7 ± 1.45[bc]	31.7 ± 0.88[bc]
60%	24.3 ± 0.88[bc]	25.3 ± 0.88[bc]	26.0 ± 1.53[bc]	26.7 ± 1.67[bc]	27.7 ± 1.67[bc]	30.**0** ± **2**.52[bc]
80%	23.7 ± 0.33[bc]	24.7 ± 0.33[bc]	25.3 ± 0.88[bc]	26.0 ± 1.00[bc]	27.0 ± 1.53[bc]	27.7 ± 1.45[c]
100%	23.0 ± 0.58[c]	23.3 ± 1.20[c]	24.3 ± 0.33[c]	24.7 ± 0.33[c]	25.0 ± 1.00[c]	26.3 ± 1.86[c]

Data are presented in means ± standard error. Means with different alphabets on the same column are significantly different using Duncan New Multiple Range Test (DNMRT) at P < 0.05.

Table 4: Mean number of leaves of *T. fruticosum*irrigated with different concentrations of ICE.

ICE Treatments	**Week after Treatment(WAT)**					
	2	4	6	8	10	12
0% (control)	15.0 ± 0.58[a]	24.7 ± 1.20[a]	28.0 ± 2.52[a]	29.0 ± 2.08[a]	30.0 ± 3.06[a]	32.0 ± 3.06[a]
20%	14.7 ± 0.88[a]	21.3 ± 1.86[a,b]	22.7 ± 1.20[b]	25.7 ± 0.88[ab]	26.7 ± 0.88[ab]	27.0 ± 0.58[b]
40%	14.3 ± 0.88[a]	19.7 ± 3.28[abc]	21.0 ± 1.16[b]	24.0 ± 2.08[ab]	24.3 ± 1.76[a,b]	25.3 ± 0.33[bc]
60%	14.3 ± 0.88[a]	17.0 ± 2.65[bc]	19.0 ± 0.58[bc]	23.0 ± 0.58[b]	24.0 ± 0.58[b]	20.7 ± 1.76[cd]

80%	14.0 ± 0.58^{a}	15.3 ± 1.45^{bc}	16.0 ± 1.16^{c}	21.7 ± 1.76^{b}	22.0 ± 2.08^{bc}	18.3 ± 0.88^{d}
100%	13.7 ± 1.20^{a}	14.0 ± 1.53^{c}	14.7 ± 1.76^{c}	15.3 ± 1.45^{c}	18.0 ± 1.16^{c}	17.7 ± 1.45^{d}

Table 5: Mean leaf area (cm^2) of *T. fruticosum* irrigated with different concentrations of ICE.

Treatments	**Week after Treatment (WAT)**					
	2	4	6	8	10	12
0% (control)	39.07 ± 0.93^{a}	58.93 ± 3.85^{a}	62.07 ± 5.62^{a}	69.30 ± 8.04^{a}	83.67 ± 3.76^{a}	102.00 ± 6.43^{a}
20%	22.67 ± 2.29^{b}	41.67 ± 1.67^{b}	53.00 ± 4.73^{a}	53.93 ± 2.99^{ab}	54.60 ± 5.80^{b}	59.87 ± 5.39^{b}
40%	20.13 ± 6.06^{bc}	31.20 ± 7.02^{bc}	34.40 ± 2.81^{b}	40.37 ±12.37^{bc}	43.33 ± 5.46^{bc}	52.33 ± 7.84^{b}
60%	17.27 ± 1.46^{bc}	21.30 ± 3.53^{c}	23.03 ± 1.35^{bc}	34.33 ± 6.69^{bc}	37.16 ± 6.02^{cd}	40.35 ± 7.71^{bc}
80%	15.83 ± 2.20^{bc}	16.47 ± 3.15^{c}	17.77 ± 3.12^{c}	22.65 ± 1.98^{c}	24.43 ± 2.72^{de}	29.18 ± 6.14^{d}
100%	12.37 ± 1.45^{c}	24.40 ± 6.84^{c}	31.03 ± 8.76^{bc}	19.14 ± 2.32^{c}	14.07 ± 2.07^{e}	10.30 ± 1.30^{d}

Table 6: Mean fresh weight (g) of *T. fruticosum* irrigated with different concentrations of ICE.

ICE Treatments	**Week after Treatment(WAT)**					
	2	4	6	8	10	12
0% (control)	26.82 ± 3.45^{a}	30.97 ± 3.16^{a}	40.68 ± 3.72^{a}	52.02 ± 3.79^{a}	60.85 ± 3.77^{a}	70.99 ± 1.06^{a}
20%	22.43 ± 0.36^{ab}	25.68 ± 3.73^{ab}	30.25 ± 3.08^{ab}	40.29 ± 2.70^{b}	52.71 ± 1.64^{ab}	66.29 ± 1.95^{ab}
40%	18.92 ± 3.90^{ab}	21.52 ± 0.74^{ab}	28.86 ± 3.47^{ab}	37.99 ± 3.78^{bc}	47.83 ± 2.83^{ab}	61.50 ± 1.76^{bc}
60%	17.33 ± 2.89^{ab}	18.31 ± 2.86^{b}	26.61 ± 3.98^{b}	33.69 ± 4.47^{bc}	43.62 ± 3.00^{b}	57.97 ± 1.93^{cd}
80%	15.69 ± 2.87^{b}	18.00 ± 3.00^{b}	23.36 ± 4.40^{b}	31.51 ± 1.84^{bc}	38.81 ± 1.42^{b}	53.65 ± 2.65^{d}
100%	14.79 ± 3.58^{b}	16.57 ± 3.23^{b}	20.97 ± 3.69^{b}	28.94 ± 0.82^{c}	20.47 ±10.02^{c}	43.19 ± 3.65^{e}

Data are presented in means ± standard error. Means with different alphabets on the same column are significantly different using Duncan New Multiple Range Test (DNMRT) at $P < 0.05$.

Table 7: Mean leaf dry weight (g) of *T. fruticosum* irrigated with different concentrations of ICE.

ICE Treatment	Week after Treatment (WAT)					
	2	4	6	8	10	12
0%(control)	2.70 ± 0.34[a]	3.27 ± 0.14[a]	4.07 ± 0.37[a]	5.20 ± 0.38[a]	6.08 ± 0.38[a]	7.10 ± 0.11[a]
20%	2.25 ± 0.04[a,b]	2.84 ± 0.30[a,b]	3.03 ± 0.30[a,b]	4.03 ± 0.28[b]	5.27 ± 0.16[a,b]	6.56 ± 0.22[a,b]
40%	1.89 ± 0.39[a,b]	2.15 ± 0.10[b,c]	2.89 ± 0.35[b]	3.80 ± 0.38[b,c]	4.78 ± 0.28[b,c]	5.85 ± 0.13[b,c]
60%	1.73 ± 0.29[a,b]	1.83 ± 0.29[c]	2.66 ± 0.40[b]	3.37 ± 0.45[b,c]	4.36 ± 0.30[c,d]	5.66 ± 0.33[c]
80%	1.71 ± 0.21[a,b]	1.80 ± 0.30[c]	2.33 ± 0.44[b]	3.15 ± 0.18[b,c]	3.88 ± 0.14[d,e]	4.62 ± 0.31[d]
100%	1.47 ± 0.35[b]	1.65 ± 0.32[c]	2.07 ± 0.12[b]	2.90 ± 0.08[c]	3.32 ± 0.27[e]	3.76 ± 0.18[e]

DISCUSSION

The chemical components of industrial coconut effluent had higher values than FEPA (1991) values for use as irrigation water for crops. The increase in BOD and COD was as a result of high level of pollutants in wastewater. This makes the effluent unsuitable for irrigation purposes. The pH value was acidic. The acidic nature of ICE may have originated from the corrosion of the machine used in processing the coconut fruits as well as organic acids found in fresh fruit (Mbagwu, 2003). Fats and oils content was above the recommended standard for discharge on land.

In this study, the results obtained from seed germination indicate that the lower concentrations of the effluent could promote germination of *T. Fruticosum* seeds while higher concentrations of ICE had inhibitory effect. Reduction in germination of seeds irrigated with the ICE is due to the high amount of oil present in the effluent. This result conforms with the findings of Osubor and Oikeh (2013) who attributed the reduction of seed germination to the oily nature of palm oil industrial effluent on maize.

In this present study, there was decline in plant height, number of leaves, leaf area and fresh and dry weight. The reduction in height of *T. fruticosum* was due to high level of oil in the effluent which cause deficiency in availability of nutrients needed to maintain physiological processes involved in plant growth. These findings agree with the work of Omosun *et al.* (2008) who reported that the oily nature of the effluent may create anaerobic condition in the soil which lead to the reduction in uptake of nutrients needed for plant growth.

The decrease in the number of leaves may be attributed to the presence of heavy metals in the effluent. This is in line with the findings of Jadoon *et al*. (2013) who noted that heavy metals accumulation in vegetables had negative impacts on the growth and yield due to impaired uptake of water and nutrients.

Meanwhile, the mean leaf area declined with increase in application of effluent. This may be due to the toxic nature of the ICE as reported by Uaboi-Egbnni *et al*. (2009) who investigated the impact of industrial effluents (toiletries and plastic effluent) from different industries on *Abelmoschus esculentus.*They observed that effluents induced detrimental effects on leaf width and length. The fresh weight of *T. fruticosum* of the control was significantly higher than other treatments due to high COD, BOD, oil content of the effluent and heavy metals. This is in line with the reports of Narain *et al*. (2012) that different concentrations of distillery effluent influence fresh and dry weight of *Cicer arietinum.*

CONCLUSION

In water scarce countries, reuse of effluents for irrigation of various vegetables is a very effective method to meet the demand, of adequate water for food supply. From this study, it was revealed that although industrial coconut oil effluent inhibited plant germination and growth at high concentrations, at low concentration (20%), if properly managed, improvement of the soil fertility and promotion of healthy growth of vegetables may be achieved.

Furthermore, higher concentrations of industrial coconut effluent caused delayed germination, low fresh and dry weigh, retarded growth and reduced leaf area,. Hence, ICE for irrigation purposes,should be properly treated or diluted for effective growth and yield of vegetables and crops.

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