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Full Length Research Paper

Composting mulch of date palm trees through microbial activator in Saudi Arabia

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The main objective of the current study is to produce high quality organic fertilizer in large scale using abundant energy resources (Date palm trees mulch produced from grinded leafs, trunks and roots) from local farms. Date palm trees mulch (DPM) was mixed with fresh farmyard manure (FYM) as nitrogen source. The mixtures were prepared by using 3 ratios (w/w) of 1:1, 2:1 and 3:1 (DPM : FCM).The C/N ratios were 44.3:1, 50:1 and 44:1 for mixtures 1, 2 and 3, respectively. Turned windrow method was applied in the composting process. The results showed that the temperature was increased up to 66, 69 and 68°C for mixtures 1, 2 and 3, respectively and then decreased to 44, 45 and 45°C by the end of the composting period for the above 3 mixtures. The final organic fertilizer had natural soil odor and brown in color. The final organic fertilizer C/N ratio recorded as 25:1, 12.5:1 and 23:1 for mixtures 1, 2 and 3 respectively. The loss in organic matter was also reached to 15.6 (mix 1), 29.54 (mix 2) and 20.00 % (mix3). The results found for mixtures of 2 and 3 were better than mixture 1, therefore these mixtures are considered to be the best for composting date palm trees mulch . Regulated elements (N, P, K, Organic matter, pH, electrical conductivity, and TDS) were improved in all mixtures. The end product was free of *salmonella*, total coliform and faecal coliform bacteria.

Key Words: Date palm trees, Mulch, Cow manure, Organic Fertilizer

INTRODUCTION

The date palm trees are normally available in the Middle East and Northern Africa. There are more than 100 million date palm trees and, each tree can grow for more than 100 years (Zaid et al., 1999).

Saudi Arabia is considered as one of the world major producer of dates. In 2005, the country had more than 22.6 million date palm trees and this number is increasing gradually (MOA, 1998). Date palm trees produce large quantity of agricultural waste.

For example, each date palm tree produces about 20 kg of dry leaves yearly (Barreveld,1993).

Although the whole palm trees waste consist of hardly decomposed elements (Cellulose, hemicelluloses, lignin and other compounds) they could be composted with microbiological process instead of burning in farms and causing serious threat to environment. (Wong et al, 2002).

Grinded date palm trees mulch applications provide the additional benefits of decreasing water evaporation from the soil surface, helping control weed invasion, dust suppression, helping prevent soil erosion loss by wind or water, providing thermal stabilization by keeping soil cooler in hot weather and warmer in cool weather (Ashworth, S. and Harrison, H., 1983). During the last 15 to 20 years, the quantity of cattle has

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undergone increased scrutiny which creates environmental and economic impact (Collection, Storage and Disposal).

Cattlemanure contains amounts of limited nutrients (N, P, and K) as well as other plant nutrients but it considered a limited nitrogen source for plant crops growth. (Harter et al. 2007). Because of that reason it was not recommended to apply fresh or fermented cattle manure as a single organic fertilizer.

The primary issue with cow manure, currently and future is recycling with agricultural wastes or palm trees mulch to produce a high quality organic fertilizer.

MATERIAL AND METHODS

Date palm trees mulch and fresh cow manure preparation

The investigation and analysis of the biodegradation during composting of date palm trees mulch (2 inch particle size, produced from grinded leafs, trunks and roots) and fresh cow manure as raw materials were done at Al Hofuf Stars Recycle Station located at Al Hasa City, K.S.A.

Characterization of organic materials used for composting

The date palm trees mulch and fresh cow manure were analyzed (pH, EC, Total dissolved solids, temperature, OC, total nitrogen, total phosphorus and total potassium) using standard procedure (APHA, 1992).

Microbial activity and temperature measurements of compost Piles

Twenty five grams of each sample (3 replicates) were homogenized into 225 mL of sterile Butterfield's phosphate-buffered dilution water (0.25 M KH2PO4 adjusted to pH 7.2 with NaOH; Butterfield, 1932) with Stomacher 400 Circulator for 3 min. Decimal dilutions were made into the buffer dilution water.

Aerobic mesophilic bacteria were counted onto standard plate count agar (PCA) incubated at 30 oC for 24–48 h (ICMSF, 1983). Total coliforms and faecal coliforms were counted onto standard violet red bile (VRB) agarincubated at 37oC and 44.5 Corespectively for 24–48h (ICMSF,1983). Microbial counts were expressed as colony-forming units per gram of honey (cfu/g). Salmonella spp. was investigated according to a modification of the standard method suggested by the Bacteriological Analytical Manual (BAM, 2001). For the pre-enrichment, 25 g was added to 225 mL of Lactose broth and cultures were incubated at 37 o C for 24 h.

The enrichment step was performed onto both tetrathionate and selenite cystine broths incubated at 37 o C for 24 h. Isolations were examined onto both media Hektoen enteric (HE) and bismuth sulfite (BS) agars, after incubation at 37 oC for 24 h.

Production process of organic fertilizer

For the preparation of organic fertilizer, followed the Turned Windrow method as per as (Fleming, 2001).

The complete date palm trees were mechanically grinded to produce date palm trees mulch particle size (2 inches) using Vermeer grinder machine with capacity (100 palm trees /h), then a standard compost pile layered in date palm trees mulch and fresh cow manure as a rule of thumb. The piles composting constructed ratio were mixture 1 (1:1) mixture 2 (2:1) and mixture 3 (3:1). One Pile with a volume of 45m3 (Length 15 x Width 2.5 X Height 1.2) was processed the required calibrated operating conditions of moisture, temperature and air flow as per as standard process (Hasen et al., 2001).

Layers of mulch and manure were alternated and each layer was inoculated by microbial activator for fasting decomposition. Pile moisture was kept and turned every 5 to 7 days. Homogenized samples were collected each intervals after turning the pile for chemical determinations. Pile temperature was monitored daily through the center of the compost piles at different locations. Composite moisture was adjusted to 60% by squeeze test in order to keep optimum bacterial growth to decompose hard organic fibrous materials.

RESULTS AND DISCUSSION

The chemical analysis results indicated that date palm trees mulch serve as a carbon source was highly non degradable. This might be due to its high content of organic matter (88.70%) and high C/N ratio (76.63) (Table 1). This was also observed from the physical shape ,due to its strong strength fiber.This was might be due to rich in cellulose and hemicelluloe (Fig.1).

(Al-Khanbashi et al., 2005).

Microbiological analysis results indicated that date palm trees mulch was free of pathogens and fresh cow manure had also a high number of total viable bacterial counts and both salmonella and E.coli strains (Table 2). Meanwhile fresh cow dung was high in N,P,K and moisture as compared with dry cow manure. However it had lower organic matter and C/N ratio than date palm trees mulch (38.00% and 19 %) respectively (Goyal et al, 2005). Consequently, composite compost mixtures were built by mixing

Table 1: Chemical composition of raw materials used for composting

Characteristics	Date palm trees mulch	Fresh cow manure	Dry cow manure
pH	6.66	7.22	8.72
Moisture (%)	4.50	41.08	22.41
Organic Matter (%)	*88.70*	38.00	30
Organic Carbon (%)	44.45	19	15
C/N Ratio	76.63	15	24.20
NDF (%)	61.38	67.38	85.58
ADF (%)	41.85	62.05	79.17
Ash (%)	18.01	70.75	83.07
Nitrogen (%)	0.58	1.26	0.62
Phosphorus (%)	0.25	0.54	0.40
Potassium (%)	1.70	1.55	0.82
Calcium (%)	2.25	2.80	2.33
Sodium (%)	0.55	0.54	0.57
Magnesium (%)	0.26	0.27	0.29

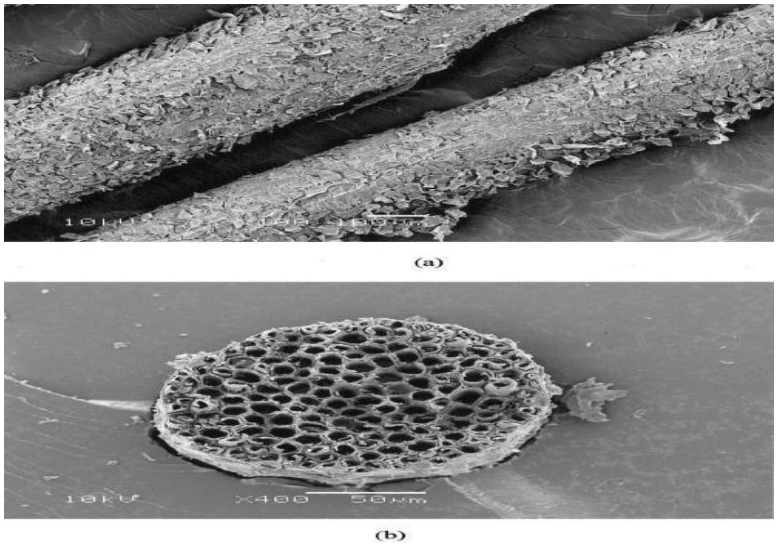

Fig1: SEM micrographs of raw DPF showing its cylindrical shape (a) and the multicellular fiber (b) in across-sectional view of the fiber

Table 2: Microbiological composition of raw materials used in composting.

Characteristics	Date palm trees mulch	Fresh cow manure
Total viable bacterial counts (cfu/g)	TNTC	TNTC
Total coliform (MPN/g)	Nil	TNTC
Bacterial detection	*Bacillus sps*	*Salmonella, E.coli*

date palm mulch as a carbon source with fresh cow dung as a nitrogen source with C/N ratios (44:1, 50:1 and 44:1 for mixtures 1, 2 and 3) respectively (Table 3).

Changes in temperature

Temperature is an important factor in composting efficiency, due to its influences on the activity and diversity of microorganisms (Finstein et al;1986).

Changes in temperature that occurred during the composting process are shown in Fig.2, Fig.3 and Fig.4. The outside temperature was about 37 oC in the day and 27 oC in the night. Data show that the highest temperature curves were recorded at the centre of the compost piles. At the beginning, the temperature was

Table 3: Chemical properties of the composted materials

week	Composite 1 (1:1)			Composite 2 (2:1)			Composite 3 (3:1)		
	Org matt (%)	Org C (%)	C/N	Org matt (%)	Org C (%)	C/N	Org matt (%)	Org C (%)	C/N
Week 1	44.60	22.33	44.30	44.00	22.00	50.00	42.00	2100	44.00
Week 4	45.20	22.60	35.90	44.00	22.00	46.00	47.70	24.00	45.10
Week 7	51.00	25.40	38.00	43.00	21.50	34.00	50.00	25.00	38.00
Week 10	38.60	19.30	29.70	37.00	18.00	27.00	35.00	17.50	29.20
Week 13	37.60	18.80	25.00	31.00	15.00	12.50	33.60	16.80	27.00

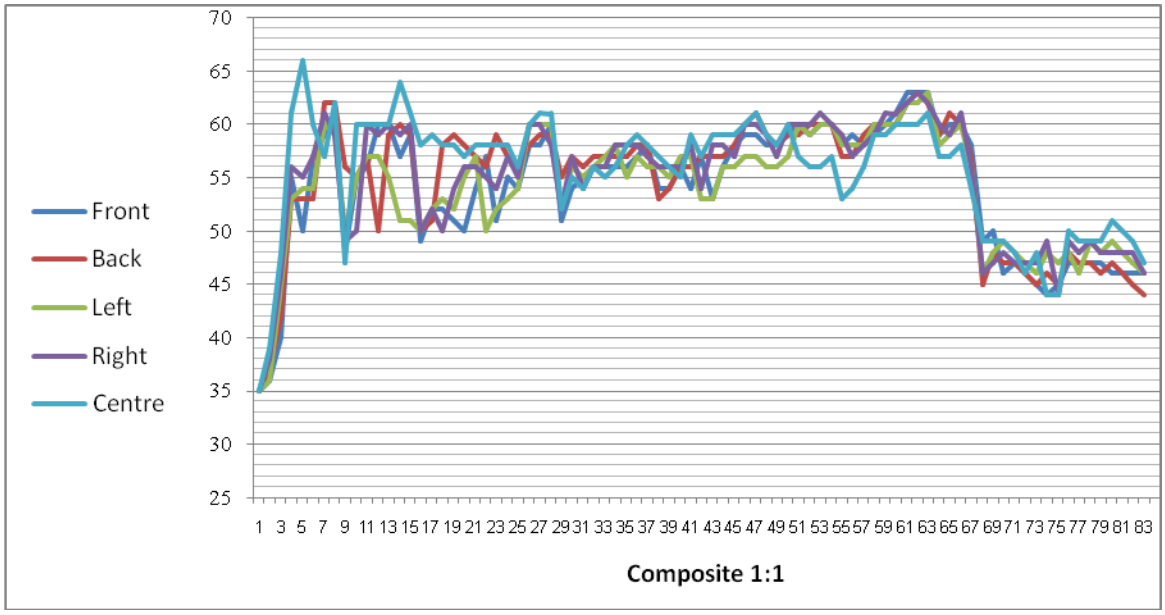

Figure 2: Results of temperature records within the composite 1**(Mix 1)**

35 oC , 32 oC and 34 oC and it was increased to 40oC (the end mesophilic stage) after 4, 3, and 4 days for mixture 1, 2 and 3. After 5 days temperature raised to 50 oC for mixture 1, 2 and 3, respectively. The maximum values 66 (mix 1), 69 (mix 2) and 69 oC (mix 3) were found after 6, 14 and 8 days. Then the temperature gradually decreased and reached to 44 (mix 1), 45 (mix 2) and 45 oC (mix 3) by the end of composting (4 months) The results revealed that a negative correlation was found between temperature and composting time, this was due to decreasing in temperature by the end of composting. Generally, the increase in temperature may be also attributed to the suitability of composting conditions (C/N ratio, moisture content, aeration, particle size) for microbial and enzymatic activities. On the other hand, the decrease in temperature was attributed to the decrease in microbial and enzymatic activities.

This was supported by the results of (Nogueira et al.,1999) . However,further expansion of composting will depend on better control of the process, compost quality and Organic matter biodegradability and biodegradation kinetics) (De Guardia et al., 2008).

Aeration is important in composting for providing the oxygen needed to support aerobic microorganisms, for controlling the temperature and for removing water vapor, CO2 and other gases (Gray et al., 1971; Poincelot, 1974; Haug, 1986). The overall goal of the aeration is to maintain compost temperature in the range 50-55 oC to obtain efficient thermophillic decomposition of organic wastes (Jeris et al., 1973 ., Mckinley et al., 1984). Thus, precise temperature control is necessary to provide pathogenic reduction,

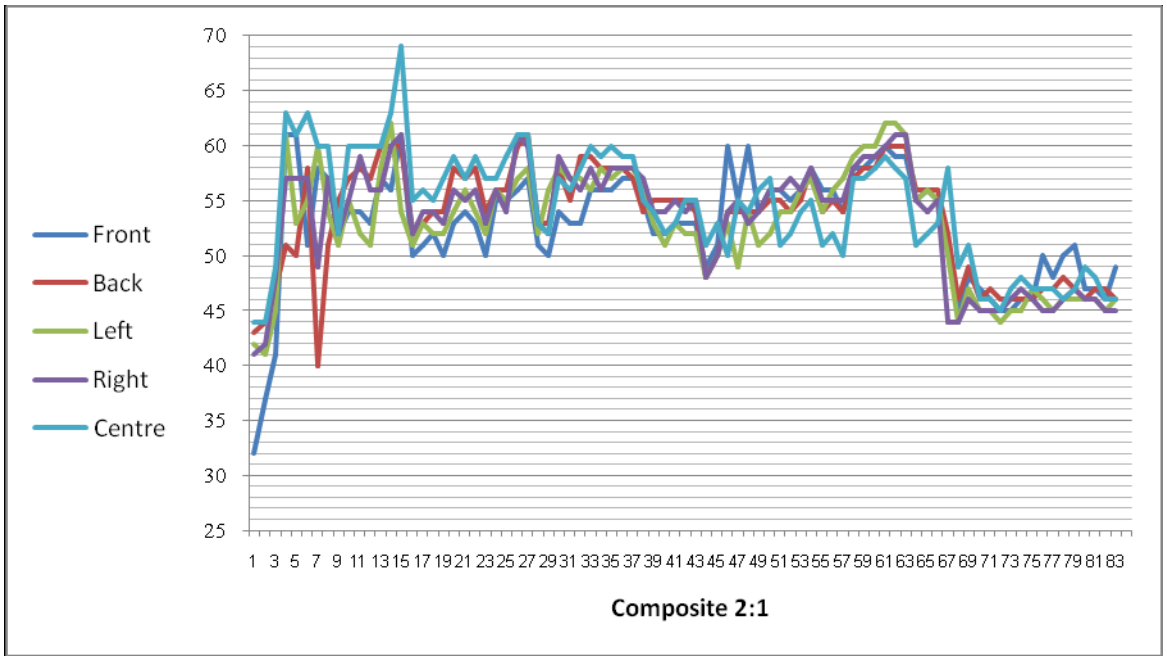

Figure 3: Results of temperature records within the composite 2 **(Mix 2)**

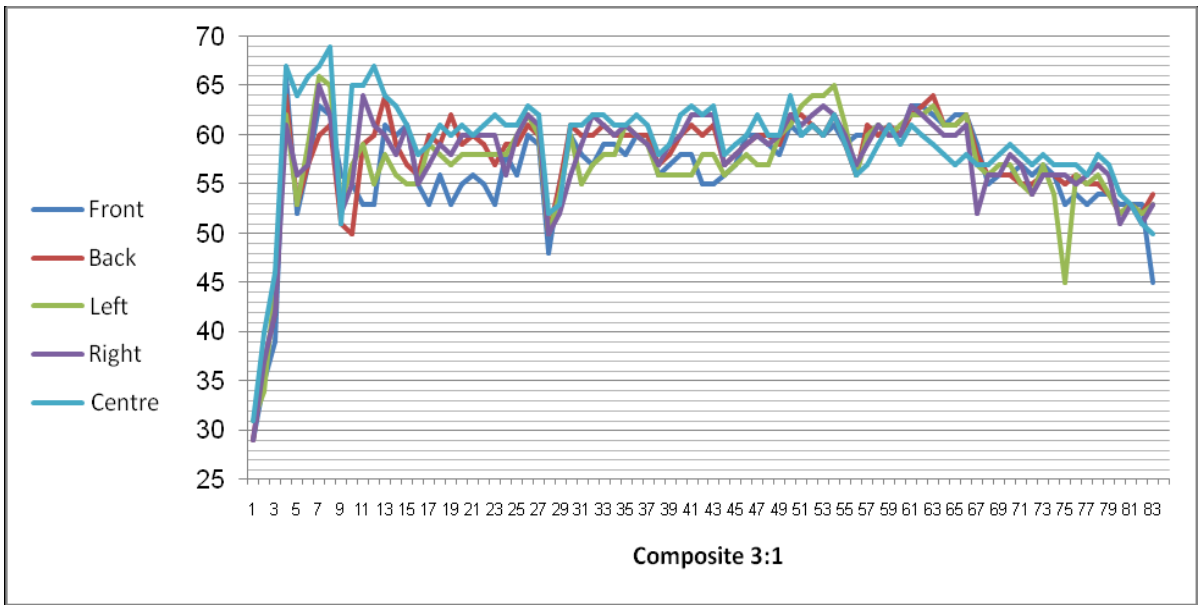

Figure 4: Results of temperature records within the composite 3 **(Mix 3)**

while maintaining a healthy comity of composting microbes (Mckinley et al., 1985).

Maturity stage started when the temperature decreased to normal air daily temperature and remain constant with turning of the piles (Gotass., 1956., Harada et al.,1981).

Therefore, this parameter is considered as a good indicator for the end of the biodegradation phase in which the compost achieves maturity (Jimenez et al., 1989).

Changes in organic matter

OM was decreased from 44.60 (mix 1) , 44.00 (mix 2) and 42.00 (mix 3) to 37.60 (mix 1), 31.00(mix 2) and 33.60 (mix 3) by the end of composting (Table 3). It was noticed that the decrease in organic matter was higher in case of mixture 2 and 3 (29.54 and 20.00,

Table 4: Major elements properties of the composite piles.

Week	Composite 1 (1:1)			Composite 2 (2:1)			Composite 3 (3:1)		
	N (%)	P (%)	K (%)	N (%)	P (%)	K (%)	N (%)	P (%)	K (%)
Week 1	0.50	0.10	0.40	0.43	0.10	0.46	0.48	0.10	0.44
Week 4	0.48	0.15	0.41	0.56	0.18	0.43	0.46	0.15	0.43
Week 7	0.66	0.32	1.29	0.64	0.30	1.13	0.66	0.35	1.50
Week 10	0.65	0.33	1.33	0.67	0.38	1.33	0.60	0.45	1.63
Week 13	0.70	0.44	1.34	1.20	0.33	1.31	0.62	0.34	1.38

respectively) than mixture 1 (15.60 %) .
Generally the low (OM) loss was reflect the persistence chemical composition of complete date
palm trees such as cellulose, lignin and other polysaccharides (Chang et al., 1967).

Changes in C/N ratio

The C/N ratio is often used as an index of compost changes. the C/N ratio was decreased from 44.30, 50 and 44 to 25.00, 12.50 and 27.00 by the end of composting period for the 3 mixtures (Table 3).

As the decomposition progressed due to losses of carbon mainly as carbon dioxide, the carbon content of the compostable materials decreased with time and nitrogen content per unit material increased, this was due to decrease in C/N ratio. The result was supported by the findings Goyal et al., (2005) a decrease in C/N ratio with time indicated that, moisture content, aeration and temperature are suitable for compost activator resulted in increase of organic matter decomposition PH- Nitrogen-Phosphorous- Potassium changes End product was found to be slightly alkaline in nature (pH 7.76) and moderate in nitrogen content (0.70 % (mix 1), 1.20 % (Mix) 2 and 0.62% (mix) (Table 4). Phosphorous was 0.44% (mix 1), 0.33% (mix 2) and 0.34 % (mix 3) while Potassium was fairly rich (1.34% (mix 1),1.31% (mix 2) and 1.38% (mix 3).

Microbial criteria of the fermented piles

Results showed that at the end matured organic fertilizer was free from salmonella, total coliform and faecal coliform. Davis et al. (1998) mentioned that achievement to maximum compost temperature (Over 55oC) in windrow systems in related times 10 days ensured hygienic conditions of compost and destruction of pathogens and parasite according to PFRP regulations of U.S.EPA.

Changes in odor

Firstly, the odor was unpleasant fresh cow dung odor. and finally changed to soil planter smell which is the pleasant odor. These results are in agreement with the reports of (Haug, 1980; Gotasas, 1956; Alexander 1990) . The final material of composting should be odorless or have slightly earthy smell odor.

Changes in color

During the composting process, a gradual change in color to brownish black took place and this gave indication of the maturity progress. The obtained results are in agreement with other studies which mentioned that the maturated compost is grayish-black or brownish-black in color, depending on whether tannins, melanin or other materials containing brown pigments were originally present.(Gotass 1956 and Diaz et al.,1993).

CONCLUSION

Complete date palms trees could be recycling biologically into organic product have criteria of organic fertilizers, soil stabilizers and soil plantation.

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