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THE EFFECT OF AN ORGANIC WASTE COMPOST ON THE AGRO-CHEMICAL CHARACTERISTICS OF THE SOIL, AND THE MINERAL COMPOSITION OF THE SUNFLOWER LEAVES

Radu Lăcătușu [1], Anca-Rovena Lăcătușu[1], Romeo Căpățână[2], Mihaela Lungu[1], Rodica Lazăr[1], Irina Ramona Moraru[1]

Key words: compost, organic waste, marine algae, soil, sunflower

Abstract: Aiming to increase the use of natural resources and unexplored opportunities in industrial and agricultural practices, the marine algae biomass, that causes serious environmental problems in the Romanian Black Sea coast, was used in association with another two organic wastes, farmyard manure from cattle-breeding farms and sewage sludge resulted from the waste water treatment, to produce a compost suitable as organic fertilizer for plant cultivation in ecologic farming systems. Four variants of compost, first representing equal parts (33.33%) of those three components, and the other three proportions of 50% of each component, the difference being ensured in a ratio of 25% of each of the other two components, have been tested in a field experiment to assess their effects, both on the agro-chemical properties of the soil and on the sunflower plants development and crops. Until the phase of sunflower calathidia formation, the compost containing 50% farmyard manure influenced the best plant development in terms of height and number of leaves, then, at the end of vegetation period, the best plant development took place under the influence of compost prevalent in marine algae. The mobile forms of N and P were statistically differentiated depending on the dose of compost, the maximum dose generating the lowest content levels in the soil, as a result of higher absorption of these chemical elements in plants. The content of P and Ca in sunflower leaves recorded significant differences.

Introduction

Some mistakes that were made in the administration of chemical fertilizers, both on soils and plants, among which the most outstanding are overdose or misuse

[1] National Research and Development Institute for Soil Science, Agrochemistry and Environment Bucharest, Romania; anca.lacatusu@gmail.com
[2] AGROMIXT Ltd. Agigea, Romania;

of certain kinds of fertilizers in certain soil types, have increased awareness, and hence the desire to use organic fertilizers.

Lack of sufficient quantities of organic fertilizers prevented the growth of the surfaces of organically fertilized land, but in the meantime, research aimed at finding new sources of organic substances which in their natural state or composted to provide nutrients to the soil, have been done. In this topic, an extensive scientific literature has been developed, among which we cite only in our country: Ionescu Șișești Vl. et al., 1980, Ionescu Al. et al., 1985, Dumitru et al., 1991, Leonard et al., 2007, Ionescu N. et al, 2011, Dumitru and Simota, 2011. In this context, the present work falls, but the novelty it brings is to obtain a compost consists of a mixture of three organic waste: farmyard manure, sewage sludge and marine algae. If on the use of farmyard manure conflicting opinions have never existed, on sewage sludge using as a source of nutrients for plants, there have been such viewpoints (Bengtsson and Tillman, 2004). As regards the marine algae, they have been used in the form of extracts with fertilizer or protective role (Zodape, 2001; Rajasulachana and Krishnamoorty, 2004). Using seaweed as part of a compost, represents a novelty. Moreover, valorization of marine algae could contribute to solving some serious problems, as waste disposal, damages caused by enormous quantities of algae, by tens of thousands of tones magnitude order, that through pestilential odors and aspect, year by year, affects the Black Sea beaches with serious consequences for tourism and regional economy

The achieved compost was used as fertilizer on a Chernozems in a field experience with sunflower as a test plant.

Materials and methods

Using of the farmyard manure to improve soil physical and chemical properties of soil is lost in the mists of the ages, but the use of the sewage sludge and particularly of the marine algae is of recent date.

Chemical analysis of the samples of the organic waste mixture subjected to composting, harvested in the initial, intermediate and final process phases, the soil used for the field experiment (0-20 cm) and plants (leaves under calathidia), were performed.

The following methods were used: pH in the aqueous suspension, potentiometric, using a couple of glass-calomel electrodes, the total soluble salts content by conductometry, and the water-soluble ions content by volumetric methods, flame photometry and atomic absorption spectrophotometry. The total organic carbon content (TOC) was determined by the Walkley-Black method, modified by Gogoașă, the total nitrogen content was determined by Kjeldahl method, and mobile forms of nitrogen ($N\text{-}NO_3$ and $N\text{-}NH_4$) potentiometric with ion selective electrodes. Mobile forms of P and K, soluble in ammonium acetate-

lactate solution (AL) at pH 3.7, were determined by spectrophotometry, flame photometry respectively, according to Egner-Riehm-Domingo method. The total content of microelements (Co, Cu, Fe, Mn, Zn) and heavy metals (Cd, Cr, Ni, Pb) have been determined by AAS in solution obtained through the weathering of materials with a mixture of $HClO_4$-HNO_3. The contents of the macroelements, except N, and microelements from marine algae and plant samples were determined using the above-mentioned methods, in the hydrochloride solution obtained by dissolving the ash obtained through the calcination of the starting materials at 450° C.

All methods are standardized in ISO and STAS systems.

The Chernozems from Agigea is a high fertile soil, with 37.4 value of the complex fertility indicator (after Lăcătuşu and Lăcătuşu, 2011), a weakly acid-neutral reaction (pHH_2O 6.7), on 0-40 cm depth, a medium content of humus (3.91%) and total nitrogen (0.22%), with a good supply of mobile forms of nitrogen (54 mg·kg^{-1} N-NO_3) and very good with P and K (49 mg kg^{-1} P_{AL} and 264 mg kg^{-1} K_{AL}). The soil is eubasic (V_{Ah} 95%), with high cation exchange capacity (T 30.2 me/100g soil), composed of large amount of exchangeable bases (SB 28.7 me/100g soil) and very low hydrolytic acidity (Ah 1.51 me/100g soil). The total content of microelements is normal, the values (mg·kg^{-1}) being: Zn 73; Cu 23; Fe 2.65; Mn 7.16; Co 14, and the heavy metals, Cd 1.17; Cr 29; Ni 38.

Table 1. Experimental treatments

No.	Treatment	Compost dose (t/ha)	No.	Treatment	Compost dose (t/ha)
1	**C =Unfertilized control**				
2	**C_F = Mineral fertilized control : 150 kg/ha $N_{16}P_{16}K_{16}$ + 150 kg/ha NH_4NO_3**				
3	Compost: 50% FM + 25% SS + 25% MA	25	9	Compost: 50% FM + 25% SS + 25% MA	**75**
4	Compost: 50% SS + 25% FM + 25% MA	25	10	Compost: 50% SS + 25% FM + 25% MA	**75**
5	Compost: 50% MA + 25% FM + 25% SS	25	11	Compost: 50% MA + 25% FM + 25% SS	**75**
6	Compost: 50% FM + 25% SS + 25% MA	50	12	Compost: 50% FM + 25% SS + 25% MA	**100**
7	Compost: 50% SS + 25% FM + 25% MA	50	13	Compost: 50% SS + 25% FM + 25% MA	**100**
8	**Compost: 50% MA + 25% FM + 25% SS**	**50**	**14**	**Compost: 50% MA + 25% FM + 25% SS**	**100**

FM = farmyard manure; SS = sewage sludge; MA = marine algae

As concerning the texture, the Chernozems from Agigea belonging to the medium loam class, with 28.7% clay, ≤ 2μ, 30.6% dust (0.002-0.02mm), 40.5% fine sand (0.02-0.2mm), and 0.2% coarse sand (0.2-2mm).

Field experiment included 14 experimental treatments with certain compost types and doses (25, 50, 75 and 100t/ha), with three replicates each, to study (table 1).

Results and discussions

Compost preparation. Detailed analytical data regarding the chemical composition of the organic waste, as well as of the compost during the intermediate and final evolution stages revealed that the neutral-weak alkaline reaction of both sewage sludge and farmyard manure, as well as the high content of macroelements and normal content of microelements and heavy metals (Cd, Cr, Ni, Pb), similar to that existing in un-polluted soils (Lăcătușu 2016), make these material to be suitable as sources of nutrients (Table 2). To these, is added a mixture of marine algae belonging to the genera Ulva and Cladophora which also contain significant amounts of macroelements and normal quantities of microelements and heavy metals (Table. 3). Although the total soluble salts content (TSSC) is quite high (tab. 4), in which the prevailing are chlorides and sulfates and partly bicarbonates (tab. 5), they will not have toxic effects as a result of dilution that will follow.

Table 2. The main agro-chemical features of the organic wastes used for composting

Sample identification	pH H_2O	TOC	Nt	$N\text{-}NO_3$	$N\text{-}NH_4$	P_{AL}*	K_{AL}
	%			mg·kg^{-1}			
Farmyard manure	8,32	29,9	1,88	41,0	28	30	6540
Sewage sludge from Eforie Sud water treatment plant	7,01	23,7	2,37	13,2	297	622	872

Sample identification	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
	mg·kg^{-1}								
Farmyard manure	0,49	7,44	21	27	9965	443	18	27	84
Sewage sludge from Eforie Sud water treatment plant	1,25	9,10	103	124	31681	391	37	54	541

Composting has been done into Könemann cubes, with a volume of 1.78 m^3, in four variants, first representing equal parts (33.33%) of those three components, and the other three proportions of 50% of each component, the difference being ensured in a ratio of 25% of each of the other two components. Composting lasted

50 days, during it has reached the maximum temperature of 63°C, the value at which all pathogens have been destroyed. Each day have been carried out temperature measurements in three positions (on the upper, the median and the lower part of the mixture), and at three different times: in the morning, at noon and in the evening, at 7, 12 and 19 o'clock (fig. 1). Finally, the cubes were deployed, compost obtained was dried at ambient temperature, and then it was passed through a special mill obtaining compost in the form of pellets (fig. 2)

Table 3. The content of macro-and microelements of the marine algae

Sample identification	N	P	K	Ca	Mg	Na
	%					
Mixture	3,40	0,29	2,20	4,95	0,92	0,88
Cladophora sp.	2,40	0,20	3,33	6,20	0,48	0,79
Ulva lactuca	2,35	0,10	3,30	5,06	1,66	0,83

Sample identification	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
	$mg \cdot kg^{-1}$								
Mixture	0,45	5,25	9,27	11	3913	385	13,8	9,28	39
Cladophora sp.	0,66	2,88	3,68	21	634	247	6,6	17,6	17,4
Ulva lactuca	0,02	1,62	0,86	2,1	200	48	3,5	2,2	11

Table 4. The main agro-chemical properties of the composted wastes

Sample identification	TSSC	HCO^-_3	SO_4^{2-}	Cl^-	Ca^{2+}	Mg^{2+}	Na^+	K^+
	mg/100 g material							
Farmyard manure	531	131	95	58	10	8	19	210
Sewage sludge	658	177	356	22	36	21	32	15

Table 5. The percentage composition (%) of the soluble salts

Sample identification	$Ca(HCO_3)_2$	$Mg(HCO_3)_2$	$NaHCO_3$	$KHCO_3$	$CaSO_4$	$MgSO_4$	Na_2SO_4	K_2SO_4	KCl
Farmyard manure	6,8	9,5	11,1	10,0	-	-	-	34,4	28,2
Sewage sludge	26,5	-	-	-	7,6	32,3	26,6	1,3	5,7

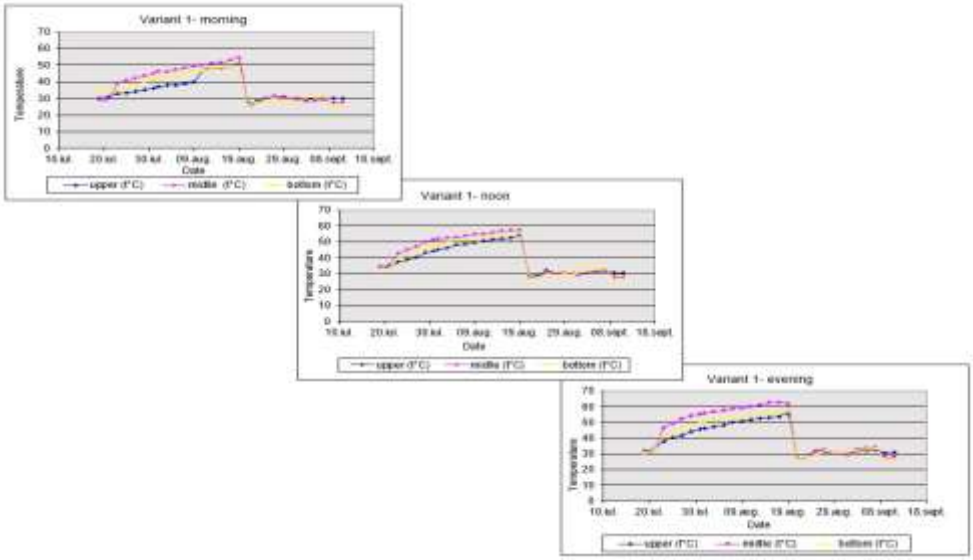

Figure 1. The dynamic of the temperature recorded in composting cube invariant with equal parts (33.33%) of the component

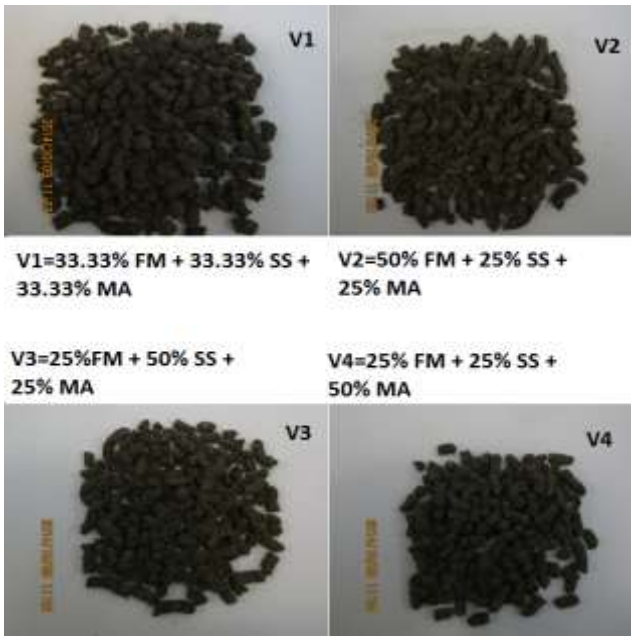

Figure 2. Pellets of different variants of compost

The effect of compost on some agrochemical indicators

The effect of the compost type. The average values of the analytical data regarding the effect of three types of compost, distinguished by the predominance in the composition of farmyard manure (1) sewage-sludge, (2) or marine algae (3), have highlighted the fact that the type of compost did not have a significant effect on the pH, while in the case of other indicators, the nature of compost composition influenced both the total forms of organic matter and nitrogen and those mobile of N, P and K.

Thus, it could be noticed (table 6), a significant increase of soil content in mobile forms of nitrogen ($N\text{-}NH_4$ and $N\text{-}NO_3$) under the influence of compost prevalent in farmyard manure (1). The compost made up mainly of sewage sludge (2) significantly influenced the content of organic matter and mobile potassium, while the compost made primarily of marine algae (3) influenced positively the increase in levels of total N and mobile phosphorus.

The effect of the compost doze. Neither dose of compost has a significant influence on the soil reaction (a difference of only 0.19 pH units), instead of the other investigated soil properties have been significantly modified. It's about the levels of organic matter and total nitrogen, which have increased substantially, up to 3.56% and 0.18% respectively, compared with values recorded in the soil that has not been added with compost. It should be noted that these changes have been generated by compost applied at a dose of 75 t/ha. As concerning the dose of 50 t/ha compost, significant changes were recorded, namely an increase in the levels of $N\text{-}NO_3$ with 787 $mg \cdot kg^{-1}$, and at a dose of 25 t/ha increases in the content of KAL and $N\text{-}NH_4$ with 286 $mg \cdot kg^{-1}$, were noticed (table 7). It should be noticed that in the sunflower calathidia forming phenophase, at the maximum dose of 100 t/ha compost the lowest values of these agrochemical parameters were recorded in soil, while finally, at this dose, the highest production, both in terms of plant height, number of leaves, and the size of the calathidia, has been recorded. Therefore, the explanation is that the plants grown in the variants with the highest dose of compost were consumed larger amounts of nutrients than the plants of the variants with lower doses of compost.

The effect of compost on the sunflower plant..

The effect of type and dose of compost on plant morphological features. Morphological assessment of the sunflower plants, in terms of height and number of leaves, made at 1st July 2015, revealed that plants grown in variant fertilized with compost (3) prevalent in marine algae (50%) presented the highest height at all compost doses (tab. 8). In descending series follows the compost (1) prevalent in farmyard manure (50%), and compost (2) prevalent in sewage sludge (50%). The mean values of the plant height, regardless of the dose, were in the series: 152 cm, 137 cm and 123 cm, and the number of leaves: 21, 20 and 17. After 15 days,

the plant growth pattern remained the same, namely, the plant height: 156 cm, 150 cm and 138 cm, and the number of leaves 20, 19 and 17.

Table 10. The influence of dose and type of compost on the content of sunflower leaves in P and Ca

Dose[x]	**%P**	**Dose**	**%Ca**	**Compost type**	**%Ca**
2	0,257 b	1	1,64 b	2	**1,62 b**
1	0,261 ab	2	1,67 b	1	**1,83 ab**
3	0,271 ab	3	1,89 ab	3	**2,20 a**
4	**0,319 a**	**4**	**2,33 a**		

Dose: 1=25 t /ha; 2-50 t /ha; 3=75 t /ha; 4=100 t/ha

Table 6. The overall effect of the type of compost on soil agrochemical indicators

Compost type	pH_{H2O}	Compost type	Organic matter %	Compost type	N_t %	Compost type	$N\text{-}NH_4$ mg·kg^{-1}	Compost type	$N\text{-}NO_3$ mg·kg^{-1}	Compost type	P_{AL} mg·kg^{-1}	Compost type	K_{AL} mg·kg^{-1}
1	6,94	1	6,73	1	0,369	2	9,58	3	555	2	314	3	485
3	6,98	3	6,84	2	0,378	3	11,50	2	665	1	357	1	503
2	7,01	2	7,30	3	0,390	1	12,33	1	711	3	362	2	530

Compost type: 1 = 50% farmyard manure (FM) + 25% sewage sludge (SS) + 25% marine algae (MA)
2 = 50% SS + 25% FM + 25% MA
3 = 50% MA + 25% FM + 25% SS

Table 7. The overall effect of the doze of compost on soil agrochemical indicators

Dose	pH_{H2O}	Dose	Organic matter %	Dose	N_t %	Dose	K_{AL} mg·kg^{-1}	Dose	$N\text{-}NH_4$ mg·kg^{-1}	Dose	$N\text{-}NO_3$ mg·kg^{-1}	Dose	P_{AL} mg·kg^{-1}
4	6,89	1	6,48	4	0,352	4	434	4	7,56 b	4	401 b	4	281 b
1	6,93	2	6,86	1	0,382	3	502	3	7,89 b	1	598 598 ab	2	355 355 ab
2	6,99	4	7,02	2	0,387	2	540	2	14,11 a	3	740 a	1	370 a
3	7,08	3	7,47	3	0,395	1	550	1	15,00 a	2	836 a	3	372 a

Dose: 1=25 t compost/ha; 2-50 t compost/ha; 3=75 t compost/ha; 4=100 t compost/h

The influence of the type and dose of compost on the chemical composition of the sunflower leaves. Sunflower leaves, harvested under the calathidia, have generally presented a low variation of the macro-elements content values. Only P and Ca were significantly influenced by the type and dose of compost, being recorded an increase in the content of these chemical elements as the compost dose is increasing. Table 9 presenting the average content values of N, P, K, Ca and Mg depending on the type and dose of compost. Thus, the dose of 100 t/ha resulted in an average increase in the P content of 0.05% against the dose of 25 t/ha compost, while the same dose of 100 t/ha compost increased the Ca content with 0.65% as

compared with the dose of 25 t/ha compost. Moreover, statistical analysis (table 10) highlighted this phenomenon, including the marine algae compost contribution to significantly increase the calcium content in the sunflower leaves.

Table 8. Morphological features of sunflower plants at 1st July and 15 July 2015

Compost dose t/ha	Date[x]	Compost 1		Compost 2		Compost 3		Average / dose	
		Height (cm)	Leaves no.	Height (cm)	Leaves no.	Height (cm)	Leaves no.	Height (cm)	Leaves no.
25	1	120±23	18±4	111±12	19±3	136±24	20±3	122±23	19±3
	2	140±14	17±4	128±16	15±3	139±2	17±3	135±19	16±3
50	1	126±26	20±3	127±30	19±4	156±23	20±4	136±30	20±4
	2	143±22	18±5	137±32	14±3	169±17	18±4	143±32	16±4
75	1	150±19	19±2	129±16	19±3	154±18	20±2	141±20	20±3
	2	153±22	20±3	134±19	20±3	157±20	20±3	145±21	20±3
100	1	152±17	23±3	126±28	21±4	160±20	25±3	146±26	23±4
	2	162±13	20±5	152±20	20±3	169±12	25±3	161±17	22±5
C* 100±16; 16±3 C_F** 102±14; 15±3	1	137	16	123	20	152	21		
C 129±9; 21±3 C_F 155±9; 19±3	2	150	19	138	17	136	20		

[x] 1. 07. 2015 ; 2. 07. 2015 ; *C – control; **C_F – mineral fertilized control

Table 9. Contents of macroelements (%) of sunflower leaves under the capitula depending on the type and dose of compost

Compost dose t/ha	N			P			K			Ca			Mg		
	1[x]	2[x]	3[x]	1	2	3	1	2	3	1	2	3	1	2	3
25	2,97	2,90	2,89	0,26	0,24	0,29	3,01	3,20	3,04	1,60	1,67	1,69	0,97	0,99	1,00
50	2,83	2,93	2,87	0,27	0,28	0,26	2,94	3,14	2,95	1,89	1,74	1,76	0,97	1,01	0,98
75	2,95	2,94	2,91	0,30	0,27	0,28	3,17	3,19	2,97	1,81	1,88	1,90	0,96	0,95	0,99
100	2,96	2,95	2,96	0,33	0,31	0,34	3,20	3,16	3,10	2,20	2,30	2,39	0,98	1,04	1,01
[x] Normal values Robinson, 1970 in Vrânceanu, 1974	3,18			0,36			3,18			1,67			0,97		

1[x] = 50% FM + 25% SS + 25% MA; 2[x] = 50% SS + 25% FM + 25% MA; 3[x] = 50% MA + 25% FM + 25% SS

Conclusions

In the north-western part of the village Agigea (Constanta county) on a Cambic Chernozem with naturally high fertility potential, was located a field experience related to the effect of a compost made by three organic waste on the plant development and sunflower crops;

Until the phase of sunflower calathidia formation, the compost containing 50% farmyard manure influenced the best plant development in terms of height and number of leaves, then, at the end of vegetation period, the best plant development took place under the influence of compost with 50% marine algae;

Doses and types of compost did not have significant effect on soil pH, organic matter content, total nitrogen and mobile potassium. Instead, the mobile forms of N and P were statistically differentiated depending on the dose of compost, thus, the maximum compost dose generating the lowest content levels in the soil, as a result of higher absorption of these chemical elements in plants;

The content of macro- and microelements of sunflower leaves was not significantly influenced by doses of compost, except P and Ca, for which there were recorded significant differences.

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