EFFECT OF FERMENTED OLIVE MILL WASTE WATER ON THE GROWTH AND PRODUCTIVITY OF SORGHUM GROWN UNDER FIELD CONDITIONS

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ABSTRACT

Olive mill waste water (OMWW) collected from an olive mill in El Maghara station, Desert Research Center, North Sinai Governorate, Egypt was fermented solely with one of each highly active phenol degrading bacteria namely *Enterobacter asburiae* and *Pseudomonas aeruginosa*. The fermented OMWW with *E. asburiae* or *Ps. aeruginosa* has a high level of total nitrogen, soluble nutrients (nitrogen and potassium), and low COD, BOD and phenol contentcompared to the unfermented one. Remarkable increases in different microbial counts were detected in the fermented end product than the unfermented one. A field experiment was conducted at Banger El-Sokkar area, Alexandria desert road, Egypt, using sorghum as the task crop to evaluate the fermented OMWW as biofertilizer. The results indicated that the individual addition of the fermented OMWW using *Ps. aeruginosa* or *E. asburiae* as soil drench recorded the highest figures of plant height, fresh weight of shoot, dry weight of shoot, leaf area index and seed weight compared with control.

Application of fermented OMWW also, had a great positive effect on the productivity of sorghum compared to control. Microbiological analysis of rhizosphere soil indicated a remarkable increase in the total microbial counts, nitrogen fixer's counts and *Pseudomonas spp.* counts in plots treated only with the fermented OMWW either with *E.*

asburiae or *Ps. aeruginosa* comparing with unfermented treatment plots. Using fermented or unfermented OMWW showed positive effect on the chemical composition, sorghum in terms of nitrogen, phosphorus, potassium and carbohydrates.
Results of this experiment clearly indicated that the fermented olive mill waste water can be used as natural liquid organic fertilizer to improve the productivity and chemical constituent of plants when applied as soil drench.
Key word: Olive mill waste water, fermentation, *Enterobacter asburiae*, *Pseudomonas aeruginosa*, Sorghum.

INTRODUCTION

Olive mill waste water can be considered as a pollutant to water and soil as aqueous by-products of olive oil separation. It can be a severe problem when disposed to the soil because of their high organic load, high polyphenols concentration, and moderately low biodegradability (Isidori *et al*., 2005). At the same time, the large proportion of organic matter and valuable nutrients constitute of OMWW make it a valuable resource as fertilizer particularly in degraded agricultural soils. Thus, elimination of high organic load and polyphenols from the OMWW is a solution for the production of safe fertilizer rich with nutrients. Piperidou *et al*. (2000) conducted an environmentally friendly bioremediation system of OMWW with high degradation efficiency of toxic constituents. The end product, branded "biofertilizer", was used as soil conditioner and liquid organic fertilizer; two bacterial strains were used as high effective biodegradable bacteria. In another study, *Pseudomonas putida* was capable of using aromatic compounds such as phenol as a sole source of carbon and energy (Movahedyan *et al*., 2009).

Sorghum is the world's fifth most important cereal crop after maize, rice, wheat and barley. It is cultivated mainly for its grains. Also, sorghum crop residues and green plants provide sources of animal feed and fuel for cooking particularly dry land. Mekki *et al*. (2006) found the treated plants with OMWW showing an improvement in seed biomass, plant growth, and a similar or even better dry productivity than plants irrigated with water.

Maize growth was significantly promoted by OMWW application reaching more than 10–11% of the growth of control (Hanifi and Elhadramy, 2007).

The objective of this study was to evaluate fermented olive mill waste water as a potential biofertilizer on sorghum yield and growth parameters under field conditions.

MATERIALS AND METHODS

Olive mill wastewater: Olive mill waste water (OMWW) samples were collected from an olive mill in El Maghara station, Desert Research Center, North Sinai Governorate, Egypt. Crude OMWW was filtered, diluted to 25 % (v/v) with distilled water and worked as the unfermented OMWW. For fermented OMWW, the samples were collected for analysis at the end of fermentation process as described later.

Microorganisms: *Enterobacter asburiae* or *Pseudomonas aeruginosa* were isolated from OMWW, according to the method described by Ramsay *et al.* (1983), and identified according to Bergy's Manual of determinative bacteriology (1994). The identification was confirmed by 16SrRNA sequencing analyses according to (Lane, 1991). Counting of all microbes was after 24hr except nitrogen fixers after 72hr.

Aerobic fermentation of OMWW: For the biodegradation of phenol content in OMWW, two separate aerobic fermentation processes were performed. For each process, OMWW was diluted to 25 % (v/v) with tap water andinoculated separately with one of the highly active phenol degrading bacteria. Different experiments were conducted to optimize the fermentation process (Data not shown)**,** the fermentations were conducted under the following conditions which gave maximum phenol degradation: Effluent 20 liter, temperature 25^{o}C and 30^{o}C, pH 6 and 7, fermentation time 27 and 30 days with the addition of ammonium sulphate (0.1 g/l) as nitrogen source for *E. asburiae* and *Ps. aeruginosa*, respectively. The total phenols in the samples were determined every three days according to Ramsay *et al.* (1983).

Chemical andphysical analyses of unfermented and fermented OMWW:

The pH and EC (Electrical Conductivity) of soil and OMWW were measured using an (OAKTON pH-meter) and (YSI MODEL 35 Conductance meter), respectively according to methods of Jacson (1958) and Richards (1954), respectively. Soluble nutrients: N, K, Ca, Mg and P were determined according to Cottenie *et al*. (1982). Organic carbon, total nitrogen and total potassium were determined according to the method described by Jacson (1958); Chapman and Pratt (1961) and Bremner and Mulvaney (1982), respectively, BOD_5 (Biological oxygen demand) and COD (Chemical oxygen demand) analyses were carried out at central laboratory, desert research center. Phenolic compounds were extracted according to the method of De Marco *et al*. (2006), and then total phenols were determined spectrophotometrecally according to Romero *et al*. (2002). For this purpose, 1 ml of OMWW and 1 ml of Na_2CO_3 (25%) were mixed and then added to 0.5 ml folin Ciocalteu reagent, and the volume was made up to 10 ml by distilled water. A calibration curve was established under the same conditions using gallic acid as standard. The optical density (OD) was measured at 730 nm using a spectrophotometer (Jenway Model 6105 UV\ Vis spectrophotometer) against a blank.

Chemical analysis: Total nitrogen, phosphorus, potassium and carbohydrate were determined in sorghum straw, leaves, stems and grains according to Jacson (1958), Watanabe and Olsen (1965), Bremner and Mulvaney (1982) and Dubois *et al.* (1951), respectively.

Microbiological analysis: Counting of different microbial densities in OMWW samples and in the rhizosphere samples of sorghum was conducted on the following media by plate count technique: King's medium (king *et al*., 1954) for *Pseudomonas*, Nutrient agar medium (Jacobs and Gerstein, 1960) for total microbial counts, MacConky's medium (Windle, 1958) for *Enterobacteriacae*, Starch nitrate medium (Waksman and Lechevalier, 1962) for *Actinomycetes*, Yeast Malt agar (Wickerham, 1951) for yeasts and Potato dextrose agar medium (Riker and Riker, 1936) for total fungi.

Ashby's medium (Abd- El – Malek and Ishac, 1968) for asymbiotic nitrogen fixers using Most Probable Number (M.P.N.) technique and counts were estimated using Cochran's tables, Cochran (1950).

Field experiment: To investigate the efficiency of OMWW as soil drench biofertilizer a field experiment was conducted at Banger El-Sokkar area – Alexandria desert road, Egypt during summer 2013. The physicochemical analysis of soil was presented in Table (1). *Sorghum bicolor* (L) var. Hony was the task crop. Field experiment involved 39 plots (13 treatments in 3 replicates) each have 6-m^2 and thus occupied net area of 234m^2, each plot has five rows. 285 ml/plot of fermented OMWW were added after 120 days from planting. Two fertilization rates, half and full normal field dose were conducted. The full dose consisted of ammonium nitrate (33.3% N) 300 Kg\fed. Calcium super phosphate (15.5% P_2O_5) 200 Kg \ fed. Potassium sulphate (48.5% K_2O) 100 Kg\Fadden were used as N, P and K inorganic fertilizers, respectively. Unfermented and fermented OMWW with (*E. asburiae*) or (*Ps. aeruginosa*) were added as soil drench (285 ml/plot). Yield was determined 16 weeks after planting. After harvesting, the following parameters were recorded: Plant height, fresh and dry weight, leaf area, seeds weight and biological yield (grains yield and straw yield).

CO_2 evolution (μ g/g dry soil/ hr.) in the rhizosphere soil were determined according to Pramer and Schmidt (1964).

Statistical analysis: Treatments were arranged in a complete randomized block design. Data were subjected to statistical analysis by ANOVA using the method described by Sndecor (1966): The least significant difference (L.S.D) and Duncan letter at 5% level of probability was used to differential between the means (Waller and Duncan, 1969).

RESULTS AND DISCUSSION

Physical and chemical analysis of the used soil at Banger El-Sokkar area:

Results presented in Table (1) showed that the soil chosen for field experiment was sandy calcareous, the results of analysis gave normal values: organic matter (1.66%), organic carbon (0.97%), total nitrogen (0.085%) and C\N ratio (11.41). The pH and EC values were slightly higher. $CaCO_3$ was detected in high percentage being 32%. Sodium and chloride anion showed the highest figures 14.2 and 18.1meq/l respectively as compared with other ions.

Chemical, physical and microbiological analysis of unfermented and fermented OMWW:

Results shown in Table (2) clearly indicated that unfermented OMWW contained high levels of organic matter, COD, BOD, potassium, phosphorus and phenols comparing with the fermented

OMWW. The fermented samples using *Ps. aeruginosa* was mostly characterized by a reduction in organic matter, COD, BOD and phenol

content. The reduction percentage of COD, BOD and phenols were (20%, 28.07% and 79.9% in the application with fermented OMWW *E. asburiae*) and (48.24%, 34.22 and 82.6% for *Ps. aeruginosa*), comparing with the control. There was no remarkable change in nitrogen content of both fermented OMWW (by *E. asburiae* 63% or *Ps. aeruginosa* 45%) as compared to control, pH values increased after fermentation process (7.5 and 6.73 for *E. asburiae* and *Ps. aeruginosa*, respectively) compared with unfermented sample (3.8). E.C. increased by *Ps. aeruginosa* (6.86 dS/m) and decreased by *E. asburiae* (6 dS/m). These results are in agreement with Amhajji *et al*. (2005), who indicated that the fermentation process was monitored by physico-chemical determinations where polyphenols degradation level was (87%), COD was also reduced by (60%), and the pH of the effluent increased from (4.5 to 6.6). Results also showed that potassium concentration increased in fermented OMWW (4600 and 4670 mg\l for *E. asburiae* and *Ps. aeruginosa*, respectively), compared to control (unfermented sample 4000 mg\l).The nitrogen content also, increased in fermented OMWW (270 and 284 ppm for *E. asburiae* and *Ps. aeruginosa*, respectively) and compared to control (262 ppm). Calcium and phosphorus decreased in fermented OMWW by either *E. asburiae* or *Ps. aeruginosa* compared to control.

The total microbial counts increased slowly during fermentation reaching up to about (116 and 289*10^6CFU/ml) after 27 and 30 days for either *Ps. aeruginosa* or *E. asburiae*, respectively comparing with control (Table 3). The increase in bacterial count during fermentation process would indicate a potent reduction in polyphenols level. The count of *Enterobacteriacae* were (177 and 292*10^2CFU/ml), Nitrogen fixers (35 and 144*10^2cells/ml), *Pseudomonas spp*. (235 and 287*10^2CFU/ml) and Yeasts (123 and 27*10^2CFU/ml) for *Ps. aeruginosa* and *E. asburiae*, respectively which indicated remarkable increase comparing with unfermented OMWW (80*10^2CFU/ml, 0.1*10^6CFU/ml, 6*10^2CFU/ml, 50*10^2CFU/ml and 4*10^2CFU/ml, for total count, nitrogen fixers and *Pseudomonas ssp.* respectively). These results are in line with those of Amal (2012), who mentioned that the microbial counts of OMWW increased slowly during fermentation reaching up to about (10^{10} CFU ml^{-1}) after 25 days. The results showed that after 25 days, *Pseudomonas putida* and *Pseudomonas fluorescence* grown individually were more efficient than *Azotobacter vinelandii* in degrading phenols at all OMWW concentrations, while a bacterial mixture of the three strains gave the best result.

Table(1): Physical and chemical analysis of used soil.

Location	Physical and chemical analysis											
	Depth (cm)	Coarse sand (%)	C+S(%)	Clay (%)	Soil texture	pH	Electrical conductivity (dS/m)	Organic matter (%)	Organic carbon (%)	Total nitrogen (%)	C/N ratio	Total $CaCO_3$ (%)
Banger El-Sokkar area	0 – 15	93.22	5.16	1.62	Sandy calcareous	8.21	3.13	1.66	0.97	0.085	11.41	32
	Cations and Anions (me/l)											
	Cations (meq/l)				Anions (meq/l)							
	Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	CO_3^{-2}	HCO_3^{-}	Cl^{-}	SO_4^{-2}				
	9.82	5.98	14.2	1.24	-	4.3	18.1	8.84				

*Note: The analyses were carried out at central laboratory, desert research center.

Table (2): Physical and chemical properties of fermented and unfermented olive mill waste waters.

Treatments		Chemical properties									Soluble nutrients				
		ECe	pH	Organic Carbon (%)	Total Nitrogen (%)	Organic Matter (%)	C/N ratio	BOD (ppm)	COD (ppm)	Total phenols (ppm)	N (ppm)	P (%)	K^{+} (ppm)	(Ca^{+2}ppm)	(Mg^{+2}ppm)
control		6.71	3.8	19.6	0.6	33.3	32.7	374	8332	748	262	0.54	4000	64	43.2
Fermented OMWW using	*Enterobacter asburiae*	6.0	7.5	22.6	0.98	38.4	23.1	269	6664	150	270	0.4	4600	50	36
	Pseudomonas aeruginosa	6.86	6.73	18.1	0.87	30.7	20.8	246	4312	130	284	0.38	4670	60	45

*OMWW: olive mill wastewater.
*Control: irrigated with unfermented OMWW.

Table (3): Microbial counts of fermented olive mill waste water.

Treatments		*Enterobacteriacae* 10^2*CFU/ml	Total count 10^6*CFU/ml	Nitrogen fixers 10^2*cells/ml	Yeasts 10^2*CFU/ml	*Pseudomonas spp.* 10^2*CFU/ml
Control		80	0.1	6	50	4
Fermented OMWW using	*Enterobacter asburiae*	292	289	144	27	287
	Pseudomonas aeruginosa	177	116	35	123	235

*Control: irrigated with unfermented OMWW.

*OMWW: olive mill wastewater.

Field experiments:

1. Plant parameters:

The inoculation with OMWW fermented by either *Ps. aeruginosa* or *E. asburiae* as soil drench recorded the highest results of plant height reaching (17.64% and 14.7% increase for fresh shoot and root, respectively comparing with control), (Table 4). No significant difference was detected in the seed weight among both the tested strains. Lower results were recorded by using unfermented OMWW (8.82%) in harvest stage. The addition of unfermented OMWW had a minor positive effect on plant height when added as soil drench. In asimilar study, OMWW- fertilized plots showed a net improvement in plant height of 10–11% compared with the control. A yield improvement reached 28% over that of the control when the plants were amended by both land application and foliar spray (Hanifi and El-Hadramy, 2007).

The maximum fresh shoot and root of plants were recorded by inoculation with OMWW fermented by *Ps. aeruginosa* which represented (60.96 and 74.9% increase for fresh shoot and root, respectively comparing with control) followed by *E. asburiae* which secured only (49.34 and 53.35% increase for fresh shoot and root, respectively comparing with control) added as soil drench. Addition of unfermented OMWW had a minor positive effect on fresh weights when added as soil drench (Table 4). In another work as mentioned by Shereen *et al*. (2011), who studied the effect of using OMWW on morphological and productive characteristics of *Manzanillo* olive trees grown in a sandy soil. Treated trees with (48 litter of OMWW) induced an apparent significant increase in sex expression fruit set, yield, stone weight and percentage of oil in dry weight of *Manzanillo* trees.

Significant variations in dry weight of shoot and root were determined among treatments. Maximum dry shoot and root weight were detected with inoculation of OMWW fermented by *Ps. aeruginosa* which represented (79.86 and 67.05% for dry shoot and root increase, respectively) followed by *E. asburiae* which represented (41.71and 49.41% increase for dry shoot and root, respectively) as soil drench comparing with control. Lower results were recorded with using unfermented OMWW comparing with control in harvest stage. Only, the application with unfermented OMWW had a minor positive effect on dry weight of shoot when added as soil drench. In other study, plants treated with OMWW improved seed biomass, plant growth, and a similar or even better dry productivity than plants irrigated with water (Mekki *et al*., 2006).

The maximum leaf area index were recorded by using OMWW fermented by *Ps. aeruginosa* followed by *E. asburiae* where the percentage increase was 77.77 and 29.55%, respectively comparing with control at harvest stage while the minimum values were observed by using unfermented wastewater (16.47% increase, comparing with control). Mild positive effects of unfermented OMWW were recorded (Table 4). The impact of OMWW dilutions (1:10 and 1:20) on Leaf area of spinach declined progressively with decreasing OMWW dilution (Asfi *et al.*, 2012).

The lower seed weight (1000 seeds) in this study was recorded by the use of unfermented OMWW (26.85% increase compared with control). This record significantly increased to (80 and 68%) using either OMWW fermented with *Ps. aeruginosa* or *E. asburiae*, respectively compared with control. No significant difference in seed weight was detected among the application with both fermented OMWW. Weight of seeds significantly decreased by using unfermented OMWW inoculation (26.85%) as comparing with other treatments. Only, addition of unfermented OMWW had a minor positive effect on seed weight when added as soil drench (Table 4). In a comparable study, the application with fermented OMWW by *Enterobacter cloacae* significantly decreased pH and increased auxin content and enzyme activities in the rhizosphere soil, and enhanced nutrient concentration in shoots and roots of soybean (R_5 stage) and wheat (panicle initiation). At maturity, inoculation significantly enhanced shoots and seeds weight up to 13.77 and 16.09 %, respectively, in soybean, and 39.13 and 49.14 % in wheat over un-inoculated control (Ramesh *et al.*, 2014).

2-Straw and grains yield:

Application of fermented OMWW had a great positive effect on the productivity of sorghum in terms of straw and grains yield compared to control or the unfermented OMWW treatment. The maximum grain yield was detectedby using OMWW fermented by *Ps. aeruginosa* (80% increase compared with control), followed by *E. asburiae* (68% increase) compared with control (Table 4).

The maximum straw yield was obtained by using OMWW fermented by *Ps. aeruginosa* (58.9% increase), followed by *E. asburiae* (47.9% increase) compared with control. Lower figures were obtained by using unfermented OMWW (20.58%) comparing with control in harvest stage (Table 4). According to Ibrahim *et al*. (2012), who indicated that, the treatment of *Beta vulgaris* with the amino acids, OMWW or compost tea significantly increased the yield of roots, leaves, sugar comparing with the untreated plots. Both of OMWW and amino acids treatments significantly increased the yield of roots and sugar comparing with compost tea.

Microbiological analysis:

There were remarkable increases in the total microbial counts in rhizosphere treated with fermented OMWW comparing with control and unfermented samples (210 and 235*10^4CFU for *E. asburiae* and *Ps. aeruginosa*, respectively) (Table 5). This is consistent with data reported by other authors as regards the presence of antimicrobial substances in OMWW. This is also true for both nitrogen fixers (47 and 51*10^4 cells/g dry soil for *E. asburiae* and *Ps. aeruginosa*, respectively) and *Pseudomonas* counts which increasedby using fermented OMWW (31*10^4CFU for *E. asburiae*) and by *Ps. aeruginosa* (35*10^4CFU), and decreased by using unfermented OMWW (11*10^4CFU) compared to control. The maximum figures of CO_2-evolution were obtained by using OMWW fermented with *Ps. aeruginosa* (80.85% increase), followed by *E. asburiae* (65.95% increase) compared with control. The minimum values were noticed by using unfermented OMWW (32.97%), comparing with control. The results of CO_2- evolution were parallel with that of microbial counts. Treatment with OMWW increased both the CO_2-evolution and microbial counts. Previous studies indicated that the irrigation with waste waters from olive oil extraction increased soil organic matter, P, K and Mg contents and total numbers of microorganisms (Proietti *et al.*, 1995).

Table (4): Effect of fertilization with fermented and unfermented OMWW on growth parameters of sorghum.

Treatments		Plant height (cm)	fresh weight (gm)		dry weight (gm)		leaf area (cm)	Weight (gm of 1000 seeds)	Yield parameters (kg\faddan)	
			Shoot	Root	shoot	Root			Straw	Grains
Control		340^{c}	342.24^{d}	28.30^{c}	122.50^{d}	8.50^{b}	210.35^{d}	17.50^{b}	3901.17^{d}	1837.50^{d}
Unfermented OMWW		370^{b}	412.83^{c}	35.20^{bc}	151.70^{c}	10.90^{ab}	245^{c}	22.20^{b}	4704.31^{c}	2331.00^{c}
Fermented OMWW using	*E. asburiae*	390^{a}	511.13^{b}	43.40^{ab}	173.60^{b}	12.70^{a}	272.52^{b}	29.40^{a}	5770.06^{b}	3087.00^{b}
	Ps. aeruginosa	400^{a}	550.9^{a}	49.50^{a}	220.34^{a}	14.20^{a}	373.96^{a}	31.50^{a}	6199.20^{a}	3307.50^{a}
LSD (0.05)		12.97	20.23	11.74	13.87	3.75	11.31	6.18	67.84	33.39

*Control: irrigation with tap water only.
*OMWW: olive mill wastewater.
*Mean representing the effect of each factor on a particular parameter and not followed by the same litter are significantly different by Duncan's multiple range test ($P<0.05$).

Table (5): Microbial counts and CO_2 evolution in the rhizosphere soil of *Sweet sorghum* at harvest stage.

Treatments		**Total count (10^4* CFU/ g)**	**Nitrogen fixers(10^4* cells/g dry soil)**	***Pseudomonas spp.*** **(10^4* CFU/g)**	**CO_2-evolution(mg\ 100g dry soil /hr)**
Control		**186**	**30**	**22**	**0.47**
Unfermented OMWW		**161**	**9**	**11**	**0.315**
Fermented OMWW using	***E. asburiae***	**210**	**47**	**31**	**0.78**
	Ps. aeruginosa	**235**	**51**	**35**	**0.85**

*Control: irrigated with tap water only.

*OMWW: olive mill wastewater.

Chemical composition of plants:

1. Total nitrogen, phosphorus and potassium (NPK):

Generally total NPK in grains were higher than that in leaves and stem. It was indicated that addition of unfermented or fermented OMWW had positive effect on NPK content of sorghum plants when added as soil drench. For N, no significant differences among the treatments were detected (Table 6). For phosphorus and potassium, using fermented OMWW were more effective than that of unfermented one, while no difference was detected between *E. asburiae* or *Ps. aeruginosa* (0.18 and 0.17% of phosphorus in grains to each microbe, respectively), while potassium concentration in grains were (0.51 and 0.55%) for each microbe, respectively. In another work, the total nitrogen, phosphate and potassium in plants increased proportionally to the amounts of untreated OMWW (Belaqziz *et al*., 2008). Total nitrogen, phosphorus, sodium, and potassium in soil were found to be increased with increasing OMWW supply (Chaari *et al*., 2014).

2. Chlorophyll content:

Chlorophyll content in fresh leaves was determined at the end of Sweet sorghum plant growth. The maximum chlorophyll content at harvest stage of Sweet sorghum was detected in plants inoculated with fermented OMWW comparing with unfermented OMWW (43.09 and 52.76% increase for *E. asburiae* and *Ps. aeruginosa*, respectively). Unfermented OMWW had a minor positive effect (11.87%) compared to control (Table 6).

3. Total carbohydrates

Data in **Table (6)** show also that the maximum total carbohydrates was recorded by using the individual application of fermented OMWW as soil drench by either *Ps. aeruginosa* or *E. asburiae* (79.28% and 52.72% increase), followed by unfermented OMWW (35.45%) comparing with control.

4. Total phenols:

Total phenols were recorded in all parts of plant; the maximum concentrations were determined in grains followed by leaves while stems recorded the lowest concentrations as shown in Table (6). Results also indicated that there were significant differences among the treatments; the lowest figures were obtained by using fermented OMWW as soil drench by *Ps. aeruginosa* followed by *E. asburiae*, and then by unfermented OMWW comparing with control which recorded the maximum values. In another study, the phenolic acids reported in cereals occur in both free and bound forms. Sorghum and millet have the widest variety of phenolic acids. The major phenolic acids in cereals are ferulic and p-coumaric acids. Phenol compounds in grains of sorghum were ranged from 385-746 mg\g as reported by (McDonough *et al.*, 2000, Zhou *et al.*, 2004, Mattila, *et al.*, 2005, Holtekjolen *et al.*, 2006).

CONCLUSION

The fermented system eliminates the phytotoxic principles of OMWW and concomitantly enriches it with an agriculturally beneficial microbial consortium and useful metabolites. The end product can be used as biofertilizer which stimulate the growth, yield and chemical composition of plants when added to plants as soil drench.

Table (6): Effect of unfermented or fermented olive mill wastewater on chemical constituents of *Sweet sorghum* plants at harvest stage.

Treatments		NITROGEN (%)			PHOSPHORUS (%)			POTASSIUM (%)			Chlorophyll	Carbohydrates (%)	Total phenols (mg \ g)		
		stem	leaves	grain	stem	leaves	grains	stem	leaves	grains			stem	leaves	grains
Control		0.2^{b}	0.4^{b}	0.4^{b}	0.02^{a}	0.03^{b}	0.04^{b}	0.1^{b}	0.2^{c}	0.35^{c}	36.2^{b}	7.53^{b}	120^{d}	210^{b}	300^{b}
Unfermented OMWW		0.31^{a}	0.57^{ab}	0.6^{a}	0.05^{a}	0.05^{b}	0.1^{ab}	0.2^{ab}	0.3^{bc}	0.5^{bc}	40.5^{b}	10.2^{ab}	217^{a}	296^{a}	335^{a}
Fermented OMWW using	*Enterobacter asburiae*	0.34^{a}	0.68^{a}	0.8^{a}	0.1^{a}	0.12^{a}	0.18^{a}	0.4^{a}	0.5^{ab}	0.51^{a}	51.8^{a}	11.5^{a}	154^{c}	286^{c}	286^{c}
	Pseudomonas aeruginosa	0.37^{a}	0.71^{a}	1.0^{a}	0.11^{a}	0.13^{a}	0.17^{a}	0.3^{ab}	0.55^{a}	0.55^{a}	55.3^{a}	13.5^{a}	177^{b}	290^{c}	290^{c}
LSD (0.05)		0.103	0.19	0.58	0.095	0.033	0.098	0.24	0.21	0.217	7.10	3.49	6.17	7.10	8.73

*Control: irrigation with tap water only.
*OMWW: olive mill wastewater.
*Mean representing the effect of each factor on a particular parameter and not followed by the same litter are significantly different by Duncan's multiple range test ($P<0.05$).

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J. Environ. Sci.
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تأثير مخلف ماء عصر الزيتون المتخمر على نمو وانتاجيه نبات السورجم

[١٠]

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المستخلص

تم تجميع عينات المخلفات السائلة من عصر الزيتون من محطة المغارة، مركز بحوث الصحراء، محافظة شمال سيناء، مصر. وقد تم عزل سلالات بكتيرية عالية القدرة فى تكسير الفينولات والتى تم تعريفها الى Enterobacter asburiae و Pseudomonas aeruginosa

وقد اوضحت النتائج ان المخلف المتخمر من ماء عصر الزيتون باستخدام الانتيروباكتر او السيدوموناس احتوى على اعلى معدلات من النيتروجين الكلى، ومن المغذيات الذائبة (نيتروجين، بوتاسيوم) كما احتوى المخلف المتخمر على اقل قيم من الفينولات وكذلك الـــ COD , BOD مقارنة بالمخلف غير المتخمر.

سجلت اعداد مختلف المجموعات الميكروبية زيادة فى المخلف المتخمر عنه فى غير المتخمر. التجربة الحقلية التى تمت فى منطقة بنجر السكر– طريق مصر الإسكندرية الصحراوى باستخدام نبات السورجم لتقييم مخلف ماء عصر الزيتون المتخمر كسماد حيوى. اشارت النتائج الى ان اضافة المخلف المتخمر من ماء عصر الزيتون رشا على التربة أعطى اعلى القيم فى اطوال النباتات، الوزن الرطب والجاف للمجموع الخضرى ودليل المساحة الورقية مقارنة بالكونترول.

بتطبيق المخلف المتخمر من ماء عصر الزيتون واستخدامه كسماد حيوى ايضا فإن له تأثير ايجابى على الانتاجية فى السورجم مقارنة بالكونترول. التقديرات الميكروبية لريزوسفير النبات تشير الى زيادة فى العد الكلى للبكتيريا، اعداد مثبتات الازوت وإعداد السيدوموناس التى استخدم فيها مخلف ماء عصر الزيتون المتخمر بالانتيروباكتر والسيدوموناس كلا على حده. استخدام مخلف ماء عصر الزيتون سواء المتخمر او غير المتخمر اعطى نتائج ايجابية فى التحليلات الكيميائية للسورجم (النيتروجين، الفوسفور، البوتاسيوم والكربوهيدرات).

هذا البحث يشير الى ان استخدام ماء عصر الزيتون المتخمر كسماد عضوى حيوى طبيعى سائل يحسن الانتاجية والمكونات الكيميائية للنبات اذا ما استخدم رشا على الاوراق.