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Research Article

Compost and Nutrient Dynamics under Irrigation and Shadowing for Horticulture in Northeast Brazil

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ABSTRACT

Purpose: Determine the decomposition of compost under two levels of shading (total and none) and central pivot and sprinkler irrigation.

Methods: Litter boxes were made with a 4mm mesh base, and PVC sides and filled with compost. Boxes were recovered after 0, 2, 4, 6, 8, 10 and 12 months. Amounts of remaining compost and nutrients were measured and decomposition rates and half-life values were calculated. Soil under the litter boxes was analyzed before and after removing boxes, for nutrient contents (N, P, K, Ca, and Mg) and organic carbon.

Results: Compost was lost quickly over time. Losses were faster under central pivot than sprinkler irrigation. Total shade caused higher rates of decomposition than without shade. Half-life values varied from 0.12 to 1.02 years. Losses of nutrients were substantial, with P and K being lost at faster rates than mass loss.

Conclusions: Nutrients were lost rapidly from compost and were mostly not present in the soil. Insects may have removed compost from the boxes. Total shadowing increases decomposition rates of compost.

Keywords: Decomposition rate; Half-life; Litter box; Soil fauna; Soil organic matter

INTRODUCTION

Many studies have focused on a better understanding of the mechanisms that control of the organic matter and how these patterns vary on a landscape scale [1-3]. The rates and patterns of organic waste decomposition are governed mainly by the chemical composition of the material and by climatic factors such as temperature and precipitation.

In arid and semi-arid ecosystems, which comprise one-third of the earth's surface [4], litter and soil organic matter decompose faster than predicted by biogeochemical models that are based on temperature, precipitation, and chemical composition of plants. Many hypotheses were proposed to explain this phenomenon, however, all failed to explain the rapid loss of mass in arid and semi-arid ecosystems [5,6].

The northeastern region of Brazil has characteristics of climate, humidity and precipitation that fit it into the classification of a semiarid region. Generally, temperatures are high throughout the year, around 28°C. This climate impacts on agriculture, including elevated carbon losses to the atmosphere and reductions in soil organic matter and crop performance.

Promoting soil cover can be considered a suitable management practice to improve crop performance, since it protects the soil against erosion and helps retain soil moisture [7]. Usually the soil cover is made from organic residues of high C / N ratio, which decompose slowly. This material can be deposited by trees present on the site or added to the soil by means of mulching after establishment of the plant culture.

Organic horticulture systems commonly utilize large amounts of mulch and organic fertilizers [8,9]. The dynamics of organic matter in these systems is dependent on many factors including soil type, climate, management practices, microbial activity and radiation. Also, normally irrigated, the increases in humidity may enhance microbial activity in compost and soil, accelerating the decomposition process and transfer of nutrients from compost to soil and plants [10].

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Organic agriculture in temperate regions has been researched in considerable detail but the management of organic systems with large applications of mulch and compost in semi-arid regions needs to be better understood [11-13].

In particular it is important to determine if it is necessary to apply very large amounts of compost, as compost is expensive in semi-arid regions. The nutrients present in compost and mulch should be retained by the soil and remain available to plants. Little is known of how irrigation methods and shade affect the decomposition of added organic material, but such knowledge is essential for the optimum management of organic agriculture enterprises in semi-arid regions.

The objective of this study was to measure organic matter decomposition and the dynamics of nutrient release from compost, under different types of irrigation and solar radiation intensities in a commercial orchard in northeast Brazil.

MATERIALS AND METHODS

Site description

The study site was located in the Chapada da Ibiapaba region, municipality of Ubajara, state of Ceará, Northeastern Brazil (3° 51'12″ S; 41°5'10″ W, at 850 m altitude). The climate is steppe hot arid (BSh), following Köeppen's classification with annual average temperature and rainfall of 28°C and 670 mm year^{-1}, respectively [14]. The rainy season lasts from January to May and the dry season generally lasts from July to November.

Cultivated areas from the Amway Nutrilite LTDA of Brazil farm were studied. The experimental location was on a large-scale organic Caribbean cherry farm that had been in operation since 1997 [15]. The historical use and management of this type of organic cultivation are detailed in work of [16].

The Amway farm was divided into areas by age of Caribbean cherry plants; there were two areas with 13-year-old plants (A13) and two areas with 10-year-old plants (A10). These areas were irrigated using micro sprinkler (S) systems. The farm also had two areas under central pivot irrigation (P) with one (A1) and six (A6) year old plants.

The organic fertilization was performed by applying 22 kg of compost per plant on the rows twice a year, at six-month interval, resulting in a total application of 25 tons of compost per hectare per year [17]. In both S and P areas the level of shading at the site of compost application varied with the age of plants. Old plants provided much shadow under the tree canopy, for the youngest trees organic compost was completely exposed to the sun. Information on the management and the historical use of the areas is presented in Table 1.

Experiment installation

A field experiment for evaluation of decomposition dynamics of organic compost was installed in both areas under P and S irrigation and incorporated two levels of shade: total shade (TS) and without shade (WS). For treatment TS, areas with oldest trees were selected (A13 and A6); for treatments involving complete exposure to the sun (WS), areas with the youngest trees (A10 and A1) were chosen. The soils were classified as Ferrasols (A1, A6 and A10) and Acrisols (A13) (Table 2) according to the Brazilian System of Soil Classification [18], which resembles the FAO/WRB system [19].

Decomposition assay was done by using rectangular litter boxes, which were made of polyvinylchloride (PVC) sheet covered by with 4-mm plastic mesh on the top and bottom. Dimensions of litter boxes were 30 cm x 13 cm x 10 cm (length x width x height). The boxes were filled with 2.65 kg of compost (wet basis) and randomly placed on the soil surface under PTS, PWS, STS and SWS conditions (Figure 1).

The typical composition of the compost is shown in Table 3 however compost varied in composition during this experiment.

Dry matter remaining in litter boxes was collected at 0, 2, 4, 6, 8, 10 and 12 months after establishment. For each collection time, four replicates were taken for analysis, and time zero was used as control. The amounts of nutrients applied to each box are shown in Table 4 and were different for pivot and sprinkler systems because the compost had a different composition for each irrigation system.

For each collection time, remaining dry matter in the litter boxes was weighed and a subsample was immediately taken for moisture determination by a gravimetric method [20-22]. The samples were dried at 105°C and analyzed for total C, N, P, K, Ca and Mg. These analyses involved total digestion with perchloric acid ($HClO_4$) after pre-treatment with nitric acid (HNO_3).

Table 1: Management procedures adopted on areas farmed for 1, 6, 10 and 13 years, under organic Caribbean cherry farming at Ubajara, Ceará, and Northeast Brazil.

Procedures	Areas			
	A1	A6	A10	A13
Year of planting	**End of 2009**	**Beginning of 2005**	**Beginning of 2001**	**Beginning of 1998**
Size of area (ha)	14	17	10	10
Past agricultural use	Traditional mango cultivation until 1998 after that fallow	Traditional mango cultivation until 1998 after that fallow	Native vegetation	Traditional strawberries and watermelon cultivation
Number of plants ha^{-1}	667	531	592	565
Number of plants area $^{-1}$	9,349	9,035	5,921	5,652
Spacing (inter plant x inter row in m)	3 x 4.85	2.85 x 6.6	3.5 x 4.82	3.5 x 5.0
Irrigation type and amount (m^3 ha^{-1} year)	Central pivot 9600	Central pivot 7906	Micro sprinklers 4028	Micro sprinklers 16780
Average productivity (kg of fruit plant^{-1})	0	24	25	29

Table 2: Chemical and physical properties of Ferrasols and Acrisols after 1 (A1), 6 (A6), 10 (A10) and 13 (A13) years, under organic Caribbean cherry farming at Ubajara, Ceará, Northeast Brazil.

Chemical and physical properties	Area and soil horizons											
	A1			A6			A10			A13		
	Ap	AB	BW	Ap	AB	BA	Ap_1	Ap_2	Ap_3	Ap	BA	Bw_1
Depth (cm)	0-10	Oct-23	23-53	0-9	09-Dec	21-41	0-7	Jul-13	13-22	0-12	Dec-56	56-92
Organic carbon (%)[a]	1.07	0.61	0.53	3.29	0.53	0.53	3.06	1.69	1.69	1.99	0.23	0.23
N (%) [b]	0.08	0.06	0.06	0.2	0.06	0.05	0.22	0.16	0.1	0.2	0.03	0.03
EC (dS m^{-1}) [c]	0.13	0.05	0.05	0.21	0.15	0.17	0.14	0.09	0.08	0.19	0.08	0.07
pH (soil:water 1:2.5) [c]	7.26	6.12	4.94	6.06	5.14	4.77	7.32	7.45	7.44	7.22	6.87	5.4
P_{M1} (mg kg-1)[c]	91.1	4.97	3.02	60.8	13.2	7.5	243	158	149	238	19	13.5
K^+(mg kg^{-1})[a]	72.8	34.9	20.1	226	61.8	57.2	122	21.5	9.03	174	20	11
Ca^{2+} ($cmol_c$ kg^{-1})[a]	2.16	0.6	0.13	3.08	0.65	0.42	6	4.67	3.67	4.1	0.95	0.24
Mg^{2+} ($cmol_c$ kg^{-1})[a]	0.4	0.19	0.09	1.54	0.35	0.36	2.06	1.31	0.92	1.6	0.3	0.2
Al^{3+} ($cmol_c$ kg^{-1})[a]	0	0	0	0	0.06	0.13	0	0	0	0	0	0.17
PA ($cmol_c$ kg^{-1})[a]	0.47	1.54	2.68	2.47	1.71	2.01	0.76	0.09	0.9	0.7	0.8	1.27
SEB ($cmol_c$ kg^{-1})[a]	2.74	0.88	0.28	5.19	1.15	0.92	5.08	5.17	5.17	6.2	1.3	0.5
ECEC ($cmol_c$ kg^{-1})[a]	2.74	0.88	0.67	5.19	1.21	1.04	8.37	6.03	4.61	6.2	1.3	0.66
CEC ($cmol_c$ kg^{-1})[a]	3.21	2.42	2.96	7.66	2.86	2.93	9.13	6.93	5.51	6.9	2.1	1.75
P $cacl_2$ (mg L^{-1})[c]	54.3	50.5	40.2	55.5	54.1	51.1	49.3	58.8	56.8	47.8	45.9	45.1
IBS (%)[a]	85.3	36.4	9.3	67.8	40.3	31.3	91.6	87	83.6	89.7	62.5	27.6
IAS (%)[a]	0	0	59	0	4.9	12	0	0	0	0	0	26.6
Sand (g kg^{-1})[d]	800	770	700	830	790	740	820	820	840	890	870	840
Silt (g kg^{-1})[d]	90	40	100	50	50	80	70	50	40	60	30	20
Clay (g kg^{-1})[d]	110	190	200	120	170	190	120	130	120	50	100	140
Water dispersible clay (g kg^{-1})[d]	100	130	120	50	100	140	30	40	60	20	90	100
Degree of flocculation (g kg^{-1})[d]	40	300	380	590	380	220	770	710	520	620	90	250
Texture[e]	LS	SL	SL	SCL	SCL	SL	LS	LS	LS	S	LS	SL
Grade or structure development/structure size/type [e]	mo/vf/ blsa	mo/vf/ blsa	mo/vf/ blsa	ms/fi/ gr	mo/fi/ blsa	mo/ fi&me/ blsa	we/fi/ gr	mo/fi/ blsa	mo/vf/ blsa	we/fi/gr	we/fi/blsa	mo/fi/ blsa
Consistancy: moist/ stickness	vfr/nst	vfr/nst	vfr/nst	vfr/sst	fr/sst	fr/st	vfr/nst	fr/nst	fr/nst	vfr/nst	fr/nst	fr/nst
Plasticity [e]	pl	pl	pl	pl	pl	pl	spl	spl	spl	spl	spl	spl
Soil colour (wet)[e]	10YR 5//2	10YR 5//2	7.5YR 5//2	10YR 3/2	10YR 5/4	10YR 5/4	7.5YR 3/2	10YR 3/2	10YR 4/2	10YR 3/2	10YR 5/3	10YR 6/2

[a] Analysis made following techniques of [20]; electrical conductivity (EC), pH in water, available phosphorus mehlich (P_{M1}), Calcium chloride extractable P content (P_{CaCl2}), potassium (K^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), aluminum (Al^{3+}), potential acidity (PA), sum of exchangeable bases (SEB), effective cation exchange capacity (ECEC), cation exchange capacity at pH 7 (CEC) index of base saturation (IBS), index of aluminum saturation (IAS), total nitrogen (N); [b] Analysis made following techniques of [21]; [c] Analyses made following techniques of [22]; [d] Analysis made using the pipette method of [23]; [e] Analysis made following techniques of [24]; Texture: LS = loamy sand, SL = sandy loam, SCL = Sandy clay loam. Grade or structure development: we = weak, mo = moderate, st = strong, ms = moderate to strong. Structure size: ec = extremely coarse, vc = very coarse/thick, co = coarse/thick, me = medium, fi = fine/thin, vf = very fine/thin. Structure type: gr = granular, bl = block, blab = angular block, blsa = subangular block, pr = prismatic. Consistency: moist: vfr = very friable, fr = friable. Stickiness: nst = non-sticky, sst = slightly sticky, st = sticky, vst = very sticky. Plasticity: spl = slightly plastic, pl = plastic, vpl = very plastic [25].

The dry matter remaining at each sampling time was calculated as the difference between the original and final weight, the decomposition and nutrient release rates were estimated using linear or simple exponential models. For curves described by the exponential model, the formula $X = X_0 e^{-kt}$ was used as described by [24-26]; where, X represents the quantity of dry matter or nutrients remaining after the time period t (in years), X_0 is the quantity of initial dry matter or nutrients, and *k* is the decomposition or nutrient release constant. Based on the fitted model, it was possible to calculate the half-life ($t_{1/2}$) of decomposition or of nutrient release as $t_{1/2}$ = ln (2)/k, where ln (2) is the naperian logarithm of the number 2, and *k* is the decomposition constant obtained for the fitted model. The half- life is the time needed for half the residue to decompose or for half the nutrients in the residue to be released. For linear relationship, the value of $t_{1/2}$ was derived directly from the fitted line.

Soil sampling and analysis

Before distribution of litter boxes in the field, soil samples were collected at 0-5, 5-10, and 10-20 cm depths at the points where boxes would be installed. These samples will be referred as control

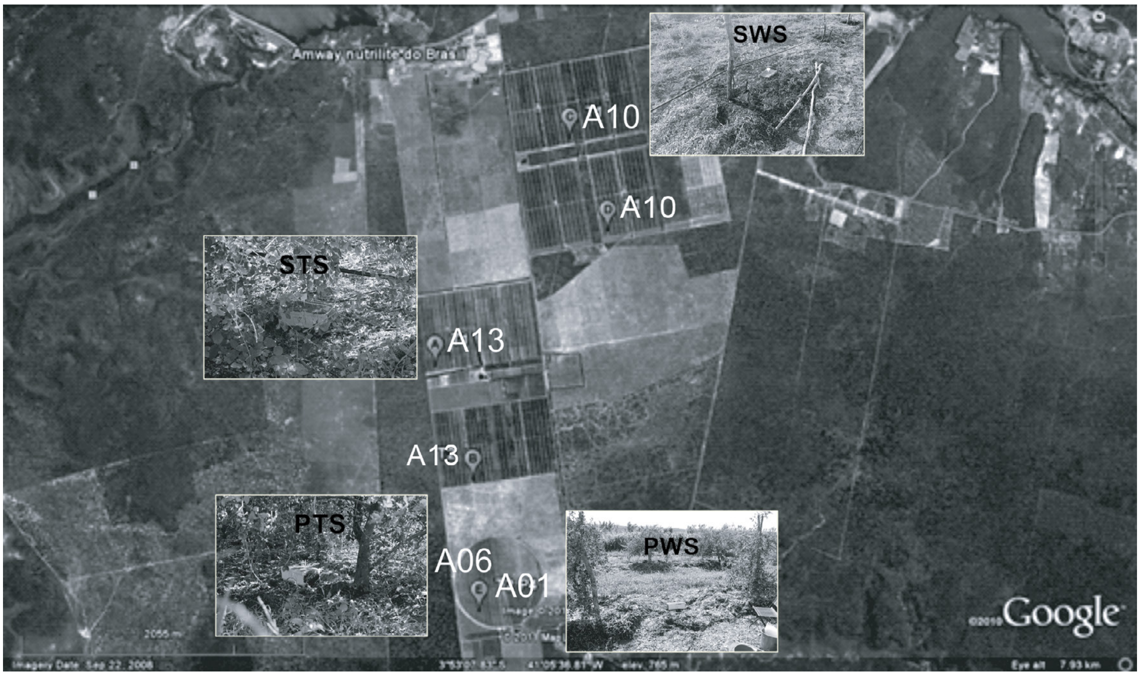

Figure 1: Area of experimental study and treatments used (A01 – Area with one year old plants; A06 – Area with six years old plants; A10 – Area with ten years old plants; A13 – Area with thirteen years old plants; PTS – pivot total shadow; PWS – pivot without shadow; STS – sprinkler total shadow; SWS – sprinkler without shadow).

Table 3: Composition and typical chemical composition of compost used for organic Caribbean cherry farming, at Ubajara, Ceará, Northeast Brazil.

Composition		Chemical composition	
Compost [a]	(%)	Compost	(%)
		Nitrogen	1.33
		Phosphorus	0.25
Biodynamic preparation[b]	0.1	Potassium	1.38
Caribbean cherry residue	9.7	Calcium	1.16
Cattle manure	19.2	Magnesium	0.51
Sugar cane bagasse	41	Organic carbon	20.5
Water	30	Moisture	63.9
		pH*	6.50

[a]Source: Amway Nutrilite of Brazil farm; [b] Herbal powder mixture made at farm.

Table 4: Amount of nutrients applied to the soil in compost for each tree in an organic Caribbean cherry farming at Ubajara, Ceara, Northeast Brazil.

Elements (g)	PTS	PWS	STS	SWS
C	256	256	323	323
N	19	19	24	24
P	4.4	4.4	3.4	3.4
K	1.1	1.1	1.6	1.6
Ca	12	12	7.4	7.4
Mg	11	11	8.3	8.3

PTS – pivot total shadow; PWS – pivot without shadow; STS – sprinkler total shadow; SWS – sprinkler without shadow.

samples. After removal of litter boxes at each collection time, soil samples were taken at the same three depths from below the location of the removed boxes.

The soil samples were air dried, sieved to < 2 mm prior to evaluation of: available phosphorus was measured by the Mehlich method (P) [22], exchangeable potassium (K), exchangeable calcium (Ca), exchangeable magnesium (Mg) and organic matter (OM) as described by EMBRAPA [27], and total nitrogen (N) according to Tedesco [21].

Statistical analysis

Statistical analysis included simple linear and exponential regression. Statistica 7.0 software was used. Mean data from the replicates was used in this analysis.

RESULTS AND DISCUSSION

Decomposition pattern and nutrient release

The percentage of remaining dry matter from compost over time is shown in Figure 2. The pattern of decomposition was best fitted by a linear model. The decomposition rates of dry matter were higher in treatments under central pivot irrigation system than under micro sprinkler. This could happen because the microbial activity and physical abrasion in wet lands are bigger compared with more dried lands [28].

Central Pivot concerns to soil/straw higher levels of humidity. In the pivot areas, shadow did not influence decomposition rates, once the trees were almost together and the space between then was short, so humidity on area was almost constant concerning good environment to microorganism's work. On the other hand, in areas under micro sprinkler irrigation shadow affected the decomposition pattern (Figure 2). In these areas the spaces between trees were bigger than on central pivot and they present smaller canopy cover.

A study made in a dry Mediterranean site (arid region) to analyze the effect of forest thinning on the foliar decomposition rate and nutrient release pattern, finds that strong reductions of canopy cover (shadow) might have an aridification effect on litter decomposition and reduced decomposition rates [29].

Treatments under total shadow (STS) exhibited higher decomposition rates of biomass than under total exposure to the sun (SWS). Effects of humidity and radiation on the decomposition of compost have been previously reported [30,31].

The dynamics of biomass loss and nutrient release were evaluated by analysis of half-life (t1/2) (Figure 3), that expresses the time (years) needed for half of the biomass to decompose or for half the nutrients in the compost to be released. The t1/2 of biomass varied

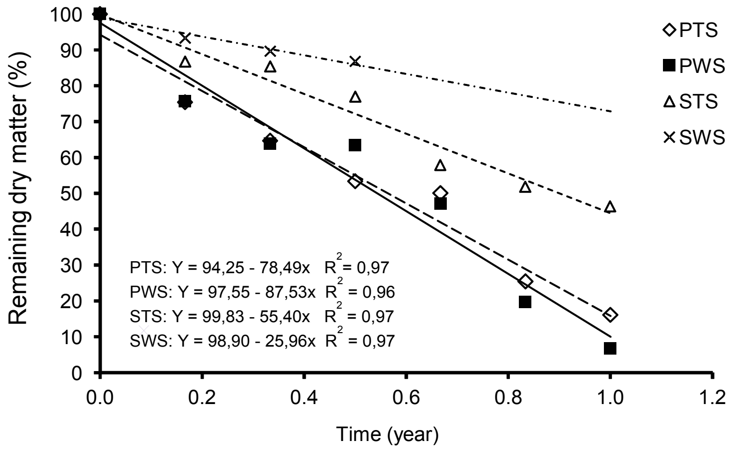

Figure 2: Remaining dry matter from compost applied to Caribbean cherry plants at Ubajara, Ceará, Northeast Brazil. Litter box installed in areas under irrigation using central pivot (P) and sprinkler (S) with total shadow (TS) and without shadow (WS).

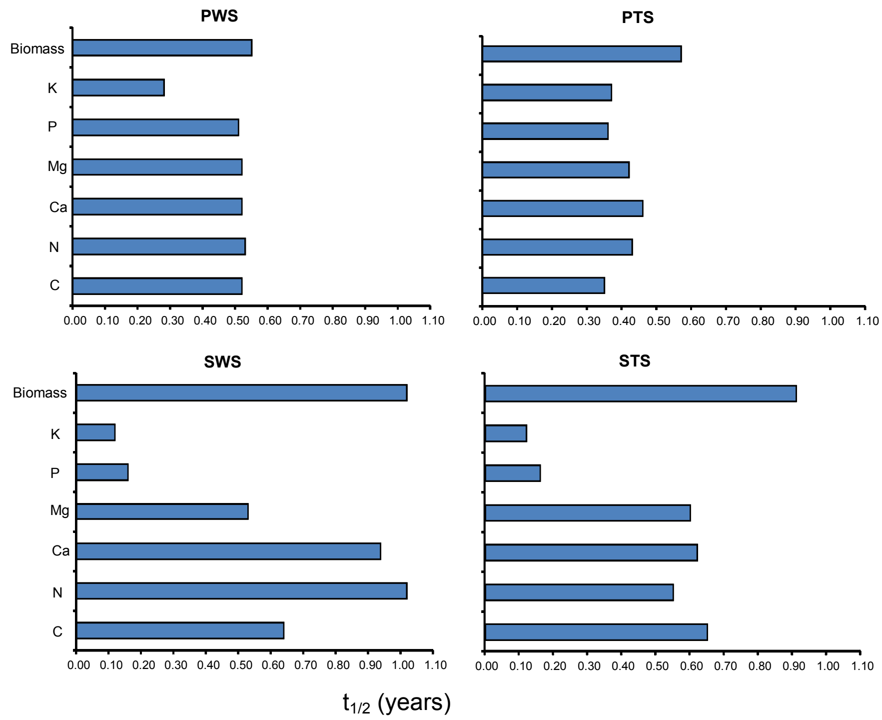

Figure 3: Half- lives ($t_{1/2}$) for biomass and nutrient release from compost applied to Caribbean cherry plants at Ubajara, Ceará, Northeast Brazil. Litter boxes were installed in areas under irrigation using central pivot (P) and sprinkler (S) without shadow (WS) and total shadow (TS).

from 0.55 to 1.02 years and was higher in areas under sprinkler irrigation compared to pivot (Figure 3), suggesting that pivot irrigation accelerates the decomposition process. Bustenchoen et al., [32] found the positive influence of humidity on litter decomposition studying the interactive effects of temperature, soil humidity and plant diversity.

In pivot areas, t1/2 of biomass was quite similar between treatments under total and without shadow, with an average half-life of 0.56 years. In general, irrigation by sprinkler caused longer values of t1/2 for all macronutrients when compared to central pivot irrigation. However, P and K release was slower under pivot than sprinkler irrigation. These differences in behavior for P and K release might be related to differences in initial composition of the compost used in the two areas.

Consequently, trends are better illustrated by plotting the ratio nutrient/carbon as shown in Figure 4. It should be noted that the initial (time zero) ratios for Ca, P and Mg differ for pivot and sprinkler treatments. This is because different batches of compost were used for the two treatments. The faster loss of P and K compared to C is evident in this diagram and is consistent with the short half-lives for these elements.

For the pivot system, with the exception of K, exposure of compost to the sun (PWS) tended to give a half-life that is very similar for the evaluated nutrients, with an average of 0.52 years. Paschoal et al. and Mackintosh et al. have documented the positive relationship between level of nutrients and microbial activity [33,34].

For total shadow treatment (PTS), losses of Mg, Ca and N were similar and slightly higher than for K, P and C (Figure 4). When considering irrigation by sprinkler, t1/2 for nutrient release differed with shadow regime. Without shadow (SWS), the order of half-life values was: K = P<Mg<C<Ca = N. Comparing this trend with results for the total shadow treatment (STS), t1/2 for Mg, Ca, N and C were quite similar whereas. K and P release was much faster than for other nutrients, which is explained by the easy mobility of K on soil. This probably happened because humidity was maintained on this treatment, favoring microbial activity on organic matter [28]. Values of t1/2 were not affected by shadow for the sprinkler system.

The $t_{1/2}$ values obtained in this experiment have been compared with some published reports (Table 5) that evaluated diverse plant materials using procedures like those employed in this research. In particular, the plant material was contained within a mesh and the environment was tropical. It is apparent that the half-lives obtained in our research are mostly longer and often much longer than the literature values. The $t_{1/2}$ values for chopped secondary forest materials [35] are quite similar to our results. However, faster release of K and P did not occur. Bolan et al., [36-39] found that half-life values for poultry manure compost were similar to our values, ranging from 0.39 to 0.52 years.

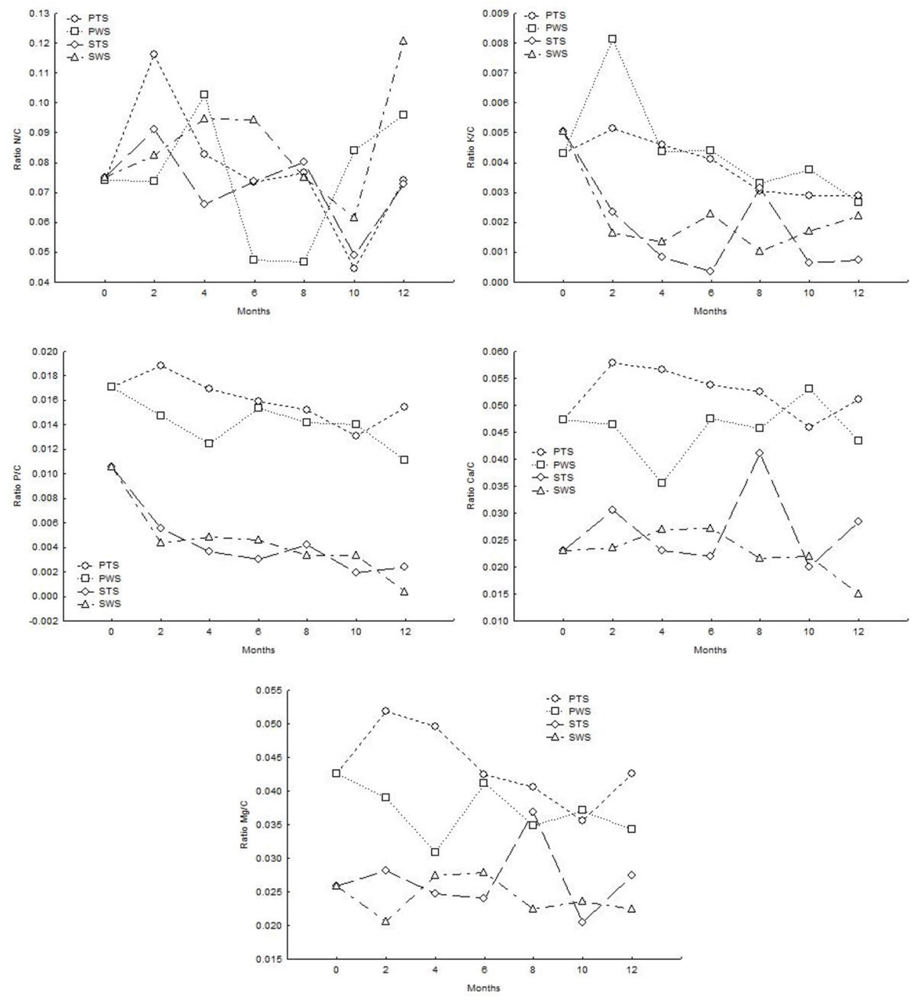

Figure 4: Ratios between nutrient and carbon concentrations in compost over time for organic Caribbean cherry farming at Ubajara, Ceará, Northeast Brazil (PTS – pivot total shadow; PWS – pivot without shadow; STS – sprinkler total shadow; SWS – sprinkler without shadow).

Changes in soil chemical attributes through compost decomposition

The substantial amounts of elements lost from the compost (Figure 3) might be expected to have been leached into the underlying soil layer. Table 6 shows the amounts of extractable P, K, Ca, Mg, total C and N in the 0-20 cm layer of soil from beneath the litter-box for each sampling time. The table shows the contents of elements in this soil layer before installation of litter boxes (control); the amount of nutrients lost from the compost (applied), the sum control+applied (expected) which is the amount of each element that would be present if all the element lost from the compost was retained in the 0-20 cm soil layer, and the amount of element measured in the soil after removing litter boxes (found).

Amounts of found-P were substantially lower than the expected-P for most treatments and sampling times. This result may indicate that P was removed from the compost by fauna and so was not leached into the soil. Alternatively, the amount of found-P in the soil was estimated by extraction with Mehlich solution that might only dissolve a minor proportion of the P leached into the soil and retained by adsorption on soil colloids.

The results for K do not show a single systematic trend. For central pivot irrigation, the amounts of found-K in the soil were greater than expected-K values for the second and fourth months in the sprinkler irrigated areas. However, values for 6 to 12 month's show that amounts of found-K were lower than expected-K. This behavior can be attributed to removal of K from soil by plant roots.

The amounts of Ca, Mg, organic C and N found in the soil were substantially lower than expected if all the elements lost from the compost had been leached into the 0-20 cm soil layer. One explanation for this discrepancy is that these elements were removed from the compost by action of insects. Several authors have made similar observations and ascribed major losses of C and nutrients from litter to the activity of termites and other insects, which are smaller than the mesh size of litter bags [37,38,10,40]. Portela [41] working in the same region, found insects of many classes and in elevated quantities were present in the soil.

Microorganisms could be working and releasing enzymes and proteases which dissolves organic contents before absorption in soil aggregates [42].

Additional studies are necessary for better understanding the role of soil organisms in causing nutrient losses from compost. Such information is extremely important for the organic amendment program of this farm, as losses must be considered before future compost applications. Other study was conducted in the same area (in press) explained the major losses of organic material from compost and mulch used at this site to removal of plant material by insects and suggested that natural mineral fertilizers might provide a superior alternative to compost.

Table 5: Half-life values for nutrient loss from compost and litter for this work and published studies.

Authors	Observations	Materials used	Climate conditions	Treatments	Half life (days)					
					C	N	P	K	Ca	Mg
This study	Range for 4 treatments PTS, PWS, STS, SWS	Compost	Steppe hot arid	PTS	129	157	129	135	166	153
				PWS	190	193	186	103	189	188
				STS	237	200	57	43	225	220
				SWS	232	373	57	44	343	194
Buldeman [10]	Three species *Gliricidia sepium/ Leucaena leucocephala/ Flemingia macrophylla*,	Leaves	Humid tropical	Gs	22	22	20	11	29	16
				Ll	30	38	26	12	46	24
				Fm	53	53	34	22	69	38
Reichard et al., [35]	Secondary forest chopped to 4 sizes (Fs1<Fs<2<Fs3<Fs4), litter bags	Secondary forest	Tropical	Fs1	-	86	78	42	49	73
				Fs2	-	128	82	119	49	78
				Fs3	-	136	140	201	76	77
				Fs4	-	96	124	77	125	64
Nygren et al., [36]	Nodules of *Erythrina variegata* 2 soils (O,V), mesofauna+microbes/ microbes(Mm/M) in humid and dry seasons,litter bags	Woody legume nodules	Humid and subhumid tropical	OMm	-	3.71	-	-	-	-
				OM	-	3.39	-	-	-	-
				VMm	-	4.37	-	-	-	-
				VM	-	2.54	-	-	-	-
Schroth et al., [37]	Leaves and branches(L,B) of *Cajanus cajan* litter bags	Leaves and branches	Subhumid tropical	L1	16	10	10	9	27	19
				B1	20	16	10	7	32	13
Luizão and Schubart [38]	Leaves of *Clitoria racemosa* litter bags	Leaves, dry and wet seasons	Humid tropical	Pd	-	-	30	50		115
				Pw	-	30	15	15	75	15
				-	-	-	-	-	-	-

PTS – pivot total shadow; PWS – pivot without shadow; STS – sprinkler total shadow; SWS – sprinkler without shadow; Gs - *Gliricidia sepium*; Ll - *Leucaena leucocephala*; Fm - *Flemingia macrophylla*;; Fs1 – 1 to 7mm residue size; Fs2 – 7 to 25mm residue size; Fs3 – 25 to 35mm residue size; Fs4 - >35mm residue size; –; d – dry season; w – wet season.

Table 6: Amount of nutrients (grams) in 0-20 cm soil layer beneath litter boxes in each sampling time in the experiment installed in the Amway farm, at Ubajara, Ceará, Northeast Brazil.

								P								
	PTS				PWS				STS				SWS			
Time	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.
2	0.82	0.96	1.78	0.62	1.73	0.94	2.68	0.22	0.95	0.40	1.35	0.20	0.67	0.20	0.87	1.02
4	0.66	1.37	2.04	0.60	1.19	1.41	2.59	0.59	0.86	0.44	1.30	0.81	0.79	0.31	1.11	1.19
6	0.72	1.81	2.53	0.35	1.33	1.42	2.75	0.56	0.42	0.70	1.12	0.42	0.91	0.40	1.31	1.12
8	0.77	1.94	2.71	0.57	1.59	2.06	3.65	1.28	0.71	1.28	1.99	0.41	0.84	-	-	-
10	0.65	2.90	3.54	0.61	0.84	3.12	3.96	0.64	0.87	1.46	2.33	0.43	0.72	-	-	-
12	0.85	3.26	4.11	0.34	1.11	3.62	4.74	1.08	0.51	1.62	2.14	0.35	0.32	-	-	-
								K								
	PTS				PWS				STS				SWS			
Time	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.
2	1.42	0.24	1.66	4.36	1.06	0.24	1.29	2.37	0.47	0.19	0.66	2.37	1.86	0.10	1.96	2.14
4	1.52	0.35	1.87	3.14	1.06	0.35	1.42	2.49	0.51	0.21	0.72	1.61	1.01	0.15	1.16	2.36
6	1.35	0.46	1.80	1.83	2.47	0.36	2.83	4.28	1.58	0.33	1.92	0.40	1.91	0.19	2.10	0.70
8	1.95	0.49	2.44	2.84	0.82	0.52	1.34	2.15	1.94	0.61	2.55	0.26	1.68	-	-	-
10	1.94	0.73	2.67	2.82	1.23	0.79	2.02	2.79	1.82	0.70	2.51	0.38	1.24	-	-	-
12	2.42	0.82	3.24	2.26	1.50	0.91	2.41	2.56	1.99	0.78	2.77	0.24	1.18	-	-	-
								Ca								
	PTS				PWS				STS				SWS			
Time	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.
2	7.54	2.64	10.18	9.31	6.60	2.61	9.21	5.90	6.89	0.87	7.76	7.39	8.38	0.44	8.82	7.69
4	8.15	3.79	11.94	6.66	7.30	3.89	11.19	8.30	8.63	0.96	9.59	7.61	8.58	0.68	9.27	7.72
6	7.84	5.01	12.85	6.65	6.21	3.93	10.13	6.18	5.54	1.52	7.05	5.26	9.79	0.87	10.66	9.11
8	6.94	5.37	12.30	5.45	6.36	5.68	12.05	7.74	7.94	2.77	10.71	9.40	9.75	-	-	-
10	8.62	8.01	16.63	7.52	6.48	8.63	15.11	7.57	7.80	3.17	10.97	7.94	8.62	-	-	-
12	8.00	9.01	17.02	7.70	7.15	10.02	17.17	10.24	6.27	3.53	9.80	7.29	6.73			
								Mg								
	PTS				PWS				STS				SWS			
Time	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.
2	2.38	2.38	4.75	3.02	1.80	2.35	4.15	1.54	2.43	0.98	3.41	1.79	2.33	0.50	2.83	1.95
4	2.45	3.41	5.86	2.50	1.97	3.50	5.47	2.22	2.38	1.08	3.46	2.28	1.76	0.77	2.53	2.15
6	2.27	4.51	6.78	2.68	1.63	3.53	5.16	1.36	1.71	1.70	3.42	1.49	2.50	0.97	3.47	1.80
8	2.12	4.83	6.95	1.69	1.58	5.11	6.69	1.82	2.36	3.11	5.47	2.47	2.21	-	-	-
10	2.49	7.20	9.69	2.41	1.64	7.76	9.41	1.55	3.08	3.55	6.63	2.13	2.12	-	-	-
12	2.50	8.11	10.61	2.57	1.84	9.01	10.86	3.05	2.16	3.96	6.12	2.41	1.47	-	-	-
								Organic C								
	PTS				PWS				STS				SWS			
Time	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.
2	168	56	224	235	146	55	201	118	154	38	192	134	123	19	143	105
4	179	80	259	160	178	82	260	163	160	42	202	133	120	30	150	99
6	181	106	286	124	152	83	235	136	89	66	155	81	176	38	213	139
8	163	113	277	140	153	120	273	155	144	120	264	188	128	-	-	-
10	197	169	367	200	139	182	321	151	171	138	309	139	142	-	-	-
12	215	190	405	214	184	212	396	215	124	153	278	116	85	-	-	-
								N								
	PTS				PWS				STS				SWS			
Time	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.	Cont.	Appl.	Exp.	Found.
2	11.89	4.14	16.03	14.20	14.72	4.09	18.80	9.88	11.82	2.85	14.67	9.22	10.49	1.45	11.95	10.65
4	12.24	5.94	18.18	10.65	11.47	6.09	17.56	12.51	12.71	3.14	15.85	10.68	7.53	2.23	9.77	8.27
6	12.80	7.85	20.65	10.52	10.22	6.15	16.37	9.13	6.83	4.96	11.79	6.02	11.59	2.84	14.43	9.82

8	10.91	8.41	19.32	8.62	9.36	8.90	18.26	10.53	9.36	9.06	18.42	11.13	9.24	-	-	-
10	13.39	12.54	25.94	11.50	10.84	13.52	24.36	11.70	10.89	10.35	21.25	10.13	8.81	-	-	-
12	13.98	14.12	28.10	11.30	12.25	15.69	27.94	11.34	7.36	11.53	18.89	6.88	6.26	-	-	-

PTS – pivot total shadow; PWS – pivot without shadow; STS – sprinkler total shadow; SWS – sprinkler without shadow; Cont. – control values (initial content); Appl. – nutrients applied through compost; Exp. – value expected to be on soil (Control+Appl.); Found – values of each nutrient measured in the soil at each time. All values are expressed in g kg^{-1} of soil.

CONCLUSION

The compost was lost quickly over time. Losses of dry matter and nutrients were faster in areas adopting central pivot irrigation when compared to areas using micro sprinklers. Total shadowing increases decomposition rates of compost; both P and K were rapidly lost from compost, their rate of loss being faster than mass loss. Soil fauna seem to determine nutrient release dynamics. It is necessary to directly investigate the role of micro and meso fauna in determining the rate at which they remove materials from compost and whether this process can be managed. The cost of compost is substantial and under the present management regime there appears to be little benefit from this practice.

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