Plant Archives Vol. 19 No. 2, 2019 pp. 4340-4346 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

COMPARATIVE STUDY BETWEEN AEROBIC AND NON-AEROBIC DECOMPOSITION FOR DIFFERENT ORGANIC FERTILIZERS AND THE ROLE OF ENRICHING ORGANIC FERTILIZERS WITH MINERAL NUTRIENTS IN THE GROWTH AND YIELD OF POTATO

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Abstract

The current research has been carried out in one of Agricultural Engineering Sciences College's fields/ University of Baghdad, Al-Jadiriyah to make comparison among results of aerobic and non- aerobic decomposition for different organic fertilizers and its effect upon the growth and yield of potato. It has been implemented two operations of aerobic and non-aerobic decomposition for three types of animalswastes which are cows, sheep and poultry approximately for 80 days. After that, it has mixed products of aerobic and non-aerobic decomposition individually of three animals wastes to get two organic fertilizers. Water extracts ofaerobic and non-aerobic decomposition products have been obtained singly for spraying on the plants. It has enriched the organic fertilizers resulted from aerobic and non-aerobic decomposition with mineral fertilizers before being added to the soil. The field experiment has been carried out in silty loam by cultivating the potato. Cultivar Sevra / Class B. The treatments of the research include 10 treatments that being distributed according to the RCBD, with three replicates, thus the number of experimental units becomes 30 with area $4m^2$ for each unit. The crop has been harvested in the end of the season and measured growth and yield criteria.

The results have indicated as follows: Getting reduction in values of electrical conductivity for the studied organic fertilizers in the aerobic decomposition, while pH was somewhat similar in their behaviour in both ways. It indicated that the loss in the content of fertilizers of nitrogen and potassium in aerobic decomposition was more than non-aerobic decomposition, while the loss in phosphorus was little in the aerobic decomposition in comparison with the non-aerobic decomposition. Whereas C/N for the non-aerobic decomposition was less in comparison with the aerobic decomposition. The treatment of organic decomposition enrichment with minerals have not been a significant differences than those of independent treatments in terms of the total yield. The treatment T8 was given higher total yield 42.5 Mg ha^{-1} with significant difference from the treatment (T1, T2, T3, T4) and higher biology yield 2.83 Mg ha^{-1} that being equal to the treatment T7 with significant difference from the treatment (T2, T1) and with higher dry weight of tubers 8.53 Mg ha^{-1} with a significant difference from the treatments (T5, T3, T2, T1).

Key words: Aerobic and Non-Aerobic Decomposition, organic fertilizers, enriching Organic fertilizers, mineral nutrients

Introduction

Potato belongs to Solancea family and is considered one of important food crops enriched with energy and most important vegetable crops and hugely used, and tops the list of tuber crops.

Potato is planted in different types of soil, but the most suitable soil the sandy loam soil enriched with organic materials. Asitis the soils of dried and semi-dried areas, including the soil of south and middle of Iraq are weak construction due to the reduction of the natural organic material owing to the prevailing environmental conditions. Thus, the need to add the animal and plant organic material to soil has been appeared, but the plants could not get benefit of the organic substance unless converted into decomposed material. The process of decomposition is known as biological converts of organic animals and plants wastes by a number of microbiology, most

importantly bacteria and fungi with presence of water and foods (Plaster, 1997).

In general, The process of decomposition is divided into two parts which are the non-aerobic decomposition known as a process of organic substances decomposition either be source of plant or animals by virtue of non-aerobic microorganisms, where organic compositions bonds are broken by thenon-aerobic microorganisms to get an energy and to produce middle composites, including methane gas known as Bio gas, Hydrogen sulphide and Ammonia gas and other materials having strong smells, and other cause poisons to plants (Aresha and al-Sawas, 2009). The aerobic decomposition is known as organic materials decomposition process owing to the activity of aerobic microorganisms with presence of Oxygen. The process of organic materials oxidation is occurred under suitable environmental conditions. The differences between aerobic and non- aerobic decomposition lies in either the presence of Oxygen or not (Plaster, 1997), in respect to moisture in the aerobic decomposition ranges between 60-70 of water preservation ability. In non-aerobic decomposition, the organic material is saturated with water. In respect to the decomposition products in each type of decomposition, in the aerobic decomposition, the final products is the water and CO_2 and affixed composites materials that being used for fertilization Orthophosphate and Nitrate. In the non aerobic decomposition, the products are gases like ammonia NH_3, hydrogen sulphate and gases could be ignited like methane gas CH_4 (Aresha and al Sawas, 2009). The organic material is a mixture of the remaining materials either be animals or plants that could be produced during the process of decomposition for a long time and the organic material includes a, number of nutritional elements, most importantly, Carbone, Hydrogen and Nitrogen, Oxygen, sulphate and phosphate and other mineral elements. Thus, as benefit of organic decomposition, is release mineral materials that have been mentioned until becoming as a source of nutrition for the plants (Awad, 1986). Stephenson (1982) has explained that the quick decomposition of organic material depended on many factors, most importantly, type of organic material and the rate of decomposition gets increased for the organic wastes by increasing Nitrogen and reducing by increasing luknain; it is also depended on the temperature and moisture and ventilation of soil. When the organic material is decomposed, the ratio of Carbone gets decreased to Nitrogen (C/N) in it and helps to release the nutritional elements including nitrogen when estimating the ratio of nitrogen in the organic wastes. If it is 1.5% or more than that, in this case, we do not need to add nitrogen to the organic wastes for accomplishing decomposition, but if we add nitrogen to these wastes, it helps increase the decomposition (al-Saedi, 1997). Bohn, *et al.,* (1985) indicated that the most active part in the soil was the organic part if being calculated on basis of the unit of weight. Golchin (1991) indicated that the organic material in the soil was considered one of the most important natural compositions that the human knew its importance, but mechanism of the effect of organic material in the soil and its fertility, was known only in modern times after the development of many sciences such as soil chemistry, microbiology and plant nutrition that contributed into knowing aspects of organic material and its composition and its converts within the soil under the effect of the activity of microorganisms (Buessa and Ghyath, 2005). Schnitzer (1991) explained that the organic material includes two parts which are (Non humified substances), it is decomposed part of organic substance, but it is possible to distinguish its physical and chemical features and that include carbohydrates, proteins, and Amino acids, fats, pigments, organic acids, they form 20-30% of the organic substance, period of remaining these substances in the soil is short, since they attack by soil microorganism. humified substances, includes a mixture of heterogeneous and non-crystallized substances with high molecular weight. The humified substances are divided by molecular weight, properties and its solubility to the fulfvic acid, humic acid and humen, which constitutes the largest ratio of organic substance ranges from 65-80 %. al-Taee (2013) explained the reasons of reducing the soils contents from the organic substance is the increase of oxidation of the organic substance due to climate conditions prevailing in Iraq and also owing to the little plantation cover.

The current study aims to make comparison between the aerobic and non- aerobic decomposition of different organic fertilizers, and role of enrichment with mineral substance for the organic fertilizers in the growth and yield of Potato.

Materials and Methods

The current study has been carried out in one of Agricultural College's fields/University of Baghdad, al-Jadiriyah for autumn season 2017 in silty loam soil and the schedule indicates some characteristics of soil before implantation, potato, cultivar sevra Class B, The study includes the following stages:

Preparation of organic fertilizers

It has brought 100kg of cows wastes, 100 kg of sheep wastes and, 100kg of poultry wastes, samples were taken

to estimate some chemical characteristics, after that, it has carried decomposition processes in the protected house that is related to the department of soil sciences as that explained below: Wastes of cows, sheep, and poultry have divided into two parts with 150kg for each method of decomposition.

The 1st part: The experiment of aerobic decomposition has been carried out by placing fertilizers on apiece of soft polyethylene dimensions 5×5m and exposed to an exhibition air, with adding water to each of experiential unit until saturation at the beginning, after that ever necessary without allowing to water to get out of wastes, and then stir the fertilizers for each 10 days and after 80 days of decomposition process.

It has been taken samples from the fertilizers and estimated some of its chemical characteristics. The 2nd part is non- aerobic decomposition where it has used thick plastic sacks (capacity 20kg), it has placed fertilizers in these sacks with 10kg from each fertilizers, until the sacks becoming 5 sacks for each of poultry, cows and sheep, the total number of sacks is 15 sack with the addition of water for every sack until saturation with closing the sacks tightly. After passing the above mentioned period, samples from the fertilizers have been taken to estimate its mechanical characteristics. After then, outputs of poultry, cows and sheep fertilizers of aerobic and non-aerobic decomposition were mixed individually. So we have two organic fertilizers, only one for the aerobic and the other for non- aerobic decomposition.

Schedule No. 1 some physical and chemical characteristics of soil before plantation.

Property	Value	Measurement Unit
PH1:1	7.3	
EC 1:1	1.94	dSm^{-1}
Organic matter	20	gkg^{-1}
ECE	19	$Cmol_{+}kg^{-1}$
Carbonate minerals	260	gkg^{-1}
Soluble ions		
HCO_3^-	8.4	
CO_3^{2-}	Nil	
SO_4^{2-}	6.9	
Cl^{1-}	3.6	$meqL^{-1}$
Ca^{2+}	10.8	
Mg^{2+}	5.9	
K^+	0.5	
Na^+	1.6	
Available N	30.0	mg kg^{-1}
Available phosphorus	12.9	
Available potassium	90.2	
Sand	78	g kg^{-1}
Silt	795	
Clay	127	
Texture	Silty loam	

25kg has taken from the decomposed fertilizers under non- aerobic decomposition, (cows, sheep and poultry), and 25kg of decomposed fertilizers under aerobic decomposition (cows, sheep and poultry) have placed inside plastic container (100kg capacity) and has added 75 liter of water free of chlorine. The fertilizer and water have been mixed carefully and left for 3 days, every 24 h, fertilizer is mixed. After passing 3 days, it has extracted fertilizer solution from the fertilizers after passing through special cloth for this purpose. Extracts of aerobic and non-aerobic decomposition have been gathered separately in a plastic container that being later used to spray the plants in the field experiment.

The Field experiment

The experiment has been carried out based on Randomized Complete Block Design (RCBD) with 3 replicates resulted 30 experimental units, area of every experimental unit is $4m^2$ with 3 rows, length of rows is 2m and a distance is 0.5m between the units and blocks.

Experimental Treatments

Comparative treatment without adding fertilizers T1, foliar application with aqueous extract from aerobic decomposition T2, foliar application with aqueous extract from non-aerobic decomposition T3, mineral fertilization treatment (300, 100, 300) N, p, Kkg ha^{-1} (T4), treatment of aerobic organic fertilization 20Mg ha^{-1} (T5), treatment of non-aerobic organic fertilization with 20Mgha^{-1} (T6), treatment of mineral fertilization plus aerobic organic fertilization 20Mgha^{-1} (T7), treatment of mineral fertilization plus anaerobic organic fertilization with 20Mgha^{-1} (T8), treatment of enriching the aerobic organic fertilizers with minerals, then added to the soil (T9), treatment of enriching the non-aerobic organic fertilizer with minerals, then added to the soil, (T10). The plantation of potato cultivar sevra Class B has been done on 28/9/2017, the distance between the rows 0.67m, the distance among plants is 0.25m, the depth of planting is 5cm.

Processes of fertilization

Fertilization done 10 days after implantation and as follows:

Adding full phosphate fertilizer and 1/2 nitrogen and potassium fertilizers and solid organic fertilizers into grooves below the plants with 5cm and then covering them and irrigate directly. Second round of potassium and nitrogen has been added 15 days after the 1st round. Foliar application of water extracts with 4 rounds after

the completion of vegetable growth. The 1st spraying has been made 45 days after implantation followed by other sprayings with 7 days between a spray and another.

Results and Discussion

Characteristics of organic fertilizers before decomposition.

The schedule 2 indicated that the electrical conductivity of poultry and sheep wastes have been high and has recorded the value 3.9dsm^{-1} and cows wastes have been less and recorded 2.63dsm^{-1} with a significant difference from poultry and sheep wastes.

It has also indicated from the same schedule that pH of poultry wastes have been acid 5.4 and base 7.93 and 8.1 for each of cows and sheep consequently. The schedule also indicated values of total nitrogen taken the following serial, poultry wastes 3%. and then sheep wastes 2. 8%. with significant difference from the cow wastes 2.2%. The contents of these wastes of phosphorus have been high among poultry wastes 1.04%, then sheep wastes 0.72% and finally cows wastes 0.5% with significant difference among the three types, the poultry wastes recorded high value of potassium 1.63% with significant difference from the sheep and cows wastes 1.43%. The data indicated that the poultry wastes have been more enriched in nutrients contents and then sheep and cows. The contents of wastes of organic Carbone, the cows have been high 56% with significant difference from poultry and sheep wastes 55.3%. In respect to C/N have been less in poultry wastes 19.0, then sheep wastes 19.8 with significant difference from the cows wastes 25.63.

Organic fertilizers characteristics after composition

The schedule 3 indicates reduction of electrical conductivity values of organic wastes in comparison with its values before decomposition, where it was high electrical conductivity in poultry wastes 3.03 dSm^{-1} with significant difference from other wastes and less conductivity of cows wastes 2.03 dSm^{-1}, the cause may be due to dilution as well as leaching salts after decomposition.

The schedule indicates a change in pH of fertilizers, where pH of poultry fertilizer got high in comparison with its value before decomposition and reduction in cow and sheep fertilizers. The differences were significant in poultry fertilizers and other. This was because of conditions accompanied fertilizers decomposition by releasing CO_2, organic acids and hydrolysis. The schedule indicates also reduction in values of nitrogen, where poultry fertilizers recorded high value 2.57% with significant difference from other fertilizers and less value in organic extracts 1%. due to volatilization of nitrogen in form of ammonia gas during decomposition. The schedule indicates reduction in values of phosphorus, where the higher value was in poultry wastes 0.91% with significant difference from other fertilizers and less value in cows wastes 0.44% owing to occurring a loss in phosphorus during saturation fertilizers with water when being prepared for decomposition. The schedule indicates reduction in values of potassium, where the high value was in sheep wastes 1.07% and less value was in water extracts 0.89%, but the differences among wastes were not significant owing to reduction in total values of potassium, occurring a loss during the process of preparation and decomposition.

The schedule indicates reduction in total values of Carbone and C/N, where high value of Carbone was in poultry wastes 39% with significant difference from sheep and cows wastes and high value for C/N in cows wastes 20.03 with significant difference from poultry wastes due to happening a loss in Carbon owing to decomposition process.

Fertilizers characteristics after non-aerobic decomposition

The schedule 3 indicates that the electrical conductivity values of organic wastes got reduced compared to pre-decomposition, where the high value was in the poultry wastes 3.3 dSm^{-1}, then in sheep wastes 3.13dSm^{-1} with significant difference from cows wastes and water extract and less value in cows wastes 2.23 dSm^{-1}. The schedule also indicates occurring changes in pH of fertilizers, where pH of cows and sheep wastes got reduced, while pH of poultry wastes got increased, this variation behaviour is due to different nutrients contents of fertilizers based on the type of animal and age along with type of foods as indicated by (Havlin *et al.,* 2005; Ali and Shakir 2018; Abdulrasool 2013). The schedule indicates reduction in values of total nitrogen in the organic fertilizer after decomposition where high concentration noted in the poultry wastes 2.67% with significant difference from other wastes, low concentration in water extract 1.2% this decline may be due to a loss in nitrogen in form of Ammonia gas during the process of

Schedule 2. Organic fertilizers characteristics before decomposition.

Characteristics	EC	pH	N%	P%	K%	C%	C/N
Poultry wastes	3.9a	5.40c	3.00a	1.04a	1.63a	55.33b	19.00b
Cows wastes	2.63	8.10a	2.20b	0.50c	1.43b	56.00a	25.63a
Sheep wastes	3.9a	7.93a	2.80a	0.72b	1.43b	55.33b	19.80b
LSD	0.224	0.26	0.38	0.14	0.19	0.411	3.02

Schedule 3. Organic fertilizers characteristics after aerobic decomposition.

Characteristics	EC	pH	N%	P%	K%	C%	C/N
Poultry wastes	3.30a	6.73b	2.57a	0.91a	0.93a	39.00a	15.20b
Cows wastes	2.03c	7.67a	1.50b	0.44b	0.90a	29.67c	20.03a
Sheep wastes	2.70b	7.60a	1.93a	0.51b	1.07a	33.0b	17.13ab
Water extract	2.57b	7.77a	1.00d	0.55b	0.89a	----	----
LSD	0.21	0.23	0.36	0.13	N.S	2.40	3.02

decomposition. It also occurred reduction in values of phosphorus in all fertilizers, where the high concentration was in poultry wastes 0.87% with significant difference from other fertilizers and reduction occurred in potassium values in all fertilizers, the high concentration in sheep wastes 1.33% with significant difference from other fertilizers, low concentration was in water extract 0.91% this decline in phosphorus and potassium values may be due to a loss during the decomposition process. The schedule indicates also reduction in organic carbon values and C/N after the decomposition of all fertilizers, where the high value of organic carbon was in poultry wastes 39.3% with significant difference from other fertilizers, and there were not differences in values of C/N among the three wastes. This reduction in the organic carbon values was because of being lost in form of CO_2 and CH_4 gas during the process of decomposition. These converts and changes in characteristics and contents of fertilizers during the non-aerobic decomposition as indicated by (Havlin, *et al.,* 2005, Mckew, *et al.,* 2013 Ali, 2012, Ali and Shakir 2018, Singh, 2015; Khalid, *et al.,* 2011, Salminen, and Rintala, 2002 Ibrahim, and Abdul Majeed 2014.

Comparison between aerobic and non-aerobic decomposition

The two schedules 3, 4 indicate that reduction in values of electrical conductivity after aerobic decomposition (2.03-3.03) dSm^{-1} was larger than non-aerobic decomposition 3.3-2.23 dSm^{-1}, the reason may be due to conditions of leaching of salts in both methods of decomposition. While the changes in pH were almost identical in both methods of aerobic decomposition 6.73-7.77 and non-aerobic decomposition 6.60-7.53. While the loss in nitrogen was great in aerobic decomposition 1.0-2.57% more than the non-aerobic decomposition method (1.2-2.67%) owing to decomposition conditions in both methods, while the content of phosphorus fertilizers in aerobic decomposition was (0.44, 0.91%) and that was more than the content of non-aerobic decomposition method (0.38-0.87%), while the fertilizer content of potassium in anaerobatic decomposition was (0.91-1.33%) and was more than aerobic decomposition (0.89-1.07%). This difference may be due to the conditions of decomposition in both methods and the loss occurred during the two processes, while reduction in value of C/N in non-aerobic decomposition was high (14.73-15.8) from the method of aerobic decomposition method (15.2.20.03). This was because of conditions of decomposition in both methods (Havlin *et al.,* 2005, Singh 2015, Khalid *et al.,* 2011, Mckew *et al.,* 2013).

Schedule 4. Organic fertilizers characteristics after an aerobic decomposition.

Characteristics	EC	pH	N%	P%	K%	C%	C/N
Poultry wastes	3.30a	6.60b	2.67a	0.87a	1.17b	39.33a	14.73
Cows wastes	2.23c	7.53a	1.90c	0.41b	1.10b	30.00c	15.80
Sheep wastes	3.13a	7.53a	2.23b	0.40b	1.33a	34.00b	15.27
Water extract	2.77b	7.53a	1.20d	0.38b	0.91c	----	----
LSD	0.25	0.33	0.29	0.06	0.12	2.66	N.S

Marketable Yield

The schedule 5 indicates that the treatment T8 gave high yield 41.83 $Mgha^{-1}$ with significant difference from other treatments (T1, T2, T3, T5), while there were not significant differences from treatments (T4, T6, T7, T9, T10). The treatment T1 recorded less yield 26.93$Mgha^{-1}$, these differences have appeared between the control treatments T1 and other treatments owing to adding mineral and organic fertilizers separately and owing to their interferences to each other because of the role of fertilizer from the nutritional side for the mineral fertilizers and improving the soil characteristics in addition to nutritional side in the organic fertilizer (Havlin, *et al.,* 2005, Abdulrasool *et al.,* 2009 and al-Fadhli 2006).

Unmarketable Yield

The schedule 5 indicates that there are not significant differences among the treatments this yield does not include only 1.6% of the total yield for higher yield T8. This result is similar to that Abdulrasool (2007) got, where he got a ratio ranging between 1.4-1.8% for unmarketable yield.

Total Yield

The schedule 5 indicates the superiority of the treatment T8 to other treatments by total yield amounted 42.50 $Mgha^{-1}$ followed by the treatment T7. While the treatment T1 appeared to be less 27.30 $Mgha^{-1}$. The schedule also indicates that there have not been significant differences between the treatments T6, T4, T9, T10, T8, T7 and there have not been significant differences between the two treatments T1, T2.

Schedule 5. Marketable and unmarketable and total potato Yield ($Mgha^{-1}$).

Treatments	Marketable Yield	Unmarketable Yield	Total Yield
T1	26.9c	0.36	27.3c
T2	31.6bc	0.54	32.1bc
T3	34.0b	0.49	34.5.b
T4	37.6a	0.52	38.1a
T5	34.4b	0.50	34.9b
T6	35.4a	0.52	36.0a
T7	40.0a	0.66	40.7a
T8	41.8a	0.66	42.5a
T9	38.0a	0.54	38.5a
T10	38.9a	0.54	39.4a
LSD	6.84	N.S	6.97

Schedule 6. BiologicalYield and dry weight.

Treatments	Biological Yield	Dry weight
T1	1.57	5.47
T2	2.10	6.43
T3	2.30	6.90
T4	2.67	7.63
T5	2.43	7.00
T6	2.63	7.17
T7	2.83	8.13
T8	2.83	8.53
T9	2.70	7.70
T10	2.80	7.87
LSD	0.66	1.39

Biological Yield

The schedule 6 indicates the superiority of the treatments T8, T7 to other treatments with yield amounted 2.83 $Mgha^{-1}$, while there have not been significant differences between these two treatments and other treatments except the two treatments T2, T1 due to the role of the organic and mineral fertilizers to increase the growth of plants and to improve properties of the soil (Havlin *et al.,* 2005).

Dry-weight for Tubers

The schedule 6 indicates the superiority of the treatment T8 to other treatments with yield 8.53 $Mgha^{-1}$, but the differences between this treatment and other treatments (T10, T9, T7, T6, T4) have not been significant, while the differences with other treatments have been significant, The treatment T1 has been given little weight 5. 47 $Mgha^{-1}$ owing to the role of the organic and mineral fertilizers to increase the production and to improve the soil properties (Havlin *et al.,* 2005).

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