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Review Article
Cow Manure Composting by Microbial Treatment for Using as Potting Material: An Overview

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Abstract
Dairy industry is flourishing in Saudi Arabia for the last two decades producing milk and milk products to meet the population needs. Simultaneously, it is also producing large amount of dairy waste (animal manure) posing a serious environmental issues. Vermicomposting (conversion of animal manure into compost by microbial treatments) is considered as one of the safest means for efficient management and to mitigate environmental pollution issues resulting from land disposal of raw dairy wastes. The main objective of this study was to summarize different processes of vermicomposting and identified the most important earthworm species suitable for vermicomposting using animal manure especially the cow dung. The review showed that among the different earthworm species, *Eisenia fetida* is the most efficient and commonly used earthworm for vermicomposting to develop compost using cow dung (dairy manure). Overall, this review has highlighted the various vermicomposting technologies, various earthworm and bacteria species involved in vermicomposting, effect on soil and plant growth as well as the benefits of using compost prepared by way of vermicomposting. The study showed a lot of potential for the production of compost by vermicomposting technology using appropriate earthworm species which is safe, friendly and is associated with minimum environmental issues for safe land disposal of dairy waste (animal manure) with minimum possible environmental issues for the adjacent population.

Key words: Vermicomposting, earthworm species, animal manure, benefits, plant growth, environmental issues

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Generally, composting is a biological treatment of organic matter by different types of organisms. It is a natural aerobic process to stabilize different types of organic matters such as agricultural wastes and dairy manure (horse or cow manure). Currently, dairy industry is flourishing all over the world resulting in the production of large volumes of organic wastes as animal manure. As such it is creating disposal problems and a potential source of environmental hazards in and around adjacent population (Inbar *et al*., 1993). It was observed that direct application of raw organic manure without treatment deteriorates soil fertility, affect nutrient mobilization (especially nitrogen) and phytotoxicity (Senesi, 1989; Inbar *et al*., 1985). Therefore some type of organic waste treatment is needed in order to minimize the environmental problems associated with its land disposal. Presently, vermicomposting or simple composting is considered as the most safest biological transformation of organic wastes into byproducts for management and soil application to avoid adverse effects on crop growth (Baca *et al*., 1992; Godden *et al*., 1986; Senesi, 1989; Inbar *et al*., 1993; Eghball *et al*., 1997).

Atiyeh *et al*. (2000) reported that vermicomposts produced from decomposition of organic wastes by earthworms contain readily available nutrients for plant uptake. They also observed significant growth enhancement of marigold and tomato seedlings by its application. Overall, they concluded that vermicomposts when added to plant growth media improved the plants growth under controlled greenhouse conditions.

Suthar (2008a, b) studied the potential of the epigeic earthworm *Eisenia fetida* for sludge stabilization mixed with cow dung under laboratory conditions. It is found that all the vermicompost ponds showed a significant decrease in pH (7.8-19.2%) organic carbon (8.5-25.8%) content and an increase in total N (130.4-170.7%), available P (22.2-120.8%), exchangeable K (104.9-159.5%), exchangeable Ca (49.1-118.1%) and exchangeable Mg (13.6-51.2%) content. Overall, the earthworms maximized the decomposition and mineralization efficiency in vermibeds showing it as a useful method for organic manure management. Garg and Kaushik (2005) found that *E. fetida* population mortality was more in textile mill sludge vermibeds. But it can be minimized by adding sufficient amount of cow dung or plant residues (Suthar, 2007a). Also, Suthar (2007b) concluded that the factors relating to the growth of earthworms may also be considered in terms of physiochemical and nutrient characteristics of waste feed stocks. Le Bayon and Binet (2006) reported earthworm-mediated phosphatase enhancement in soils. They concluded that earthworm were responsible for additional alkaline phosphatases produced in the worm gut and excreted through cast deposition. Previous studies indicated that earthworms can accumulate heavy metals in their tissues during the vermicomposting process (Hartenstein and Hartenstein, 1981; Graff, 1974; Garg and Kaushik, 2005; Gupta *et al*., 2005). Yamada *et al*. (2007) developed an alternative composting method of cattle dung wastes consisting of a hyperthrmophilic pre-treatment reactor (HTPRT) (first step) combined with a general windrow post-treatment system (WPOT).

Composting is considered a well established technology for decomposition and changing the organic wastes, such as cattle dung, municipal solid waste and sewage sludge into a usable fertilizer or land reclamation materials and is an environmentally friendly and an economically alternative technology. Microbes mainly contribute to the biodegradation and humification of organic wastes and the production of composts with high quality. For sustainable use of organic wastes as materials of composts, it is important that pathogens and other health-related problems must be controlled (Yamada *et al*., 2007). Many researchers have reported that addition of compost improved the water holding capacity, bulk density and biological properties, reduced the odour and mortality of fly eggs as well as the amount of herbicide or tillage needed for weed control (Flavel and Murphy, 2006; Larney *et al*., 2006; Larney and Blackshaw, 2003; Wiederholt *et al*., 2011). Also, Grewal *et al*. (2006) did not find any of the *Escherichia coli*, *Salmonella* and *Listeria monocytogenes* in the compost after 27 days of composting.

According to Rynk *et al*. (1992), in general the microorganisms responsible for composting are present in the raw manures. Some investigators have reported that pulverization of manure beds is important to have good contact with the microbes during composting (Mathur *et al*., 1993; Francou *et al*., 2005; Steger *et al*., 2007). Because, compost maturity is highly related to microbial activities during the composting process. Several studies have provided information about the composting process and specific information for making compost (The Art and Science of Composting) (Cooperband, 2002), composting on organic farms (Baldwin and Greenfield, 2009) and On-Farm Composting Handbook (Rynk *et al*., 1992). Eze and Okonkwo (2013) evaluated three methods namely composting in pits, composting on plain soil surface and anaerobic digestion in a biodigestor for cow dung stabilization. They found that anaerobic digestion is the most efficient and effective in cow dung stabilization. The bacteria identified in the composting process were *Klebsiella*, *Bacillus pumilus*, *P. restrictum*, *Aspergillus niger* and *Psudomonas aeroginosa*. Yadav *et al.* (2013) used two vermicomposting units containing Cow Dung (CD) and Biogas Plant Slurry (BPS) and inoculated with Eisenia fetida species of earthworm for preparation of vermicompost. They found that the CD and BPS were converted into a homogeneous, odourless and stabilized humus material.

Previously, vermicomposting was considered as a bio-oxidative process where earthworms interact with microorganisms and other fauna within the decomposer community thus increasing the stabilization of organic matter. Many investigators have reported the benefits of vermicomposting for recycling organic wastes and animal wastes (Edwards *et al.*, 1998; Aira *et al.*, 2002, 2011; Loh *et al.*, 2005; Molina *et al.*, 2013), crop residues (Bansal and Kapoor, 2000), industrial wastes (Elvira *et al.*, 1998; Kaushik and Garg, 2003, 2004; Yadav and Garg, 2010; Garg *et al.*, 2012). Besides, animal wastes are useful alternative sources of organic matters for the improvement of soil conditions (Garg *et al.*, 2005). Manyi-Loh *et al.* (2014) reported that anaerobic digestion of animal manure is a promising technology in reducing the microbial load of dairy manure composting. The study showed that the order of reduction of public health pathogens was *Campylobacter* sp.<*Escherichia coli* sp.<*Salmonella* sp. from a viable count of 10.1×10^3, 3.6×10^5, 7.4×10^3 below the detection limit (DL = 10^2 CFU g^{-1} manure), respectively. Page *et al.* (2008) presented an anaerobic digestion model No. 1 (ADM1) for the treatment of dairy manure after considering the manure characteristics. Overall, the model predicted higher inorganic nitrogen than measured or known results. However, this model along with the set of associated parameters can be applied for simulating and optimizing the performance of full-scale dairy manure digesters. Atandi and Rahman (2012) reviewed various approaches and challenges of co-digestion to enhance biogas production and methane yield. They also mentioned that dairy manure poses handling, storage and disposal challenges.

Cattle farms are producing large volumes of manure all over the world and needs to follow appropriate disposal techniques to minimize the adverse impacts on environment (Burton and Turner, 2003). The issue of waste management is increasing due to the environmental awareness. It has encouraged the researchers to identify cost effective and environmental friendly technologies for animal manure for use as soil fertilizer (Zhang and He, 2006). Composting is an aerobic process depending on microbial activities which is considered environmentally sound technology to minimize organic waste and produce organic fertilizer or soil conditioner (Gajdos, 1992). The composting process usually transforms the raw and unstable organic wastes such as sewage sludge, municipal solid waste, tannery waste, animal manure and poultry manure etc into more stable forms by converting into humus thus resulting into a valuable agronomic by-product for soil application (Kashmanian, 2000).

Recently, Anwar *et al.* (2015) reported that application of compost prepared from a mixture of dairy manure with wheat straw and sawdust yielded higher plant biomass. However, compost prepared from cattle manure and rice straw contained high levels of total N and C:N ratio which are suitable to be used as soil amendment. Zhen *et al.* (2014) tried to reclaim degraded soils by applying manure compost and bacteria fertilizers alone or in combination on maize growth. They found that the number of microorganisms increased by the application of compost manure due to improved microbial activity and diversity of degraded irrigated lands. Ewulo *et al.* (2007) determined the effect of cow dung on soil, leaf mineral composition and pepper yield. The results showed that plant height, yield and fruit weight increased when Cow Dung (CD) was added up to 7.5 t ha^{-1}. Wani *et al.* (2013) observed that cow dung based compost, prepared by using the epigeic earthworm *Eisenia fetida*, contained high concentration of nitrogen, phosphorus and potassium nutrients compared to other waste materials. In an earlier study, Inbar *et al.* (1993) noticed that compost prepared from cattle manure between 40-60 days showed adverse effects on plant growth. Nahar *et al.* (2006) found significant differences in chemical composition and microbial population by application of raw and composted animal manure. They found negative relationship (r = -82) between the population of non-plant and plant parasitic nematodes. Ngakou *et al.* (2014) observed that the compost prepared from cow dung was higher in N, P and K contents as compared to kitchen manure.

Garg and Kaushik (2005) observed that mortality of *E. fetida* population was higher in vermibeds containing small amount of organic matter in textile mill sludge. While, Suthar (2007a) reported that earthworm mortality was higher in vermibeds with high contents of industrial sludge which can be minimized by addition of cow dung. In another study, Suthar (2007b, c) reported that conditions such as nature and types of waste material should be considered because organic waste palatability of earthworms is important for enhancing the reproduction capacity of the earthworms. Earlier, Le Bayon and Binet (2006) found that earthworms were responsible for the additional alkaline phosphatases in soils. Previous studies indicated that earthworms are capable of bioaccumulation of heavy metals in their body during the process of vermicomposting (Hartenstein and Hartenstein, 1981; Graff, 1974; Garg and Kaushik, 2005; Gupta *et al.*, 2005). Lallawmsanga *et al.* (2012) studied the effect of vermicompost and cow dung compost on growth and biochemical characteristics of *Solanum melongena*. They reported a considerable decrease in the length of the root and shoot, fresh and dry weight of the plant with increasing the concentration of the effluent. Also, all the plant growth parameters showed gradual increase except the leaf area when the concentration of effluent increased with vermicompost and cow dung.

An extensive reviewed showed that a very little has been accomplished for the preparation of compost using different types of microorganisms under local conditions for safe disposal of locally produced dairy manure. Also to minimize environmental hazards associated with its land disposal and lower the burden of importing huge quantities of compost for landscape development in Saudi Arabia. Therefore, the main objective of this study is to summarize different composting techniques used elsewhere and to develop vermicomposting technology under local environmental conditions. Also to establish and commercialize this technology locally for producing vermicomposts, which is environmental friendly and safe for proper disposal of large amount of dairy manure with minimum health hazards for the adjacent population.

EARTHWORMS FOR VERMICOMPOSTING

Selection of suitable earthworm species for vermicomposting is an important step of this process. There are thousands of known earthworm species, but only a few are suitable for vermicomposting of cow manure or dairy manure. Among these, epigeic species of earthworms are widely used for vermicomposting of different types of organic wastes. Out of these, *Eisenia fetida* earthworm species is the most commonly used for vermicomposting of agricultural wastes and animal manures (Edwards *et al*., 1998). Neuhauser *et al*. (1988) evaluated the overall reproductive capabilities of five earthworm species, viz., *Eudrilus eugeniae*, *Perionyx excavatus*, *E. fetida*, *Drawida veneta* and *Perionyx hawayana*. They suggested that *E. fetida* is the most appropriate species for vermicomposting process using animal waste especially the dairy manure (cow manure). Similarly, red wiggler (*Eisenia fetida* or *Eisenia andrei*); *Lumbricus rubellus* (a.k.a. red earthworm or dilong (China)) is one of the earthworm species most commonly used for composting. While, red wiggler is another earthworm specie which can be used for composting, but is not suitable for shallow compost beds as compared to other worm species such as *Eisenia fetida*. Howver, European nightcrawlers (*Eisenia hortensis*) can also be used for composting. Many other earth worm species such as European nightcrawlers, dendrobaenas, dendras and Belgian nightcrawlers, African Nightcrawlers (*Eudrilus eugeniae*), *Lumbricus terrestris* (a.k.a. Canadian nightcrawlers (US) (Loh *et al*., 2005) and blueworms (*Perionyx excavatus*) (Edwards *et al*., 1998).

Composting manure process: The microorganisms responsible for composting are indigenous to manures. By properly managing compost, the producer facilitates these decomposing microbes. The manure must be piled, the Carbon-nitrogen (C/N) ratio should be 30-to-1, 50% of the pore space should contain water and the pile must be aerobic (having oxygen) as described by Rynk *et al*. (1992).

Compost aeration methods: Turning manure is essential to composting manure. The process of turning compost incorporates oxygen into the system, homogenizes the pile and breaks up clumps. Also, the mixing process allows more contact of manure with microbes. On the other hand, applying immature compost can cause issues that include malodors, insect swarms, nitrogen immobilization and phytotoxicity (Mathur *et al*., 1993; Francou *et al*., 2005; Steger *et al*., 2007). Compost maturity is strongly related to microbial activities during the composting process. The data in Table 1 shows various studies carried for vermicomposting using animal excreta waste called as dairy manure.

Table 1: Various studies conducted on vermicomposting of animal excreta/waste

Animal waste	Earthworm	Scale	References
Cow dung	*Perionyx ceylanensis*	Laboratory	Karmegam and Daniel (2009)
Cow, sheep, pig and chicken wastes	*Eudrilus eugeniae*	Laboratory	Coulibaly and Zoro Bi (2010)
Cattle manure	*Eisenia andrei*	Laboratory	Lazcano *et al*. (2008)
Cattle manure	*Eisenia andrei*	Pilot	Elvira *et al*. (1998)
Cow manure	*Eisenia fetida*	Laboratory	Contreras-Ramos *et al*. (2005)
Cattle solids, pig solids, horse solids and turkey waste	*Perionyx excavates*	Laboratory	Edwards *et al*. (1998)
Cow manure and poultry droppings	*Metaphire posthuma*	Laboratory	Bisht *et al*. (2007)
Cow, buffalo, horse, donkey, sheep, goat and camel wastes	*Eisenia fetida*	Laboratory	Garg *et al*. (2005)
Cow manure	*Eisenia fetida*	Industrial	Aira *et al*. (2011)
Pig manure	*Eisenia fetida*	Laboratory	Aira *et al*. (2007)
Rabbit manure	*Eisenia fetida*	Laboratory	Molina *et al*. (2013)
Rabbit manure	*Eisenia fetida*	Industrial	Gomez-Brandon *et al*. (2013)
Goat manure	*Eisenia fetida*	Laboratory	Loh *et al*. (2005)

Table 2: Physical and chemical composition of compost quality

Parameters	Treatments (Mean±SD) 100FW	75FW25M	50FW50M	25FW75M	p-value
EC (dS m^{-1})	4.02±0.41	3.19±0.62	2.51±0.42	2.83±1.40	0.21
pH 1:2:5	7.67±1.06	7.79±0.40	7.83±0.70	7.62±0.29	0.975
AK (cmol (+)/kg soil)	27.07±9.24	26.64±4.05	21.63±4.23	21.74±6.42	0.595
AP (mg kg^{-1})	676.67±200.24	385.67±190.08	694.67±95.02	663.67±204.80	0.997
TN (%)	1.94±0.40	1.63±0.13	1.51±0.13	1.41±0.72	0.488
OC (%)	33.16±3.93	31.36±1.70	31.08±3.59	31.35±2.13	0.820
CEC (cmol (+)/Kg soil)	60.87±6.18	61.05±4.01	62.14±4.01	60.51±2.20	0.970

Source: Wolka and Melaku (2015)

Table 3: Soil properties after applying various treatments

Parameters	Treatment (Mean±SD) 100FW	75FW25M	50FW50M	25FW75M	Control	Commercial fertilizer	p-value
EC (dS m^{-1})	0.05±0.02	0.06±0.00	0.04±0.01	0.06±0.01	0.05±0.02	0.04±0.00	0.33
pH 1:2:5	6.16±0.11	6.14±0.06	6.32±0.17	6.27±0.12	6.29±0.17	6.18±0.14	0.99
AK (cmol (+)/kg soil)	0.79±0.29	0.68±0.07	0.58±0.12	0.73±0.25	0.71±0.15	0.62±0.16	0.30
AP (mg kg^{-1})	12.15±1.24	9.27±4.16	7.01±3.29	8.49±4.56	4.62±2.36	6.56±1.13	0.13
TN (%)	0.16±0.04	0.16±0.03	0.17±0.03	0.14±0.02	0.15±0.03	0.18±0.05	0.69
OC (%)	1.66±0.40	1.53±0.23	1.70±0.31	1.39±0.20	1.25±0.29	1.78±0.50	0.43
CEC (cmol (+)/kg soil)	15.49±1.62	14.86±2.82	17.32±1.37	15.15±2.58	15.00±3.83	17.82±1.06	0.54

Source: Wolka and Melaku (2015)

Table 4: Comparing soil properties before and after treatment application

Parameters	Treatment	Mean±SD	p-value
EC (dS m^{-1})	Before treatment	0.04±0.01	0.07
	After treatment	0.05±0.01	
pH (1:2.5)	Before treatment	6.28±0.12	0.3
	After treatment	6.22±0.13	
AK (cmol (+) kg soil	Before treatment	0.67±0.01	0.8
	After treatment	0.69±0.01	
AP (mg kg^{-1})	Before treatment	9.63±5.40	0.4
	After treatment	8.02±3.56	
TN (%)	Before treatment	0.42±0.05	0.00
	After treatment	0.16±0.03	
OC (%)	Before treatment	3.73±0.5	0.00
	After treatment	3.65±0.4	

EC: Electrical conductivity of soil extract, AK: Alkalinity of soil, AP: Available phosphorus, TN: Total nitrogen, OC: Organic carbon, Source: Wolka and Melaku (2015)

PREVIOUS WORK ACCOMPLISHED ON VERMICOMPOSTING

Wolka and Melaku (2015) prepared compost from dairy manure and presented the physical and chemical composition to determine its quality for using a potting material (Table 2). They used a combination of Farm Waste (FW) and Manure (M) during the vermicomposting process. They noticed that all the quality parameters showed gradual decrease with increasing rate of application of manure in the mixture. This would mean that FW with higher rate of manure produced good quality compost, although most of the nutrients showed slight decrement.

Effect of compost application on soil properties: According to the study of Wolka and Melaku (2015), all the quality parameters of compost were appreciably higher than the control treatment (Table 3). This suggests that addition of more manure in the mixture improved the nutrient status of the compost which can be used as a potting material for nursery and landscape development. Although, the nutrient status of compost is slightly low when compared to the commercial fertilizer, but its addition has an additional advantage of addition of organic matter to the soils thus improving its physical structure especially the water and nutrient holding capacity than the virgin soil.

Effect on soil properties: The effect of compost application on soil properties before and after its application was observed by Wolka and Melaku (2015) and presented in Table 4. They found that almost all the quality parameters showed decreasing trend after compost application. This might be due to the leaching of the nutrients as a result of improved soil structure.

In another study, Adhikary (2012) compared the chemical and microbiological properties of soil, vermicompost and the manure for application to soil and use as a potting material (Table 5). It is evident from the results in Table 5 that all the parameters were slightly higher both in vermicompost and manure than the original soil. This indicated poor soil fertility status when compared to soil properties after application of both types of organic manures.

Table 5: Comparison of the chemical, microbiological properties of soil, vermicompost and manure

	Nutrient available from		
Parameters	Soil	Vermicompost	Manure
pH	5.96±0.11	8.09±0.09	8.59±0.14
Electrical conductivity (mS cm^{-1})	0.33±0.04	0.18±0.02	3.05±0.08
Moisture content (g kg^{-1})	249±4	535±3	864±5
Water holding capacity (g kg^{-1})	361±4	1103±13	ND
DOC (mg g^{-1} dry matter)	0.13±0.03	0.60±0.24	15.4±7.91
DN (mg g^{-1} dry matter)	0.04±0.01	0.07±0.03	1.89±1.07
Total C (g kg^{-1})	31±1	181±3	299±6
Total N (g kg^{-1})	3.0±0.3	8.7±0.7	14.2±1.5
C-to-N ratio	10.2	20.9	21.1
3 (mg g^{-1} dry matter) NO^-	<0.1	<0.1	<0.1
4NH^+ (mg g^{-1} dry matter)	<0.1	<0.1	1.0±0.7
P (mg g^{-1} dry matter)	<0.1	<0.1	2.2±1.6
K (mg g^{-1} dry matter)	0.9±0.2	1.3±0.1	2.1±0.1
Ca (mg g^{-1} dry matter)	10.5±3.4	26.3±2.2	0.3±0.1
Na (mg g^{-1} dry matter)	0.05±0.05	0.21±0.04	0.42±0.02
Background heterotrophicbacteria (log10 CFU g^{-1})	7.85	8.41	8.93
Escherichia coli O157:H7 (log10 CFU g^{-1})	0.00	0.00	0.00

ND: Not determined, Source: Adhikary (2012)

Table 6: Nutrient composition of vermicompost and garden compost

Nutrient element	Vermicompost (%)	Garden compost (%)
Organic carbon	9.8-13.4	12.2
Nitrogen	0.51-1.61	0.8
Phosphorus	0.19-1.02	0.35
Potassium	0.15-0.73	0.48
Calcium	1.18-7.61	2.27
Magnesium	0.093-0.568	0.57
Sodium	0.058-0.158	<0.01
Zinc	0.0042-0.110	0.0012
Copper	0.0026-0.0048	0.0017
Iron	0.2050-1.3313	1.1690
Manganese	0.0105-0.2038	0.0414

Source: Adhikary (2012)

Similar to the above, Adhikary (2012) presented the nutrient composition of vermicompost and the garden compost (Table 6). It was observed that all the macro and microelements essential for optimal plant growth were considerably higher in vermicompost as compared to garden compost. This difference might be due to the difference in the type and nature of the organic material used during composting process. There is a possibility that the organic garden waste material has low basic nutrient levels in the waste material as compared to the manure.

According to the investigation of Dickerson (1994), a comparison between the quality characteristics of garden compost and vermicompost is shown in Table 7. He found significantly higher concentration of all the plant nutrients in vermicomposts compared to the garden compost. As mention earlier, this difference in fertility status between these two composts may be subjected to the difference in the quality of organic material used during composting process.

Table 7: Comparison of chemical characteristics of garden compost and vermicompost, 1994

Parameter*	Garden compost 1	Vermicompost 2
pH	7.80	6.80
EC (mmhos cm^{-1})**	3.60	11.70
Total Kjeldahl nitrogen(%)***	0.80	1.94
Nitrate nitrogen (ppm)****	156.50	902.20
Phosphorous (%)	0.35	0.47
Potassium (%)	0.48	0.70
Calcium (%)	2.27	4.40
Sodium (%)	<0.01	0.02
Magnesium (%)	0.57	0.46
Iron (ppm)	11690.00	7563.00
Zinc (ppm)	128.00	278.00
Manganese (ppm)	414.00	475.00
Copper (ppm)	17.00	27.00
Boron (ppm)	25.00	34.00
Aluminum (ppm)	7380.00	7012.00

1 Albuquerque sample 2 Tijeras sample *Units: ppm = parts per million mmhos/cm = millimhos per centimeter, **EC: Electrical conductivity is a measure (millimhos per centimeter) of the relative salinity of soil or the amount of soluble salts it contains, ***Kjeldahl nitrogen: Measure of the total percentage of nitrogen in the sample including that in the organic matter, ****Nitrate nitrogen: Nitrogen in the sample that is immediately available for plant uptake by the roots, Source: Dickerson (1994) Vermicomposting Guide H-164, Extension Horticulture Specialist Cooperative Extension Service College of Agriculture and Home Economics New Mexico State University, USA

Compost benefits: The benefits expected from the addition of compost include the improvement of soil fertility, water-holding capacity, bulk density and biological properties (Flavel and Murphy, 2006). Because, the odors were reduced and the mortality of fly eggs increased due to high temperatures during microbial decomposition (Larney *et al*., 2006). Some weed seeds remain viable in properly prepared

Fig. 1: Nursery crops grown in a greenhouse using treated animal manure, Source: Wolka and Melaku (2015)

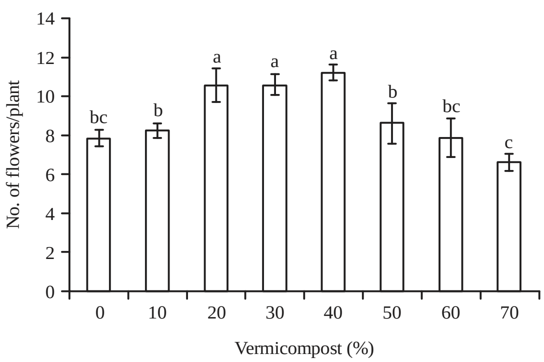

Fig. 2: Effect of vermicompost on number of flowers per plant, Source: Wolka and Melaku (2015)

composted manure thus resulting in reduced amount of herbicide or tillage needed for weed control. Larney and Blackshaw (2003) studied weed seed viability in composted livestock manures. It is found that downy brome, false cleavers, foxtail barley, scentless chamomile, wild mustard and wild oat, as well as the weed seeds did not germinate 21 days after com posting. Some weed seeds such as green foxtail, redroot pigweed, round-leaved mallow, stinkweed and wild buckwheat were difficult to kill or eliminate. Wiederholt *et al*. (2011) compared the energy requirement of a 180-head feed lot operation when applied the raw manure and composted manure to agricultural fields. They concluded that composting and applying livestock compost are more energy efficient than hauling raw manure. They further compared the life span of pathogens in the simulated composted dairy manure, a simulated dairy manure pack and a simulated liquid dairy lagoon. They also found that after three days of composting at 131°F, some of the bacteria such as *Escherichia coli*, *Salmonella* and *Listeria monocytogenes* could not be detected. While, *Salmonella* was detected after 28 days in the manure pack and lagoon simulations. *Escherichia coli* and *Listeria monocytogenes* were found in the lagoon after 14 days and *Listeria* was not found after seven days in the bedded pack simulations.

Uses of compost: Animal manure can provide nutrients in the early growth stage of plants and play the role of starter fertilizers that growers frequently apply. On the other hand, use of these components requires careful management of both nutrient application and irrigation management. Overall, nursery managers who have successfully produced a wide variety of nursery crops with varied soil types also can successfully grow nursery crops using treated animal manure (Fig. 1-2) and benefit considerably from its use.

CONCLUSION

The review showed that among the different earthworm species, Eisenia fetida is the most efficient and commonly used earthworm for vermicomposting to develop appropriate compost using cow dung (dairy manure).Overall, this review has highlighted the various vermicomposting technologies, various earthworm and bacteria species involved in vermicomposting, effect on soil and plant growth as well as the benefits of using compost prepared by way of vermicomposting. The study showed a lot of potential for producing compost by vermicomposting technology using cow manure which is safe and environmentally friendly.

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