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Cane Molasses: An Ammonia Suppressant in the Composting Manure and Municipal Wastes

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Abstract: The aim of this study is to evaluate effect of cane molasses on total nitrogen and C/N ratio of municipal wastes compost and cattle manure. Treatments included different amounts of molasses with municipal decomposable wastes and cattle manure that were added to organic wastes in 2 and 4 weeks after composting start (first and second stages). Each of treatments with 20 kg fresh organic wastes (decomposable municipal wastes and manure) in three replicates as a completely randomized design was done. After 50 days, a 100 g sample of every treatment was taken to measure total nitrogen, organic carbon, C/N ratio, EC and pH in 1:6 dry organic matter/water. Results indicated that the molasses held nitrogen in compost caused to reduce C/N ratio. The effect of molasses on total nitrogen of manure treatments is more than municipal wastes. Total nitrogen of 4% molasses-manure treatment at the second stage increased 4.6 times than its control; while this was only 1.43 times for 4% molasses-municipal wastes treatment at the same stage than municipal wastes-control treatment.

Key words: Cane molasses, composting, cattle manure, municipal wastes

INTRODUCTION

Iran has located in dry belt of earth to take pains from organic matter poverty in agriculture lands and so this status is observed in the great area of humid and semi-humid regions of Iran. Deficit of organic matter with decrease in microorganism's activity caused to reduce soil productivity. Therefore, using organic matter in Iran's soil should be inserted in the soil management program. A way to compensate soil organic matter deficit is the use of the manure and municipal wastes composts. It is a well known fact that composting is one of the most suitable ways of converting organic wastes into more stable products which are safe and beneficial to plant growth, as well as an environmentally friendly and economical alternative method for treating solid waste (Liang *et al*., 2006).

Composting is a biochemical process converting various components in organic wastes into relatively stable humus-like substances that can be used as a soil amendment or organic fertilizer. Even though composting is a proven-technology that can be applied on the spot, there are many aspects that should be improved in the performance of current composting facilities. One of these areas is the conservation and enhancement of the nutrients value of the product by reducing the loss of nitrogen (Jeong and Kim, 2001). The decreased ammonia loss may lead to an alleviation of the odor problem that is usually encountered in full-scale composting facilities (Switzenbaum *et al*., 1994). Ammonia (NH_3) is generated from decomposition of nitrogenous material, i.e., proteins and amino acids. Its emission frequently occurs during the thermophilic stage of aerobic decomposition and tends to be high with low C/N ratio. However, when different types of organic materials are composted, a higher C/N ratio does not necessarily indicate an effective solution for preventing N loss (Baca *et al*., 1992; Brink, 1995; Eklind and Kirchmann, 2000; Mahimairaja *et al*., 1994). Several factors such as C/N ratio, temperature, mixing and turning and aeration rate can influence the volatilization of ammonia during

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composting (Morisaki *et al*., 1989). Gaseous nitrogen losses during composting occur mainly as ammonia, but may also occur as nitrogen and NO_x (Eklind and Kirchmann, 2000). Use of the carbon sources affects the ammonia volatilization and total nitrogen of produced compost. Both chemical form and particle size of carbon (C) source affect the availability of C to microorganisms. Glucose, a readily available C source, appeared to cause immediate immobilization of N when an appreciable amount was added to soil (Okereke and Meints, 1985). Subair (1995) found that glucose was effective in reducing NH_3 volatilization from liquid hog manure, whereas material resistant to decomposition (sawdust) was not.

There are several sugar mills located in the sugar cane cultivation areas of Iran. On an annual basis, the sugar production process releases molasses by products amounted 30000 t, in Haft Tappeh sugar factory. The utilization of this by-product is important for the economy of the global use of the crop. There is a market for molasses as a matter for domesticated meal, organic acid production and as soil amendment. Currently, an option for molasses utilization is as an amendment for production of organic wastes compost (Liang *et al*., 2006). The objective of this study is to evaluate the effectiveness of molasses as a carbonic amendment in reducing N losses and increasing municipal compost quality.

MATERIALS AND METHODS

This study was conducted in 2008, at Islamic Azad University, Rasht Branch, Rasht, Iran. Cane molasses was prepared from Haft Tappeh Sugar Factory, Khouzestan Province. Molasses is a by-product of sugar production so that sugar extraction from the cane stalks provides molasses it as a by-product of the plant fresh weight. Applied molasses has an acidic pH (pH = 5.5), its electrical conductivity is 25 dS m^{-1} and C/N ratio is equal 72.3. Municipal wastes were collected from the compost factory of Rasht, Guilan Province. The material discharged from the rotary drum was passed through the trammel screen with the finer size fraction being collected through the screen and the coarser size fraction being collected on the screen. The finer fraction contains mainly biodegradable organic materials and was used for composting and the coarse fraction contains mainly non-biodegradable organic (e.g., plastics) and inorganic (e.g., metals, glass) materials was sent to a landfill. The fines account for 50-55% of the original weight of material and have a moisture content of 55-60%. Some properties of the used molasses, cattle manure and municipal wastes are observed in Table 1-3.

Each of treatments with 20 kg fresh organic wastes (decomposable municipal, manure or their mixture) in three replicates as a completely randomized design was done. Treatments included different amounts of molasses that were added to decomposable municipal wastes and manure in 2 and 4 weeks after composting start (first and second stages) as following:

- Municipal wastes control treatment (M_0): no amendment
    - M_{2-1} treatment i.e., 2% molasses mixed with municipal wastes at the first stage
    - M_{4-1} treatment i.e., 4% molasses mixed with municipal wastes at the first stage
    - M_{2-2} treatment i.e., 2% molasses mixed with municipal wastes at the second stage
    - M_{4-2} treatment i.e., 4% molasses mixed with municipal wastes at the second stage
- Manure control treatment (M_a): no amendment
    - MaM_{4-1} treatment i.e., 4% molasses mixed with municipal wastes at the first stage
    - MaM_{4-2} treatment i.e., 4% molasses mixed with municipal wastes at the second stage
    - Ma_{20} treatment i.e., municipal wastes mixed with 20% manure
    - $Ma_{20}M_{4-1}$ treatment i.e., municipal wastes mixed with 20% manure and 4% molasses at the first stage
    - $Ma_{20}M_{4-2}$ treatment i.e., municipal wastes mixed with 20% manure and 4% molasses at the second stage

Table 1: Concentration of the some elements and pH in the used municipal wastes

Parameters	Amount	Parameters	Amount
pH (1:6 dry OM/water)	6.24	Cl (%)	0.51
N (%)	1.12	Na (%)	0.62
C (%)	16.27	S (%)	0.24
P (%)	0.29	Fe (%)	0.70
K (%)	0.24	Zn (ppm)	302.00
Ca (%)	1.86	Mn (ppm)	311.00
Mg (%)	0.22	Cu (ppm)	186.00

Table 2: Chemical compounds of the used cane molasses

Molasses compounds	Kind	Percent
Sugar and non sugar compounds	Sugar	27.30
	Brix	84.60
	Purity	32.27
	Sucrose	33.11
	Ash	11.82
Organic compounds	Starch	0.10
	Gum	1.47
	Wax	0.20
	Total nitrogen	0.20
Non metallic compounds	Cl^-	1.96
	SO_4^{2-}	2.50
	P_2O_5	0.09
Metallic compounds	Na_2O	0.11
	K_2O	6.10
	CaO	1.22
	MgO	0.66
	SiO_2	0.36

Table 3: Organic mass temperature in different treatments during the composting

	Time after composting start (week)						
Treatments	1	2	3	4	5	6	7
M_0	32	37	42	51	48	39	28
$M_{2\text{-}1}$	30	33	44	52	50	41	27
$M_{4\text{-}1}$	27	37	42	50	47	38	30
$M_{2\text{-}2}$	29	28	38	49	54	43	32
$M_{4\text{-}2}$	30	37	39	54	58	41	30
Ma	31	29	36	39	40	32	28
$MaM_{4\text{-}1}$	27	26	35	41	40	34	30
$MaM_{4\text{-}2}$	31	30	38	42	44	35	30
Ma_{20}	32	35	42	49	44	33	28
$Ma_{20}M_{4\text{-}1}$	30	36	45	51	43	34	28
$Ma_{20}M_{4\text{-}1}$	28	34	42	48	49	37	30

Molasses, with a composition of mainly sucrose, was chosen as the readily available C source to be added into composting mixture. Increasing dosage of molasses were dissolved in the same amount of water and added in treatments. Treatments in free space weekly twice to turn upside down for aeration, while exercising some treatments and adding water for adjusting moisture of organic wastes were also done. After 50 days, a 100 g sample of every treatment was taken. The samples were air dried and ground to pass through a 1 mm sieve. Total Kjeldahl Nitrogen (TKN) and Total Organic Carbon (TOC) of samples were estimated by using a micro-Kjeldahl method (Randhir and Pradhan, 1981) and Walkey and Blacks (1934) rapid titration method. The pH and EC were determined on a water extract from compost using compost to water ratio of 1:6 by weight. The pH and EC values were determined from three 5 g samples that for each sample, 30 mL of DD water was added and mixed to compost.

Microbiological assays (microbial activity detecting) were done with bacteria, actinomycetes and fungi plate counting method as described by Storm (1985). Actinomycetes and fungi were isolated on the agar plates by dilution plating. Mesophilic and thermophilic microbial strains were obtained by plating samples taken from composting processes and cultivating the plates at 30 and 60°C, respectively (Xi *et al*., 2005).

Data were analyzed by standard ANOVA procedures using MSTATC and SAS software and significant differences was determined based on $p<0.05$ level for the least significant difference test.

RESULTS

Table 3 indicates the temperature of the organic wastes during 7 weeks of composting process. In molasses treatments of municipal wastes at the first stage, organic wastes temperature was maximum at the fourth week increased to more than 50°C. Temperature in these treatments of second stage at the fifth week has reached to maximum. This trend more or less exists for manure and mixture of the manure and municipal wastes treatments. Temperature level of manure treatments is less than municipal wastes treatments. Table 4 shows the total heterotroph counts in different treatments during the composting (log cfu/g). It is observed that there is conformity between total heterotroph counts and temperature, so that, more microorganisms population is related to the higher temperature.

Table 4 shows the effect of molasses on the total nitrogen of final compost. At the first stage, application of 2 and 4% of molasses have increased the total nitrogen than in the control but this increase in 2% molasses treatment not significant. In all molasses treatments, carbon has decreased compared with control, but changes not significant (Table 4). Thus, C/N ratios in molasses treatments have decreased than in the control. Decrease in C/N ratio between 2 and 4% molasses is also observed but not significant. A result of Table 4 indicated that the use of the 2 and 4% molasses in both stages did not significantly affect on the pH than in control.

A comparison between the control treatments of manure and municipal wastes (M_0 and Ma) shows that the carbon level of the manure is more than in the municipal wastes, but its nitrogen is less. Molasses has remarkably increased total nitrogen of manure compared with control (Ma). This increase is 2.92 and 4.6 times than in the control (Ma) by using 4% molasses at the first and second stages, respectively. Although use of 4% molasses at the first stage has significantly decreased manure carbon, but the decrease in C/N ratio of manure treatments by using 4% molasses at the second stage is more than its first stage (6.63% versus 9.66%). An important point is the lower EC of manure treatments as compared with the municipal wastes. While electrical conductivity is 6.65 dS m^{-1} in municipal wastes control treatment, this is only 1.43 dS m^{-1} for manure control treatment.

When molasses treatments in manure are compared with municipal wastes, we see that the effect of molasses on total nitrogen of manure is more than municipal wastes. This is correct that the C/N ratio of municipal wastes control treatment is lower than the manure control treatment but since

Table 4: Total hetrotrophs counts in different treatments during the composting (log cfu g^{-1})

	Time after composting start (week)						
Treatments	1	2	3	4	5	6	7
M_0	6.1	7.4	8.2	9.4	9.3	8.0	6.0
$M_{2\text{-}1}$	8.3	8.7	9.9	10.6	10.5	9.3	7.5
$M_{4\text{-}1}$	7.7	9.3	9.6	10.3	9.5	8.6	7.6
$M_{2\text{-}2}$	6.1	6.3	7.3	10.0	11.2	9.4	8.7
$M_{4\text{-}2}$	8.4	9.0	9.2	11.0	11.4	9.2	7.0
Ma	8.0	6.7	8.3	9.0	9.2	8.0	6.4
$MaM_{4\text{-}1}$	7.4	7.6	8.0	9.1	9.0	8.3	8.0
$MaM_{4\text{-}2}$	8.1	8.2	9.2	9.2	10.0	8.1	7.4
Ma_{20}	6.6	8.1	9.0	10.1	9.7	8.4	8.0
$Ma_{20}M_{4\text{-}1}$	7.5	9.0	9.3	10.8	8.7	8.5	7.9
$Ma_{20}M_{4\text{-}2}$	6.3	8.8	9.0	9.7	10.0	9.2	7.0

molasses has more increased total nitrogen of manure than municipal wastes, consequently, C/N ratio of molasses-manure treatments is less than molasses-municipal wastes treatments. Total nitrogen of the municipal wastes treatment mixed 20% manure (Ma_{20}) had a middle status of manure and municipal wastes control treatments. Adding 20% manure and 4% molasses to municipal wastes did not caused to significant change in total nitrogen compared with adding only 4% molasses to municipal wastes at the first stage but significantly increased it at the second stage.

DISCUSSION

It seems that the use of molasses at the first stage caused to occur thermophilic stage in the 4th week after composting, but with the use of molasses at the second stage, microorganism activities has increased until the 5th week, consequently, we observe the temperature pick in this week that Table 5 confirm this.

Ammonia (NH_3) is generated from decomposition of nitrogenous materials, i.e., proteins and amino acids with low C/N ratio (Liang *et al*., 2006). Ammonia loss of the great N-compounds decomposition is led to decrease in the total nitrogen. Xi *et al*. (2004) reported that the ammonia volatilization is the most important reason nitrogen loss of the chicken manure compost. Therefore, it would be desirable if N is retained and converted to organic forms during composting. Ammonia emission frequently occurs during the thermophilic stage of aerobic decomposition and tends to be high with low C/N ratio. Xi *et al*. (2004) concluded that the addition of 1% rice straw in the chicken manure could reduce the loss by 2.52%. Pilot composting experiments of swine manure with corncob by Nengwu (2006) showed that the composting system could destroy pathogens, converted nitrogen from unstable ammonia to stable organic forms and reduced the volume of waste.

Using molasses in organic wastes has promoted microorganisms activity, consequently they have decomposed organic wastes to obtain carbon for production of microbial biomass, which contributed to the nitrogen immobilization by microorganisms and a resultant reduced N loss. This is in agreement with the results of Liang *et al*. (2006). They reported that addition of the molasses, a readily available form of carbon has reduced cumulative ammonia emissions substantially, so that nitrogen loss of the most-molasses (10% of initial DM) was the lowest (12.1%), while the highest N loss (24.6%) occurred with no amendment.

The more increase in total nitrogen of 4% molasses treatment second stage between municipal wastes treatments can be due to use of the more molasses, aeration and adding it in second stage. Reports indicated that NH_3 volatilization increased remarkably in thermophilic stage and with the increase of air supply (Beck *et al*., 1997; Osada *et al*., 1997). Maeda and Matsuda (1977) reported a linear relationship between NH_3 collected in acid trap an aeration rate when composting swine, dairy and poultry manure with varying C/N ratios from 15 to 45 under various levels of constant aeration. Therefore, it seems that the greatest increase in the total nitrogen of recent treatment is because of adding molasses near thermophilic stage.

Table 5: Treatments effect on total nitrogen, carbon, C/N ratio, pH and EC of produced compost

Treatments	Total nitrogen (%)	Carbon (%)	Ratio C/N	pH	EC
M_0	0.78fghi	11.80cd	15.56cde	8.11abc	6.65d
$M_{2\text{-}1}$	1.00efgh	11.03d	11.16defg	8.02abcd	7.56ab
$M_{4\text{-}1}$	1.10ef	11.36cd	10.40efg	8.04abcd	7.93a
$M_{2\text{-}2}$	1.02efg	11.26cd	11.00defg	8.02abcd	6.80cd
$M_{4\text{-}2}$	1.12e	11.20d	9.96efg	8.10abc	7.50ab
Ma	0.50ij	14.70a	29.86b	8.00bcd	1. 43f
$MaM_{4\text{-}1}$	1.46d	13.96b	9.66efg	8.20a	1. 30f
$MaM_{4\text{-}2}$	2.30a	15.23a	6.63g	8.15ab	2.86e
Ma_{20}	0.69hi	13.36b	19.73c	8.05abcd	7.06bc
$Ma_{20}M_{4\text{-}1}$	0.99efgh	13.93b	14.26cdef	7.93cde	6.36d
$Ma_{20}M_{4\text{-}2}$	1.53cd	13.70b	9.43efg	8.09abc	7.60ab

Mean values with same letter(s) are not significantly different

Carbon variations are approximately similar in molasses-municipal wastes treatments, but to differentiate their C/N ratios that is related to the total nitrogen differences. The greatest decrease in C/N ratio is related to 4% molasses treatment amounted 1.56 times than in the control. Molasses has increased treatments electrical conductivity compared with the control, but it should be regarded that this increase in EC can be adjusted by the soil EC, when it is mixed in the soil because increase in EC was not considerable than in the control.

A comparison of manure and municipal wastes shows that the manure has a more carbon but its nitrogen is lower. It seems that the decomposition process of organic wastes and ammonia volatilization in composting manure is more than municipal wastes. Adding 4% molasses to manure has a more effect on stopping ammonia and increase in total nitrogen than same amount of molasses (4%) in municipal wastes. Although loss of nitrogen in manure-control treatment is more than municipal wastes-control treatment, but use of molasses in manure has more retained nitrogen. C/N ratio of manure-control treatment is 29.86; while this ratio has reached to 6.63 in 4% molasses second stage i.e., it is observed a decrease in C/N ration amounted 4.5 times. In treatments having 80% municipal wastes and 20% manure, the amount of the total nitrogen had a middle status of manure and municipal wastes control treatments.

Variations trend to differentiate fully the effect of molasses on manure and municipal wastes. It seems that the decomposition of organic matter in municipal wastes must more than manure, since manure has a more C/N ratio. Therefore, growth and activity of microbial population in municipal wastes is more than manure encouraged by adding molasses. It decreases, consequently, ammonia volatilization caused to increase in total nitrogen of the final compost. But results don't show this, so that, total nitrogen in manure treatments is more than municipal treatments. Investigations of pH show that the considerable different doesn't exist between pH of manure and municipal treatments, but this difference is considerable for electrical conductivity. EC is 1.43 and 6.65 dS m^{-1}, respectively in manure-control and municipal wastes-control treatments. This is 7.93 and 1.3 dS m^{-1} for the use of 4% molasses in manure and municipal wastes, respectively. Therefore, it seems that the effective factor in connection with the more total nitrogen of manure treatments is salinity. Salinity has a negative effect on microbial biomass to slow microorganisms' growth.

CONCLUSION

Molasses as a readily carbon resource is a suitable ammonia suppressant for municipal wastes and manure compost production to increase the total nitrogen of the final compost. Influence of molasses on total nitrogen and C/N ration of manure compost is more than municipal wastes that is because of the lower salinity of manure. This increases microorganisms' growth and their activity caused to the more stop of ammonia and increase in total nitrogen. The best treatments with the view of C/N ratio were obtained by using 4% molasses 4 weeks after composting start at both manure and municipal wastes.

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