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Growth of *Abelmoshus esculentus* L. (Okra) and *Telfairia occidentalis* Hook F. (Fluted Pumpkin) Treated with Beauty Salon Wastewater

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Abstract: Waste water has been identified as a widespread problem in all categories of dense settlements in Africa due to poor or absence of waste management. Beauty salons generate large amount of waste water and its indiscriminate discharge into water drains in Nigeria predisposes home gardens and water sources for irrigation to contamination, thus having contact with crops and affecting their growth. In view of this, two widely grown field and home garden vegetables in Nigeria, *Abelmoschus esculentus* L. (Okra) and *Telfairia occidentalis* HOOK F. (Fluted pumpkin), treated with beauty salon wastewater (BSWW) were assessed for growth. The plants were cultivated in experimental pots and irrigated with 0(control), 25, 50, 75 or 100% concentration of the wastewater. The experiment lasted for eight weeks and laid out in a completely randomized (CRD) design with each treatment having 6 single-plant replicates. The height of both plants increased significantly at 25-75% concentrations of BSWW when wastewater-treated plants were compared with the control. *T. occidentalis* produced significantly ($p \leq 0.05$) more number of leaves at 50% BSWW than the control when plants irrigated with waste water were compared with the control. The highest increase in number of *A. esculentus* leaves was also significant at 75% BSWW concentration. Significant ($p \leq 0.05$) increase in leaf area of *T. occidentalis* was recorded at 75% concentration of BSWW with 78.83cm^2 compared to 48.85cm^2 in the control. Similarly, *A. esculentus* had the highest value of leaf area that was significant at 75% concentration of wastewater when plants exposed to waste water treatment were compared with the control. At 25-75% concentrations of BSWW, a significant ($p \leq 0.05$) increase in stem girth of both plants was recorded relative to plants without wastewater treatment. The use of beauty salon wastewater in irrigation of vegetables can serve as an alternative source of fertilizer for improved growth.

Keywords: Beauty Salon Wastewater, Pollution, Fertilizer, Vegetable Production

1. Introduction

Wastewater reuse for irrigation in agriculture is a significant management approach in areas with limited and inadequate freshwater resources, yielding prospective economic and environmental benefits. The practice has diverse benefits in the form of water conservation, nutrient recycling and prevention of surface and ground water pollution [1].

Burton and Stensel described wastewater as any water that has been adversely affected in quality due to human activities. They include domestic liquid waste from residences, industries or agriculture [2]. Beauty salons offer wide range of services from skin treatments and hair styling to manicure, makeup and tanning application. In providing these services, wastewater is generated. It is usually discharged indiscriminately into open land and gutters where they can get in contact with crops and some cases flow to discharge in water bodies. In some cases, this waste goes into the sanitary sewer system, where it can have a negative impact on the environment [3]. A typical example of what happens, is logging of contaminated water in the soil. In this situation, oxygen becomes less available as electron acceptor, results in the reduction of available nitrate into gaseous nitrogen which has negative effects. Leaching into ground water is a major concern, because of the recalcitrant nature of some contaminants [4].

As demand for fresh water intensifies, wastewater is frequently being seen as a valuable resource and an important alternative source of water for irrigation [5]. Good quality water resources are becoming scarce and are allocated for urban water supply. Large amounts of water are needed for irrigation in agriculture; therefore, if the wastewater can be used as alternative water source for irrigation, both the problems of water scarcity and soil nutrient deficiency can be solved. Kiziloglu *et al.* reported that the application of wastewater to crop land is an attractive option for disposal because it can improve physical properties and nutrient contents of soils [6]. In many areas, the few freshwater supply stations (boreholes) are owned by individuals, and the water is sold to others who cannot afford to set up one. In such a situation, the subsistent farmers are forced to resort to a cheaper alternative wastewater. One of the applications of wastewater is its reuse as irrigation water in agriculture.

Wastewater is rich in organic materials and plant nutrients (N, P, K, Ca, S, Cu, Mn and Zn) and has been reported to increase crop yield [7]. Moreover, wastewater provides nutrients other than N and P for improving crop production through improving soil fertility and soil organic matter content. Thus, its use would help in water conservation, nutrient recycling, reduction in direct fertilizer inputs and minimizing pollution loads to receiving water bodies [8-11]. Alderfasi reported the increase in the growth of wheat plants irrigated with treated wastewater [12]. The effect of irrigation with secondary treated wastewater was reported by many authors [13-17]. The wastewater being a rich source of organic matter and plant nutrients for improved crop growth is used by poor farming communities for irrigation to reduce dependency on chemical fertilizers.

However, apart from plant nutrients, waste water may contain various potentially toxic elements and organic matters with highly harmful effects on human and animal health. Wastewater contains relatively high amounts of sodium, which can be accumulated in the soil during irrigation with this wastewater and display toxic effects on the plants. If this wastewater is not disinfected or treated in stabilization ponds, it is highly contaminated with microorganisms. Therefore, the utilization of municipal wastewater for the irrigation of crops is associated with a number of risks. Very serious risks are those of crop yields reduction, crops quality deterioration, crops contamination with pathogens and intestinal helminthes [18]. Tabari *et al.* reported that wastewater irrigation could enrich soils with heavy metals to levels that may pose potential risk to the environment and human health [19]. Tabatabaei observed that continuous wastewater application to the soil could alter soil infiltration characteristics [20]. Mojiri *et al.* found increased electrical conductivity (EC), organic matter (OM), total N, Na and heavy metals in soil due to wastewater irrigation [21].

Vegetables play important role in meeting the food requirements of people world-wide because they are important sources of various essential components i.e. minerals, dietary fibers and vitamins [22]. They are also potential sources of essential nutrients and constitute functional food components by providing protein, iron and calcium which have noticeable health effects [23]. The continuous demand for vegetables has increased the need to cultivate these crops all year round. This in effect leads to the dependence on wastewater during the dry seasons or during periods of drought. Also, due to high water requirement of some crops, the use of wastewater to supplement the freshwater, if any, becomes inevitable.

Okra and fluted pumpkin constitute a major part of the commonly consumed vegetables which are widely grown on the field and in home gardens where there is high tendency of contact with beauty salon wastewater. The study is therefore aimed at investigating the impact of beauty salon wastewater on okra and fluted pumpkin growth.

2. Materials and Method

2.1. Experimental Location

The experiment was carried out in the screen house of Plant Science and Biotechnology Department, Adekunle Ajasin University, Akungba Akoko, Ondo State, Nigeria (latitude 7^0 37^iN and longitude $5^0$44E).

2.2. Planting Materials

Matured seeds of *A. esculentus* were obtained from the Premier Seed Company Ibadan, Oyo State, Nigeria, while that of *T. occidentalis* were obtained from a local market at Oka-Akoko, Ondo State, Nigeria.

2.3. Source of Soil for Planting

Top soil used for the experiment was collected from the experimental farm of Plant Science and Biotechnology Department, Adekunle Ajasin University, Akungba Akoko. The soil physicochemical properties had earlier been determined by Kekere and Omoniyi [24].

2.4. Source of Beauty Salon Wastewater

The beauty salon wastewater was collected from a septic wastewater tank from a beauty salon in Akungba Akoko, Ondo State.

2.5. Experimental Set-up

Concentrations of 25, 50, 75, and100% of the wastewater were prepared in a plastic keg just before each treatment by dilution with tap water to make the desired concentrations. Three viable seeds each of *A. esculentus* and *T. occidentalis* were sown in perforated polythene bags containing 3kg of top soil. Seedlings were allowed to establish for three weeks and thinned to one seedling per pot. Each plant was irrigated with 250ml (volume enough to keep the soil moist) 2 times in a week; thus each pot received 500ml of irrigation per week. Plants were treated for 8 weeks from July to October, 2016. Pots were laid in a completely randomized design, with 6 single plant replicates per treatment.

2.6. Growth Measurement

Plant height was measured from the stem base to the apical bud using meter rule while stem girth was measured using a digital digital Vernier caliper (model 0-200 mm)at the 5cm point from the base of the stem. The plants were carefully uprooted after soaking the soil with water to prevent root damage. The roots were washed and their length measured. The leaves were counted and their area measured by comparing the weight of a cut-out traced area with standard paper of known weight to area ratio [25].

Total leaf area was determined using,

$$\text{Specimen area} = \frac{\text{Standard paper area x specimen weight}}{\text{Standard paper weight}}$$

The relative growth rate was calculated using the formula: Relative growth rate = In mass 2 –In mass 1/time (days), where mass 1= the initial biomass at the commencement of the experiment, mass 2= total biomass at the end of the experiment, time = the period interval between the two biomass determinations in days.

2.7. Chlorophyll Content Analysis

The total chlorophyll content was determined using the Arnon method [26]. One gram of fresh leaves was ground with acid leached sand, (sand washed with concentrated sulphuric acid (H_2SO_4) and thoroughly rinsed with distilled water to remove all nutrients). The chlorophyll content was extracted using 10ml of 80% acetone and centrifuged at 2000rpm for 15minutes. The clear supernatant liquid was decanted and the absorbance read with photo spectrophotometer at 663nm and 645nm respectively. The 80% acetone served as reference blank. The total chlorophyll content was calculated using the formula:

Total chlorophyll content= $\{20.2 \text{ x } D_{645} + 8.02 \text{ x } D_{663}\} \text{ x } \{(50/100 \text{ x } (100/5) \text{ x}1/2\}$

2.8. Statistical Analysis

Data obtained were subjected to One-way Analysis of Variance (ANOVA) and means were separated with Tukey HSD test at 5% level of probability using SPSS 21.0 version.

3. Results and Discussion

There was variation in growth of the plant species as a result of beauty salon wastewater treatment. Table I shows that a significant ($p \leq 0.05$) increase in plant height occurred in *A. esculentus* and *T. occidentalis* at 25-75% concentrations of the beauty salon wastewater but decreased at the 100% concentration in comparison with the control. The highest increase in plant height of *T. occidentalis* was obtained at 50% concentration of the beauty salon wastewater. At week eight (8) of treatment with BSWW, the height was 166.01cm as against 162.75cm in the control and 146.52cm at higher concentration of 100% of the wastewater. *A. esculentus* also showed maximum increase in plant height at 50% treatment level of the wastewater (Table 2). This result is consistent with that obtained by Alderfasi who reported an increase in the growth of wheat plants when irrigated with treated wastewater [12]. Wastewater having high level of Na can enhance the growth parameters in treated plants. Also wastewater is full source of nutrition elements such as N, P, K that are necessary for plant growth [27]. Kakere *et al.* stated that waste water had positive effect on the growth of plants but at a high concentration, it would raise the soil pH, EC and SAR values which would in turn make the soil saline and reduce the plant ability to absorb nutrients needed for vegetative growth [28]. Omran *et al.* likewise reported increased growth density and shoot length in Navel Orange trees irrigated with wastewater in Egypt [29]. Afyuni *et al.* found that existing high level of organic materials percentage in wastewater can improved soil physical condition [30]. Then plants grow better by the reason high concentration of macro and micro-elements [31]. Bansal and Kapoor pointed out that the usage of wastewater supplied nutrients to different crops and also improved soil physical properties and its fertility [32].

There was also a significant ($p \leq 0.05$) increase in the number of leaves of *T. occidentalis* and *A. esculentus* at 75% concentration of the beauty salon wastewater (Tables 3 and 4). The leaf area of *T. occidentalis* increased at 25-75% concentrations, with a significant difference ($p > 0.05$) at 75% concentration when compared with the control (Table 5). The leaf area of *A. esculentus* also increased at 25-75% concentration in comparison with the control (Table 6). Table 7 and 8 show the effects of beauty salon wastewater on the stem girth of the two vegetables. Stem girth of plants irrigated with 75% concentration of beauty salon wastewater increased compared with the control. Table 9 shows the effect of beauty salon wastewater on the root length of the two vegetables. According to the table, *T. occidentalis* and *A. esculentus* had significantly longer roots at 25-27% concentrations of the wastewater in comparison with the control. These findings are consistent with that of Detalis who reported that existing high level of K in wastewater can significantly increase root growth and leaf area in treated plants compared to the control [33]. Mohammad and Ayadi also stated that wastewater can have a positive effect on soil and eventually improved plant growth due to its being rich in organic matters and nutrients [34]. According to Paliwal *et al.* wastewater irrigation significantly influenced growth performance of *Hardwickia binata*. Shoot length, root length and root collar diameter of *H. binata* seedlings increased by 25, 50 and 75% as the result of use of wastewater in different treatment [35]. Nissim *et al.* showed that, irrigation with wastewater had a positive effect on willow growth and biomass yield [36]. Qaryouti *et al.* concluded that, raw wastewater irrigation increased significantly tomato crop parameters, cucumber plant height and fruit yield and average fruit weight, and tomato leaf area and plant dry weight [37]. The relative growth rate of the two vegetables were also affected upon application of beauty salon wastewater in different concentrations (Figure 1 and 2).

Figure (3 and 4) show the effects of beauty salon wastewater on the chlorophyll content of *T. occidentalis* and *A. esculentus*. BSWW treatments reduced the chlorophyll content of *Abelmoschus esculentus* but at non-significant level when compared to the control. The Chlorophyll content of *Telfairia occidentalis* reduced significantly with a significance difference at 25-75% concentrations when compared to the control upon treatment with BSWW. Many authors have reported adverse effect of wastewater on chlorophyll content and metabolism [38-40]. Agrawal *et al.* suggested that heavy metals can inhibit chlorophyll formation by preventing magnesium uptake [41].

Generally, the results of this study show that high concentration of 100% beauty salon wastewater reduced all the growth parameters of the vegetables. This is in accordance with the earlier findings of Sawadogo *et al.* who recorded growth inhibition in plant growth as a result of exacerbated soil salinity by wastewater [42].

Table 1. *Effect of beauty salon wastewater on the stem height (cm)of Telfairia occidentalis.*

Weeks after treatment	Concentration of beauty salon wastewater applied (%)				
	0	25	50	75	100
2	80.07^{a}	73.85^{a}	69.90^{a}	81.88^{a}	80.03^{a}
4	137.15^{a}	134.88^{a}	153.90^{a}	155.05^{a}	138.55^{a}
6	138.55^{a}	136.85^{a}	160.37^{a}	163.18^{a}	144.07^{a}
8	162.75^{a}	163.03^{a}	166.01^{a}	165.02^{a}	146.52^{a}

Each value is a mean of 6 replicates. For each value, means with the same letter (s) in superscript on the same row are not significantly different at P≥0.05 (Tukey HSD test).

Table 2. *Effect of beauty salon wastewater on the stem height (cm) of Abelmoschus esculentus.*

Weeks after treatment	Concentration of beauty salon wastewater applied (%)				
	0	25	50	75	100
2	24.52^{a}	30.02^{b}	34.25^{c}	35.10^{c}	29.10^{b}
4	49.83^{bc}	51.12^{bc}	40.78^{ab}	56.70^{c}	35.75^{a}
6	64.46^{b}	71.53^{b}	74.58^{b}	72.83^{b}	51.28^{a}
8	65.73^{ab}	71.15^{b}	75.52^{b}	74.32^{b}	57.23^{a}

Each value is a mean of 6 replicates. For each value, means with the same letter (s) in superscript on the same row are not significantly different at P≥0.05 (Tukey HSD test).

Table 3. *Effect of beauty salon wastewater on the number of leaves of Telfairia occidentalis.*

Weeks after treatment	Concentration of beauty salon wastewater applied (%)				
	0	25	50	75	100
2	32.17^{a}	29.83^{a}	29.83^{a}	29.67^{a}	29.00^{a}
4	40.67^{a}	48.50^{ab}	53.50^{ab}	52.67^{b}	41.67^{a}
6	46.67^{ab}	53.00^{bc}	57.83^{c}	56.17^{c}	43.50^{a}
8	49.33^{a}	59.83^{b}	60.00^{b}	59.83^{b}	45.50^{a}

Each value is a mean of 6 replicates. For each value, means with the same letter (s) in superscript on the same row are not significantly different at P≥0.05 (Tukey HSD test).

Table 4. *Effect of beauty salon wastewater on the number of leaves of Abelmoschus esculentus.*

Weeks after treatment	Concentration of beauty salon wastewater applied (%)				
	0	25	50	75	100
2	4.67^{ab}	5.17^{b}	5.33^{b}	4.83^{ab}	3.50^{b}
4	5.00^{a}	6.07^{ab}	6.00^{ab}	6.67^{b}	5.50^{ab}
6	7.33^{a}	7.50^{a}	7.33^{a}	10.17^{b}	7.17^{a}
8	7.39^{a}	7.65^{a}	7.83^{a}	11.83^{b}	7.67^{a}

Each value is a mean of 6 replicates. For each value, means with the same letter (s) in superscript on the same row are not significantly different at P≥0.05 (Tukey HSD test).

Table 5. *Effect of beauty salon wastewater on the leaf area (cm^2) of Telfairia occidentalis.*

Weeks after treatment	Concentration of beauty salon wastewater applied (%)				
	0	25	50	75	100
2	35.90^{a}	39.34^{a}	37.72^{a}	39.65^{a}	42.71^{a}
4	38.41^{a}	48.96^{ab}	49.80^{ab}	58.29^{b}	46.23^{ab}
6	42.84^{a}	50.73^{a}	50.95^{a}	55.36^{a}	52.66^{a}
8	43.85^{a}	54.07^{a}	65.80^{b}	78.83^{c}	52.73^{a}

Each value is a mean of 6 replicates. For each value, means with the same letter (s) in superscript on the same row are not significantly different at P≥0.05 (Tukey HSD test).

Table 6. *Effect of beauty salon wastewater on the leaf area (cm^2) of Abelmoschus esculentus.*

Weeks after treatment	Concentration of beauty salon wastewater applied (%)				
	0	25	50	75	100
2	106.52^{a}	82.46^{a}	89.30^{a}	123.72^{a}	112.95^{a}
4	228.78^{b}	168.97^{a}	164.39^{a}	230.84^{b}	160.23^{a}
6	268.23^{bc}	273.99^{ab}	237.61^{ab}	300.39^{c}	167.15^{a}
8	296.31^{b}	314.48^{b}	306.29^{b}	317.16^{b}	178.53^{a}

Each value is a mean of 6 replicates. For each value, means with the same letter (s) in superscript on the same row are not significantly different at P≥0.05 (Tukey HSD test).

Table 7. *Effect of beauty salon wastewater on the stem girth (cm) of Telfairia occidentalis.*

Weeks after treatment	Concentration of beauty salon wastewater applied (%)				
	0	25	50	75	100
2	0.53^{a}	0.50^{a}	0.55a	0.55^{a}	0.53^{a}
4	0.71^{a}	0.65^{a}	0.71a	0.83^{b}	0.62^{a}
6	0.82^{b}	0.83^{b}	0.97^{c}	1.10^{d}	0.70^{a}
8	0.83^{ab}	0.93^{bc}	1.03^{bc}	1.10^{c}	0.71^{a}

Each value is a mean of 6 replicates. For each value, means with the same letter (s) in superscript on the same row are not significantly different at P≥0.05 (Tukey HSD test).

Table 8. *Effect of beauty salon wastewater on the stem girth (cm) of Abelmoschus esculentus.*

Weeks after treatment	Concentration of beauty salon wastewater applied (%)				
	0	25	50	75	100
2	0.58[b]	0.85[c]	0.83[c]	0.88[c]	0.38[a]
4	0.70[b]	0.85[c]	0.87[c]	0.88[c]	0.58[a]
6	0.75[a]	0.97[b]	0.95[b]	1.08[b]	0.78[a]
8	0.82[a]	1.00[b]	1.00[b]	1.10[b]	0.85[a]

Each value is a mean of 6 replicates. For each value, means with the same letter (s) in superscript on the same row are not significantly different at P≥0.05 (Tukey HSD test).

Table 9. *Effect of beauty salon wastewater on the root length (cm) of Telfairia occidentalis and Abelmoschus esculentus.*

Vegetable species	Concentration of beauty salon wastewater applied (%)				
	0	25	50	75	100
Telfairiaoccidentalis	28.8[ab]	35.5[b]	32.3[b]	34.5[b]	22.7[a]
Abelmoschusesculentus.	17.9[a]	18.4[a]	17.5[a]	19.0[b]	15.3[a]

Each value is a mean of 6 replicates. For each value, means with the same letter (s) in superscript on the same row are not significantly different at P≥0.05 (Tukey HSD test).

Figure 1. *Effect of beauty salon wastewater on relative growth rate of Abelmoschusesculentus.*

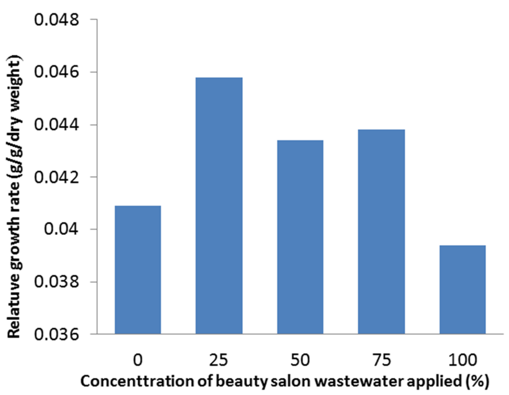

Figure 2. *Effects of beauty salon wastewater on Relative Growth Rate of Telfairiaoccidentalis.*

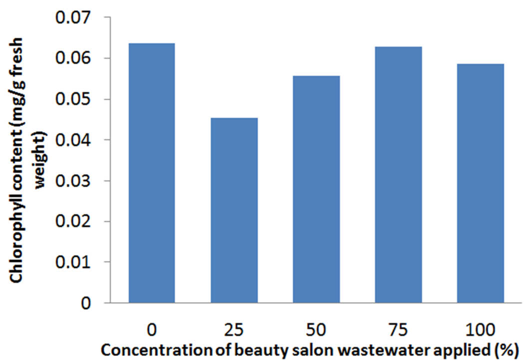

Figure 3. *Effect of beauty salon wastewater on the chlorophyll content of Abelmoschusesculentus.*

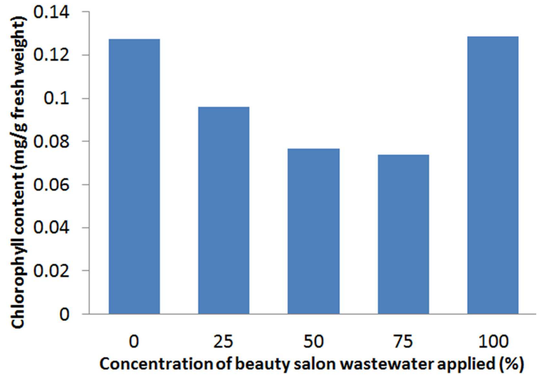

Figure 4. *Effect of beauty salon wastewater on the chlorophyll content of Telfairiaoccidentalis.*

4. Conclusion

The use of beauty salon wastewater improved seedling growth of *A. esculentus* and *T. occidentals* when diluted with water at 25-75%. Consequently, beauty salon wastewater can serve as an alternative liquid fertilizer in the production of *A. esculentus* and *T. occidentalis* if applied to soil at levels not above 75% concentration of the wastewater. This study cofirms that high concentration (>75% concentration) of beauty salon wastewater can have negative impact on soil make it unfavourable for plant growth. Therefore, wastewater should not be used directly on crops without sufficient treatment or dilution with water. There is however the need for further research on the yield performance and nutritional quality of the vegetables irrigated with beauty salon wastewater. There is also the need to evaluate environmental health challenges associated with beauty salon waste disposal.

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