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USING IRRADIATION TECHNIQUE OF GAMMA RAYS TO IMPROVE COMPOST QUALITY

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ABSTRACT: ***Composts produced from leucaena leaves (LL) poultry manure (PM), sugarcane bagasse (SB) were studied. LL were used also irradiated (ILL) with gamma rays at doses of 2.5, 5.0 and 10.0 kGy (ILL). LL, ILL (2.5 kGy), ILL (5 kGy), ILL(10 kGy), PM + SB+ ULL, PM+ SB+ ILL(2.5 kGy), PM+SB+ ILL (5 kGy) and PM+SB+ ILL (10 KGy) were prepared representing C1,C2,C3,C4, C5,C6,C7 and C8 treatments respectively. During composting period (60 days) samples of each pile were taken at 0, 15, 30, 45 and 60 days of composting and analyzed for their content of organic C (OC), N, P and K. OC decreased with the increase in composting period and with irradiation. PM and SB applications combined with either un- irradiated or irradiated LL increased N, P and K with the increase composting period and irradiation doses of gamma rays.***

Key words: ***Compost, Composting period, Chemical composition, Gamma rays and Leucaena leaves.***

INTRODUCTION

Composts contain a considerable variety of macro- and micro nutrients. Although often seen as good sources of N, P, and K, composts also contains S, Ca, and Mg, as well as micro nutrients. Because composts contain relatively stable sources of organic matter. These nutrients are supplied in a slow-release form. Compost is usually applied at much higher rates than inorganic fertilizer; thus it can have a significant cumulative effect on nutrient loading and availability. Compost made from biosolids often has a higher N and P content than compost made from animal manures and yard trimmings (Alexander, 2001 and Nada 2011). Elvire *et al.*, (1998) reported that 55 to 100% increases in total N due to mineralization of organic matter. Warman and Anglopez (2002) observed 42 to 85 % increases in total N in three vermin composts after 45, 68 and after 90 days. However, total N returned to levels only slightly above initial contents of 13, 24, and 20 g kg^{-1}. Mineral N content in composts is generally low, since N is partly lost during composting due to NH_3 volatilization (Zwart, 2003). Total N is not readily available to plants and can be mineralized, and then potentially taken up by the plants, immobilized, denitrified, volatilized, fixed within the clay minerals and/or leached.

Phosphorus in composts generally range from < 0.4 to >23 g kg^{-1} (He *et al.*, 1995 and Vogtmann *et al.*, 1993), depending on compost source. Bio-solids generally contain greater P content than most feedstocks. However, a varying proportion of P in bio-solids is in organic forms, which are less available to plants (He *et al.*, 2000). Lee (2016) reported availability of N and P from various composted wastes. Most municipal solid waste composts in U.S. and European countries have 2 to 6 g P kg^{-1} with a mean of 3.3 g kg^{-1}. Such P contents are about 2 to 10 times greater than total P in most arable soils (He *et al.*, 2001). Application of compost can increase available P in soil. Organic P in

composts made of plant residues is readily decomposed to release available to plants. Availability of P in composts ranges from 20 to 40 % of total P (Vogtmann *et al.*, 1993). Biosolids/ sawdust compost applied to a sandy soil at 7.5 to 30 g kg^{-1} had little effect on organic P and its labile form (Coutinho *et al.,* 1997 and Nada, 2011).

Contents of K in composts vary from 0.7 to >12 g kg^{-1}, with a mean of 5.4 g Kg^{-1}(He *et al.*, 2001). Such range is lower than the K in plant (8 to 35 g kg^{-1}). Potassium is highly mobile in plants at all levels (Marschner, 1995). Part of K in plant materials may be lost during composting. Composts can be alternative sources of K for crops. Plant availability of K in composts can be more than 85% of their total K (Vogtmann *et al.*, 1993).

MATERIALS AND METHODS

Four organic wastes varying in their origin and chemical composition were used. These organic wastes were:

a- Poultry manure (PM) taken from a private farm.

b- Sugarcane bagasse (SB) collected from different sources.

C- Leaves of leucaena trees collected from a farm under drip irrigation (Un-irradiated leaves).

d- Irradiated leaves of leucaena trees (ILL) where a portions of the collected and irradiated leaves using gamma rays of doses 0, 2.5, 5.0 and 10 kGy were used.

These organic residue were air-dried and shredded into small pieces of about 1 cm diameter. Properties the residues are shown in Table 1.

Table 1: Chemical composition and total nutrients content of the raw materials of the used organic residues.

Properties and units		Organic residues					
		P M	S B	I LL (0.0 KGY)	ILL (2.5KGY)	ILL (5.0KGY)	ILL (10.0KGY)
pH		6.8	4.2	6.9	6.7	6.5	6.2
EC** (dSm^{-1})		21.3	0.03	0.2	0.21	0.24	0.27
OM (%)		6.29	4.85	8.22	7.8	7.1	5.95
C/N ratio		12.1	104.3	23.5	20.8	17.75	13.8
Total macro and micro-nutrients (mg g^{-1})	N	52	4.65	35	37.5	40	43.6
	P	20.2	9.9	17.7	17.9	18.5	18.9
	K	20	3.8	9.3	9.5	9.8	10.2
	Fe	0.461	0.284	0.165	0.195	0.258	0.315
	Mn	0.89	0.045	0.035	0.038	0.042	0.048
	Zn	0.92	0.019	0.028	0.031	0.035	0.039
	Cu	0.091	0.022	0.043	0.046	0.051	0.057

* In 1:10 soil: water sups. ** in soil paste extract. PM : Poultry manure, SB : sugarcane bagass, LL : leucaena leaves (LL), ILL: Irradiated leucaena leaves (ILL).

The experiment consisted of 8 treatments of composting process as shown in Table 2. The design was a randomized complete block, factorial with 3 replicates. Factor 1 was the compost (8 treatments) and factor 2 was the composting period (5 period).

Composting was carried out in containers with 50 × 50 × 50 cm. The materials were shredded into fine pieces of about 1 cm diameter. Each pile was mixed with 100 g calcium carbonate, 500 g super phosphate and 500 g of ammonium sulfate as chemical activator, Along with bacterial strain was added as microbial activators. The mixture of each container was mixed well gently and arranged in equal six layers within the container.

The organic residue materials were moistened by water up to 50 -60 % of its water holding capacity (WHC) and left for decomposition up to 60 days. The piles of materials were turned upside down every ten days. After each turn off samples of each pile were taken for analysis. Maturity time for the organic materials was obtained after 60 days (Abou-Hussein *et al.*, 2017). Samples were taken at intervals of 0, 15, 30, 45 and 60 days for analysis.

The relative change (RC) of yield (grains and straw) was calculated according to Khalil *et al.,* (2015) as follows:

$$RC = \frac{\text{dry matter yield of treated plants} - \text{dry matter yield of untreated plants}}{\text{dry matter of untreated plants}} X100$$

The agronomical efficiency (AE) was calculated according to Sisworo *et al.,* (1990) as follows:

$$AE = \frac{\text{dry matter yield of treated plants} - \text{dry matter yield of untreated plants}}{\text{added compost } ton\ fed{-1}}$$

The harvest index (%) of yield was calculated according to Khalil *et al.,* (2015) as follows:

$$\text{Harvest index (\%)} = \frac{\text{grains yeild (ton fed}-1\text{)}}{\text{biological yeild (ton fed}-1\text{)}} X100$$

Table 2: Materials and material mixtures used in making composts.

Compost code	Mixture rates of the used organic materials
C1	0 kg PM + 0 kg SB + 15 kg ILL 0.0 KGy
C2	0 kg PM + 0 kg SB + 15 kg I LL 2.5 KGy
C3	0 kg PM + 0 kg SB + 15 kg I LL 5.0 KGy
C4	0 kg PM + 0 kg SB + 15 kg I LL 10.0KGy
C5	5 kg PM + 5 kg SB + 5 kg ILL 0.0 KGy
C6	5 kg PM + 5 kg SB + 5 kg I LL 2.5 KGy
C7	5 kg PM + 5 kg SB + 5 kg I LL 5.0 KGy
C8	5 kg PM + 5 kg SB + 5 kg I LL 10.0 KGy

RESULTS AND DISCUSSION

Organic carbon (OC) content

Data in Table 3 show that , increasing period of composting process was associated by a significant decrease of OC. The relative changes "RC" were negative along the 60 dayes of composting. This can be mainly attributed to chemical and biological transformation during composting (Stevenson, 1994). Elgezairi (2016) and Abou.Hussien *et al.* (2017) and sisouane *et al.* (2017) obtained results with composting indicating a decrease in OC with composting. Irradiation decreased OC in the composts produced from LL alone and its mixture with PM and SB, particularly with increased dose of irradiation with time. At 30 days of composting period RC of compost content of OC in relation with irradiation doses were -9, -5 and -7 % for C2 , C3 and C4 irradiated by 2.5, 5 and 10 KGy respectively. Applying irradiation increased decomposition rate and maturing degree of produced compost. This effect may be attributed to the degradation effect of gamma rays on the tissues of organic materials (Fan *et al* , 2018). These results agree with those obtained by Hagemann *et al.* (2018). At all composting periods and with the three doses of gamma rays composts from C2,C3 and C4 LL mixed and irradiate C6, C7and C8 had OC compared with those in the composts of C1 and C5. This may be attributed to presence bio – and chemical activates in the PM and SB which would to increase decompositing (Stevenson, 1994). Gohar (2011) and Abou Hussien *et al* (2016) noted a clear effect of raw materials sources on the produced content of OC.

Table 3: Effect of raw organic materials source and irradiation using gamma rays on produced compost content (%) of organic carbon (OC) and its relative change "RC" (%) at different composting periods (day).

Compost type (CT)	Composting period " CP ": (Day)									Mean
	0	15		30		45		60		
	%	%	RC %	%	RC %	%	RC %	%	RC %	%
C1	27.34	27.18		27.10		26.49		21.74		25.97
C2	26.41	25.79	-5	24.56	-9	22.34	-16	21.73	0	24.17
C3	26.26	25.71	-5	25.64	-5	25.26	-5	24.64	13	25.50
C4	25.71	25.49	-6	25.10	-7	24.86	-6	21.73	0	24.58
C5	26.44	26.38	-3	26.34	-3	26.00	-2	21.13	-3	25.26
C6	26.29	26.28	-3	26.25	-3	25.64	-3	20.63	-5	25.02
C7	26.24	25.88	-5	25.63	-5	24.26	-8	19.88	-9	24.38
C8	25.50	25.31	-7	25.28	-7	23.95	-10	19.50	-10	23.91
Mean	26.27	26.00		25.74		24.85		21.37		
LSD at 0. 05 CT: 0.87; CP: 0.81; CT×CP:2.30										

- **C1 up to C8 are leucaena leaves (LL), irradiated leucaena leaves (ILL at 2.5 kGy,), irradiated leucaena leaves (ILL at 5 kGy), irradiated leucaena leaves (ILL at 10 kGy), 1:1:1 mixture of poultry manure (PM) : sugarcane bagasse (SB) : LL ; mixture PM:SB:ILL at 2.5 kGy, mixture PM:SB:ILL at 5 kGy; , mixture PM:SB:ILL at 10 kGy.**

Total N:

The presented data in Table (4) increasing in both composting periods and irradiation doses of gamma rays resulted in a significant increases in RC values of N were positive and increased with the increase in composting period and irradiation doses. This indicates decreases of pH with the increase in the composting time. Elgezairy (2016) and Abou Hussien *et al* (2017) obtained results indicating increased N in compost produced from maize stalk. jain *et al* (2018) pointed out that irradiation of organic wastes using gamma rays increased decomposition of their composts. At 30 days of composting , RC of total N content were 4 , 12 and 40 % for C2,C3 and C4 irradiated by 2.5, 5.0 and 10.0 KGy compared with C1, respectively. This indicate that organic residues characterized by hardness of their tissues may be irradiated to increase their decomposition (liu *et al.,* 2018).

Composts C5 to C8 have high contents of N. This reflect the high N content in PM and SB. Materials of high N produce compost of high N (Stevenson , 1994). Gohar (2011) mentioned that, total N in compost depended on the chemical composition of the composted organic materials. Iqbal *et al* (2015) obtained indicating high N content in compost C/N ratio. kononova (1966) and Stevenson (1994) mentioned that, C/N ratio of organic matter and their composts may be used to organic substances. Data in Table 5 show that C/N ratio depend on the source of composted residues. Increasing composing period and irradiation dose resulted in a decrease of C/N ration of the composts. This results from the decrease in the compost content of total OC and increase in the content of total N, PM and SB application with un-irradiation and irradiation of leucaena leaves tended to decrease C/N ration of the produced composts. The rate effect of composting period, irradiation dose and sources of the composted organic materials may be defined and cleared from the calculated RC(%) values of C/N ratio, Gohar (2011); Elgezeiry (2016) and Abou Hussien *et al* (2017) obtained results indicating narrow C/N ratio in composts.

Table 4: Effect of raw organic materials source and irradiation using gamma rays on total N in compost and its relative change "RC" (%) at different composting periods.

Compost type (CT)	Composting period " CP ": (Day)									
	0	15		30		45		60		Mean
	%	%	RC %	%	RC %	%	RC %	%	RC %	%
C1	1.33	1.61		1.74		1.95		1.99		1.72
C2	1.53	1.61	0	1.81	4	1.95	0	2.01	1	1.78
C3	1.86	1.95	21	1.95	12	2.03	4	2.11	6	1.98
C4	1.89	2.15	33	2.44	40	3.16	62	3.26	64	2.58
C5	1.60	1.84	14	1.95	12	1.96	1	2.10	6	1.89
C6	1.58	2.20	36	2.41	39	2.65	36	3.11	56	2.39
C7	1.79	2.48	54	2.54	46	3.19	63	3.26	64	2.65
C8	1.95	2.54	57	2.64	52	3.28	68	3.33	67	2.75
Mean	1.69	2.05		2.18		2.52		2.65		
LSD at 0.05 CT: 0.08; CP: 0.07; CT×CP: 0.20										

See footnotes of table 3 for treatments description.

Table 5: Effect of raw organic materials source and irradiation using gamma rays on produced compost C/N ratio and its relative change "RC" (%) at different composting periods.

Compost type (CT)	Composting period " CP ": (Day)									Mean
	0	15		30		45		60		
	Value	Value	RC %	Value	RC %	Value	RC %	Value	RC %	Value
C1	20.63	16.85		15.59		13.58		10.93		15.57
C2	17.31	15.99	-5	13.55	-13	11.45	-15	10.79	-1	13.81
C3	14.10	13.18	-21	13.15	-15	12.47	-8	11.66	6	12.91
C4	13.62	11.85	-29	10.29	-34	7.86	-42	6.65	-39	10.05
C5	16.52	14.35	-14	13.50	-13	13.25	-2	10.06	-8	13.53
C6	16.69	11.94	-29	10.88	-30	9.67	-28	6.62	-39	11.15
C7	14.67	10.45	-38	10.09	-35	7.61	-44	6.09	-44	9.78
C8	13.07	9.97	40	9.58	-38	7.31	-46	5.86	-46	9.15
Mean	15.82	13.03		12.07		10.40		8.58		
LSD at 0.05 CT: 0.45; CP:0.42; CT×CP: 1.19										

See footnotes of table 3 for treatments description.

Contents of P and K have a wide range, P content ranged from 0.99% in C1 at zero day of composting to 1.56 % in C8 at composting period f 60 days, K content ranged from 0.78% in C1 at zero day of composting to 1.09 % in C8 at 60 day of composting. Increasing composting period were associated with increases in P and K. In C5 P increased from 1.03 % at zero day of composting to 1.24 % after 60 days. While at zero day of composting was 0.80 % . and increased to 0.93 % after 60 days of compositing. Values of RC for P and K were positive and widely varied from one compost to another. Increases in the P and K in compost are attributed with composting period (Elgezairy, 2016 and Abou Hussien *et al.,* 2017).

Data in Tables 6 and 7 show that, increases in the composts contents of P and K of irradiated organic materials ILL compared with the materials of unirradiated. After 45 day of composting contents of P and K in C1 and C5 were 0.89 % and reached 0.90, 0.93,0.99 % in C2, C3 and C4. Thus, irradiation increase composting process. This shows that RC value was affected by irradiation of P and K after 30 days showed RC of 2, 4, 7, 2, 4, 11 and 14% for P content were 0, 3, 6, 2, 0, 7 and 9% for K content due to C2, C3, C4, C5, C6, C7 and C8 compared with those found in C1, respectively. These results mean that irradiation of organic residues using gamma rays decreased composting period to obtain on mature compost with a high content of P and K. These results are in agreement with those obtained by Liu *et al.* (2018).

Table 6: Effect of raw organic materials source and irradiation using gamma rays on produced compost content (%) of phosphorus (P) and its relative change "RC" (%) at different composting periods.

Compost type (CT)	Composting period " CP ": (Day)									Mean
	0	15		30		45		60		
	%	%	RC %	%	RC %	%	RC %	%	RC %	%
C1	0.99	1.09		1.15		1.19		1.19		1.12
C2	1.09	1.14	4	1.18	2	1.23	3	1.26	6	1.18
C3	1.11	1.15	6	1.20	4	1.26	6	1.41	19	1.23
C4	1.14	1.21	11	1.23	7	1.35	13	1.54	29	1.29
C5	1.03	1.13	3	1.18	2	1.21	2	1.24	4	1.16
C6	1.11	1.16	7	1.20	4	1.24	4	1.30	9	1.20
C7	1.16	1.19	9	1.28	11	1.35	13	1.36	14	1.27
C8	1.21	1.26	16	1.31	14	1.54	29	1.56	31	1.38
Mean	1.10	1.17		1.21		1.30		1.36		
LSD at 0.05 CT: 0.02; CP: 0.02; CT×CP: 0.05										

See footnotes of table 3 for treatments description.

Table 7: Effect of raw organic materials source and irradiation using gamma rays on produced compost content (%) of potassium (k) and its relative change "RC" (%) at different composting periods (day).

Compost type (CT)	Composting period " CP ": (Day)									Mean
	0	15		30		45		60		
	%	%	RC %	%	RC %	%	RC %	%	RC %	%
C1	0.78	0.83		0.88		0.89		0.89		0.85
C2	0.81	0.86	4	0.88	0	0.90	1	0.93	4	0.88
C3	0.86	0.86	4	0.91	3	0.93	4	0.94	5	0.90
C4	0.83	0.91	10	0.93	6	0.99	11	1.06	19	0.94
C5	0.80	0.84	1	0.90	2	0.89	0	0.93	4	0.87
C6	0.85	0.89	7	0.88	0	0.93	4	0.96	8	0.90
C7	0.89	0.90	8	0.94	7	0.95	7	0.99	11	0.93
C8	0.91	0.93	12	0.96	9	1.06	19	1.09	22	0.99
Mean	0.84	0.88		0.91		0.94		0.97		
LSD at 0.05 CT: 0.01; CP: 0.01; CT×CP:0.02										

See footnotes of table 3 for treatments description.

P and K shown in Tables 6 and 7 were indicate variation between composted organic residues. At all composting periods, P and K contents in the composts produced only from LL were lower than those presence in the composts produced from the mixture of LL, PM and SB. This is attributed to high content of P and K in this mixture due to high contents of nutrients in PM

(Kononava, 1966). Gohar (2011) mentioned that, P and K in compost depend on the source of the composted organic materials and its chemical composition. These results are in agreement with those obtained by Liu *et al* (2018).

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استخدام تقنيه التشعيع باشعه جاما لتحسين جوده الكمبوست

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الملخص العربي:

اجريت هذه الدراسه فى قسم بحوث الأراضي والمياه – مـركز البحوث النوويه – هيئه الطاقه الذريه لدراسه تاثير التشعيع باشعه جاما لاوراق شجر الليوسينا عند جرعات مختلفه علي التركيب الكيميائي للكمبوست المنتج من هذه الاوراق. ولقد استخدم في هذه الدراسه سماد دواجن ومصاصه القصب وورق الليوسينا الغير مشعه والمشعه باشعه جاما عند جرعات ٢,٥,٥,١٠ كيلوجراي. تم تجهيز ثمان كومات كمبوست من المخلفات العضويه المستخدمه (ورق ليوسينا غير مشعع – ورق ليوسينا مشعع عند ٢,٥ كيلوجراي – ورق ليوسينا مشعع عند ٥ كيلوجراي – ورق ليوسينا مشعع عند ١٠ كيلوجراي – ورق ليوسينا غير مشعع +سماد دواجن +مصاصه قصب وورق ليوسينا مشعع عند ٢,٥ كيلوجراي +سماد دواجن +مصاصه قصب – اوراق ليوسينا مشععه عند ٥ كيلوجراي +سماد دواجن +مصاصه قصب واوراق ليوسينا مشععه عند ١٠كيلوجراي + سماد دواجن +مصاصه قصب) ممثله بكمبوست ارقام علي الترتيب التالى : (C1,C2,C3,C4, C5,C6,C7). اثناء فتره التحضين (٦٠يوم) اخذت عينات من كل كومه عند فترات تحضين الكربون العضوي والنيتروجين والفوسفور والبوتاسيوم .

انخفض محتوي (%) الكمبوست من الكربون العضوي بزياده فتره التحضين وجرعه التشعيع باشعه جاما كما يتناقص هذا المحتوي نتيجه لاضافات سماد الدواجن ومصاصه القصب الي اوراق الليوسينا سواء كانت الغير مشععه او المشععه . ومن ناحيه اخري فقد ازداد محتوي الكمبوست من النيتروجين والفسفورو البوتاسيوم بزياده كل من فتره التحضين وجرعه التشعيع باشعه جاما كما وجد زياده مماثله بمحتوي الكمبوست من هذه المغذيات نتيجه لاضافه سماد الدواجن ومصاصه القصب الي اوراق الليوسينا الحديثه سواء الغير مشععه او المشععه .

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