COMPOSTING FARM YARD AND CHICKEN MANURES THROUGH AEROBIC, ANAEROBIC, FORCED AERATION AND VERMEN PROCESSES

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Abstract
This study was carried out at the Demonstration Farm, Agricultural Research Corporation, Shambat, Khartoum North, Sudan in 2014/2015 and 2015/2016 seasons. The objective was to come up with a compost preparation procedure to improve the quality of the compost and hence crop productivity. Farm yard (FYM) and Chicken manures (CHM) were collected from the Top Farm and the Faculty of Animal Production, University of Khartoum, respectively and were mixed at a ratio of 10:1 (FYM:CHM) and moistened to 50% of its volume. The mixed material was divided and composted into four preparations; aerobic, forced aeration at the rate of 10 CFM, anaerobic (buried in 90cm auger holes) and vermin (1kg vermin/2kg organic matter). The experiment was laid out in a completely randomized design (CRD). The composts prepared were sampled every month and analyzed for organic carbon (OC); nitrogen (N); phosphorus (P) and potassium (K). Microbiological examinations were made every month. Compost maturation was reached by reduced volume, brown color and crumbly with earthy smell. It was observed that the best and appropriate time of opening compost was after three months. The results obtained showed that the best treatment was the aerobic, followed by forced aeration in the two seasons. The results illustrated that the bacteria population was significantly (P<0.05) different from the aerobic and the vermin treatments. The nitrogen, phosphorus and potassium were significantly (P<0.05) different in the two seasons in the aerobic treatment compared with other treatments, whilst potassium and phosphorus were significantly (P<0.05) lower for the anaerobic treatment in the first season.

Key words: Composting, Aerobic, Anaerobic, Forced aeration and Vermin processes

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I. INTRODUCTION

The decomposition or breakdown of organic wastes naturally occurs by mixed population of microorganisms in warm moist and aerated environment. Organic matter content; microbial activity and general soil health are taken as a measure of soil fertility. In the past people thought that chemical fertilizers were the most crucial input for enhancing crop yield, but they soon realized that the practice of intensive mineral fertilization has adverse, long-term environmental consequences [1]. Organic fertilizers are so far restricted to limited traditional use in horticultural sites while mineral fertilizers are coming into common use in nearly all integrated areas of crop production [2]. However, the direct effect of these wastes may cause new problems derived from the presence of heavy metals, pathogenic organisms, bad phototoxic organic compound [3]. Availability of inorganic fertilizers in Sudan is limited because of their high cost [4]. The soils of Sudan are known to be low in organic matter and nitrogen [5]. In spite of this fact, there is a remarkable lag in the use of organic manures due to a variety of reasons.
These include factors such as unilateral development of crop and animal systems of production, lack of appreciation of the value of organic manures in the maintenance of soil fertility.

The objective of this study was to come up with a compost preparation procedure that would improve the quality of the compost and hence crop productivity. The ultimate aim was to reduce the cost of production by decreasing the use of inorganic fertilizers and protect the environment through increasing the efficiency of the use of animal waste as fertilizers thereby reducing waste disposal.

II. MATERIALS AND METHODS

The study was conducted at the Demonstration Farm, Agricultural Research Corporation, Shambat, Khartoum North, Sudan (latitude 15° 40’ N and longitude 23° 32’ E) in 2014/2015 for two consecutive seasons (2014/15 and 2015/16). Farm yard (FYM) and Chicken (CHM) manures samples were collected from Khartoum University Top Farm and the Faculty of Animal Production, University of Khartoum respectively. A mixture of Farm yard manure (FYM) and chicken manure (CHM) with the ratio of 10:1 was prepared and mixed thoroughly and moistened to 50% of its volume. The mixed material was divided into four parts. The first part was set for aerobic composting (2 m width, 5 m length and 1.5 m height). Three plots were prepared for the aerobic composting method. Monthly samples were taken from the three plots for three consecutive months. The second part was composted (having the same dimension as the earlier) with a net of perforated pipes installed inside the heap/pile through which forced air was passed every other day. The forced air composting method was similarly sampled as the first one. The third part was an aerobically preserved (buried) in 90cm auger holes for destructive sampling every month. A total of 27 auger pits were prepared for the anaerobic composting method. Samples in the anaerobic composting treatment were taken from the first nine auger pits in the first month, then from the following nine auger pits in the second month and finally from the last nine auger pits in the third month. Samples from every three auger pits were thoroughly mixed as one sample (composite), ending with three samples every month. Vermin was added to the fourth part and sampled as described for the first and second methods the compost sampling from the different treatments was executed every month for three consecutive months. The compost samples were analyzed for organic carbon (OC); nitrogen (N); phosphorus (P) and potassium (K). Microbiological examinations for bacteria and fungi were made every month.

The data was statistically analyzed using a completely randomized design [6] and the means were separated using Duncan Multiple Range Test (DMRT).

III. RESULT AND DISCUSSION

A. Effect of compost preparation method on microbial profile

The results in Table 1 present the effect of compost preparation method on bacterial activities (μg/cm³). In the first season the treatments resulted in a significant (P<0.05) difference in the number of bacteria across the different sampling months (Feb. March and April). Aerobic preparation method recorded the highest bacterial concentration during February and April months, whereas the forced air method had the highest concentration during March (P<0.05) in the first season. Lowest concentrations were found for anaerobic method during February and for the vermin method during March and April. In the second season, the aerobic method had the highest bacterial concentration in February with the anaerobic method recording the lowest value (P<0.05) while the forced air method had the highest concentrations during March and April, with the vermin method had lowest bacteria during March and April. However, it worth noting that overall bacterial concentration monthly increased progressively during both seasons (Fig. 1). This monthly increase in the number of bacteria is expected because the
The first part of the compost to be degraded is the starch. Many of the microbes involved in the decomposition are present on the wastes themselves.

**Table 1. Effect of compost preparation method on Bacteria (μg/cm³)**

| Treatment  | First Season | Second season |
|------------|--------------|---------------|
|            | Feb | Mar | Apr | Mean  | Feb  | Mar | Apr | Mean  |
| Aerobic    |     |     |     |       | 82.0 |     |     |       |
| Forced air | 30.0 | 79.3 | 139.3 | 44.0 | 30.7 | 67.7 | 139.3 | 79.2 |
| Vermin     | 32.0 | 36.0 | 64.0 | 44.0 | 36.3 | 35.3 | 61.3 | 44.3 |
| Anaerobic  | 21.3 | 49.7 | 114.0 | 61.7 | 21.7 | 43.3 | 106.7 | 57.2 |
| Mean       | 32.5 | 53.7 | 116.8 | 40.57 | 50.25 | 111.5 |       |

Means in the same column having a letter in common are not significantly different at P≤ 0.05

**Table 2. Effect of compost preparation method on Fungi (μg/cm³)**

| Treatment    | First Season | Second season |
|--------------|--------------|---------------|
|              | Feb | Mar | Apr | Mean | Feb | Mar | Apr | Mean |
| Aerobic      | 20.0 | 2.33 | 1.67 | 8.0 | 18.3 | 2.0 | 2.67 | 7.67 |
| Forced air   | 5.0 | 4.67 | 2.00 | 3.9 | 4.33 | 4.67 | 1.33 | 3.44 |

Table2 display the effect to compost preparation method on fungi (μg/cm³) concentration. In the first and second season there were highly significant (P<0.01) differences between treatments during the three months of decomposition. For both seasons, during February, aerobic method had the highest (P<0.01) fungi concentration, during March the vermin treatment recorded the highest concentrations, whereas the anaerobic method recorded the highest concentration during April. The overall mean during both seasons shows that the aerobic method had resulted in the highest fungi concentration while the anaerobic method had the lowest concentration. Furthermore, a monthly downward trend was observed in fungi concentration during both seasons (Fig.2). Fungi express their role in decomposition under aerobic condition because fungi are one of the aerobes [7]
Means in the same column having a letter in common are not significantly different at $P \leq 0.05$

**Figure 2.** Mean monthly fungi concentration (μg/cm$^3$) during both seasons

**B. Effect of compost preparation method on mineral profiles**

Significant differences were observed in the organic carbon (%) contents between treatments in the first season ($P < 0.05$) only during the first month (February) and third month (April) while the second season ($P < 0.01$) differences were only during the third month (April) of decomposition. This could be due to the decrease in the materials targeted by the microbes with time. Similar results were shown by [8] who concluded that the organic matter in sugar beet residues decreased with time at composting in case of aerobic compost compared to anaerobic compost (Table 3).

**Table 3. Effect of compost preparation method on Organic carbon (%)**

| Treatment  | First Season          | Second season          |
|------------|-----------------------|------------------------|
|            | Feb       | Mar       | Apr       | Mean     | Feb    | Mar      | Apr     | Mean     |
| Aerobic    | 50.0 $^a$ | 35.6 $^a$ | 50.3 $^b$ | 45.32 $^a$ | 50.3 $^a$ | 42.7 $^a$ | 45.33 $^b$ | 46.11 $^a$ |
| Forced air | 47.0 $^{ab}$ | 34.9 $^a$ | 66.7 $^a$ | 49.51 $^a$ | 50.0 $^a$ | 41.33 $^a$ | 52.67 $^{ab}$ | 48.00 $^a$ |
| Vermin     | 38.7 $^c$ | 38.3 $^a$ | 61.7 $^{ab}$ | 46.22 $^{ab}$ | 48.3 $^a$ | 49.0 $^a$ | 58.33 $^a$ | 51.88 $^a$ |
| Anaerobic  | 40.3 $^{bc}$ | 34.7 $^a$ | 41.7 $^c$ | 38.8 $^b$ | 50.0 $^a$ | 43 $^a$ | 46.53 $^b$ | 46.51 $^a$ |
| LSD        | 8.08      | 5.09      | 12.537    | 10.3      | 11.166 | 8.025    | 8.98     | 5.8096   |
| Mean       | 44.00 $^b$ | 35.88 $^c$ | 55.08 $^a$ | 49.67 $^a$ | 44.00 $^b$ | 50.72 $^a$ | 44.00 $^b$ | 50.72 $^a$ |

Means in the same column having a letter in common are not significantly different at $P \leq 0.05$

The effect of compost preparation method on nitrogen (%) content is shown in Table 4. No significant differences were observed in the first month (February) of the first season while the differences were significant ($P < 0.05$) in the second and the third month (March and April). The nitrogen content was low in the anaerobic treatment compared to other treatments. Significant differences were observed in the nitrogen content compared to the control treatment. The nitrogen contents in the
Composted material increased with time during both seasons (Fig.3) and there was a gradual decrease of the bulk volume of the compost. A highly significant increase in the nitrogen content was noticed in the third stage of decomposition with the forced air treatment. The increase in the nitrogen content may be attributed to the release of the organic-bound nitrogen resulted from the treated materials. Similar results were obtained by [9] and [8] who showed increased nitrogen content with time in composted sugar beets. These results were also in line with that of [10]. The same results were obtained in the second season.

Table 4. Effect of compost preparation method on nitrogen content (%)

| Treatment | First Season |  | Second Season |  |
|-----------|--------------|---|---------------|---|
|           | Feb          | March | April | Mean | Feb | March | April | Mean |
| Aerobic   | 1.23<sup>a</sup> | 1.23<sup>a</sup> | 2.10<sup>b</sup> | 1.79<sup>a</sup> | 1.5<sup>a</sup> | 1.67<sup>a</sup> | 1.97<sup>a</sup> | 1.71<sup>a</sup> |
| Forced air| 1.4<sup>a</sup> | 1.63<sup>a</sup> | 2.33<sup>a</sup> | 1.52<sup>a</sup> | 1.17<sup>a</sup> | 1.33<sup>ab</sup> | 1.83<sup>a</sup> | 1.44<sup>ab</sup> |
| Vermin    | 1.33<sup>a</sup> | 1.37<sup>ab</sup> | 1.6<sup>b</sup> | 1.43<sup>a</sup> | 1.03<sup>a</sup> | 1.3<sup>ab</sup> | 1.5<sup>ab</sup> | 1.28<sup>bc</sup> |
| Anaerobic | 0.9<sup>a</sup> | 0.93<sup>b</sup> | 1.0<sup>c</sup> | 0.94<sup>b</sup> | 0.97<sup>a</sup> | 0.93<sup>b</sup> | 1.0<sup>b</sup> | 0.97<sup>c</sup> |
| LSD       | 0.6431       | 0.5675 | 0.597 | 0.399 | 0.624 | 0.47 | 0.53 | 0.314 |
| Mean      | 1.217<sup>b</sup> | 1.292<sup>b</sup> | a | 1.167<sup>b</sup> | 1.308<sup>ab</sup> | 1.575<sup>a</sup> |

Means in the same column having a letter in common are not significantly different at P<0.05

As shown in Table 5 the effect of compost preparation method on the phosphorus (mg/l) content.

Figure 3. Mean monthly nitrogen concentration (%) during both seasons.

The overall phosphorus content was high in the vermin method during the first season and in the aerobic treatment during the second season. This may be attributed to the availability of oxygen availed by the turning of compost in the aerobic treatment during the second season. On the other hand the anaerobic treatment showed the lowest (P<0.05) level of phosphorus in the third month (March) during the first season whereas the highest phosphorus level resulted in the forced air method. In the second season the phosphorus content was not significant among treatments across all months. However, comparatively higher phosphorus contents were under the aerobic method during April and the lowest were under the anaerobic method during February. These results are similar to that of [11]. Phosphorus concentration increase may be explained by the gradual increase in the microbial activity that may reach its peak at the end of the third month of biodegradation indicating a positive relation between the microbial biomass.
and the phosphorus content. It may also be attributed to the rapid decomposition of the easily decomposed manure, which enhances the phosphorus release [12] [13]. The phosphorus content of the compost decreased significantly at the end of the third month. The rate of phosphorus mineralization increased as the organic acids built up in the medium due to the activation of phosphates enzymes, but phosphorus will complex again organically and becomes difficult to be mineralized and released after the third month [14]. The phosphorus content increase perhaps due to the decrease in the level of organic acids and the activity of microorganisms increased again. All treatments showed a general increasing trend of phosphorus content with time. The phosphorus content of the aerobic treatment increased compared to the control. Similar result was obtained by [14] who indicated that the nitrogen in the compost significantly increased the phosphorus content through the enhancement of the microbial activity and hence the organic matter degradation.

**Table 5. Effect of compost preparation method on phosphorus (mg/l)**

| Treatments | First Season | | | | Second Season | | | |
| --- | --- | --- | --- | | --- | --- | --- | --- | | Feb | March | April | Mean | Feb | March | April | Mean | | Aerobic | 0.46<sup>ab</sup> | 0.51<sup>a</sup> | 0.48<sup>a</sup> | 0.48<sup>ab</sup> | 0.46<sup>ab</sup> | 0.56<sup>a</sup> | 0.70<sup>a</sup> | 0.575<sup>a</sup> | | Forced air | 0.38<sup>b</sup> | 0.27<sup>b</sup> | 0.54<sup>a</sup> | 0.398<sup>b</sup> | 0.38<sup>b</sup> | 0.27<sup>b</sup> | 0.54<sup>a</sup> | 0.398<sup>b</sup> | | Vermin | 0.57<sup>a</sup> | 0.55<sup>a</sup> | 0.50<sup>a</sup> | 0.541<sup>a</sup> | 0.60<sup>a</sup> | 0.55<sup>a</sup> | 0.57<sup>a</sup> | 0.573<sup>a</sup> | | Anaerobic | 0.37<sup>b</sup> | 0.54<sup>a</sup> | 0.30<sup>b</sup> | 0.406<sup>b</sup> | 0.37<sup>b</sup> | 0.52<sup>ab</sup> | 0.51<sup>a</sup> | 0.466<sup>ab</sup> | | LSD Mean | 0.1815 | 0.2400 | 0.1539 | 0.115 | 0.1875 | 0.2680 | 0.2153 | 0.129 | | Mean | 0.446<sup>a</sup> | 0.469<sup>a</sup> | 0.460<sup>a</sup> | | | | | |

Means in the same column having a letter in common are not significantly different at P≤ 0.05

Potassium contents (mmol/l) were significantly (P<01) different during first (February) and third (April) month in the first and the second season Table 6 being higher in the anaerobic and vermin methods. These results agree with the findings of [11] who found that the organic treatments increased the potassium and nitrogen content. This could be explained by the release of potassium ions from the composted materials [15]. The potassium content started to increase from the start of composting up to the end of the composting period (12 week). Organic compost treatments increased potassium content compared to the control treatment by accelerating the biochemical degradation of organic matter and hence the formation of potassium carbonate that conserve potassium from being released to soil solution [8].

**Table 6. Effect of compost preparation method on potassium (mmol/l)**

| Treatments | First season | | | | Second season | | | |
| --- | --- | --- | --- | | --- | --- | --- | --- | | Feb | March | April | Mean | Feb | March | April | Mean | | Aerobic | 0.83<sup>a</sup> | 1.47<sup>a</sup> | 1.07<sup>a</sup> | 1.12<sup>a</sup> | 0.60<sup>b</sup> | 1.06<sup>a</sup> | 0.89<sup>b</sup> | 0.851<sup>a</sup> | | Forced | 0.77<sup>a</sup> | 1.53<sup>a</sup> | 0.31<sup>b</sup> | 0.87<sup>a</sup> | 1.09<sup>a</sup> | 1.39<sup>a</sup> | 0.29<sup>c</sup> | 0.924<sup>a</sup> | | Vermin | 0.77<sup>a</sup> | 0.89<sup>b</sup> | 1.47<sup>a</sup> | 1.04<sup>a</sup> | 1.09<sup>a</sup> | 1.23<sup>a</sup> | 1.10<sup>ab</sup> | 1.14<sup>a</sup> | | Anaerobic | 0.27<sup>b</sup> | 0.83<sup>b</sup> | 1.48<sup>a</sup> | 0.86<sup>a</sup> | 0.55<sup>b</sup> | 0.84<sup>a</sup> | 1.40<sup>a</sup> | 0.932<sup>a</sup> | | LSD Mean | 0.3026 | 0.4963 | 0.4786 | 0.457 | 0.3709 | 0.8944 | 0.4549 | 0.415 | | Mean | 0.66<sup>a</sup> | 1.18<sup>a</sup> | 1.08<sup>a</sup> | | | | | |

Means in the same column having a letter in common are not significantly different at P≤ 0.05

Table 7 presents the effect of compost preparation method on the nitrogen and organic carbon (C:N) ratio. In the first season significant (P<0.05) difference among treatments were observed only during the second month (March), while significant differences were significant during March (P<0.01)
and April (P<0.05) in the second season. Direct relationship is known to exist between N content of the decomposing plant material and the rate of decomposition. High initial N, low C/N ratio, favor high rate of decomposition of plant residue [16]. This is because organic matter under physical protection becomes accessible to microbes. In fact, the C/N ratio was found to be an important index of N release for a wide range of N concentrations.

| Treatments | First season | Second season |
|------------|--------------|---------------|
|            | Feb | March | April | Mean | Feb | March | April | Mean |
| Aerobic    | 41.6  | ab  | 29.7  | b   | 23.9  | a   | 31.71 | b   |
| Forced     | 36.8  | ab  | 22.7  | b   | 29.3  | a   | 26.1  | ab  |
| Vermin     | 29.3  | b   | 28.6  | b   | 43.3  | a   | 33.76 | ab  |
| Anaerobic  | 45.5  | a   | 41.6  | a   | 42.6  | a   | 43.24 | a   |
| LSD        | 15.273 |      | 11.711 |     | 23.957 |    | 9.842 |     |
| Mean       | 38.33 | a   | 31.05 | a   | 34.77 | a   | 45.44 | a   |
|            | 38.33 | a   | 31.05 | a   | 34.77 | a   | 45.44 | a   |

Means in the same column having a letter in common are not significantly different at P≤ 0.05

IV. CONCLUSIONS

The results of this study clearly indicated that:

- Three months composting period was suitable for compost to mature.
- Aerobic method of preparation had resulted in the best effect with respect to quality and composting time. Forced air compost preparation method came second to aerobic, followed by vermin method and the least one was the anaerobic preparation method.

BIBLIOGRAPHY

[1] Kuipers, A.; F. Mandersloot and R. L. G. Zom. 1999. Approaches to nutrient management in dairy farms. Journal of Animal Science 77:84-89.
[2] FAO 1992. Origin of maize, maize in human nutrition, Bulle tin 11, Rome, Italy pp:8.
[3] Diez, J., A. Dela, A., Torre, A. I., Cartagena, M., Cabrillo, M., Vallejo, A., Munoz, M.J. (2001). Evaluation of application of pig slurry to an experimental crop using agronomic and ecotoloxicogical approaches. J. EnvironQual (30): 2165-2172.
[4] Awadallah, E. A. and N. H. Basioni,(1993). Fertilizers and Fertilization (in Arabic), 1st edition, Computer Centre, Cairo University pp:140, Egypt.
[5] Mekki I. I. (1997) Comparative study on the fertilizing effect of biogas sludge on yield of microbial population PH.D (Agric) Thesis, University of Khartoum.Sudan.
[6] Steel, R. G. D. and Torrie, J. H. 1980. Principles and Procedures of Statistics: A biometrical approach. McGraw-Hill Co., New York, USA 633 pp.
[7] Frankenerger,W.T. and Abdelamagid, H.M. (1985). Kinetic parameters of nitrogen mineralization rates of leguminous crops incorporate into the soils. Plant and Soil, 78: 257-271.
[8] Habib, F. M., A. Negm, and N. M. Hassan (2001).Composting of sugar beet Residues.A study on condition and period of composting. Egypt. J. Agric. Res79(2) PP373-383.
[9] Abo-Sedera, S. A. (1995). Biological and chemical studies on organic wastes decomposition PH.D Thesis Fac- (Agric) AL-AZHAR University - Egypt.
[10] Valtche, D., Zheljaakov and Philip, Warman, R. (2004). Application of high Cu compost to Dill and peppermint.J.(Agric) food Chem, 52, pp2615-2622.)
[11] Eltilib, A.M.A., Elmahi, Y.E., Abdel Maged H.M., and Ahmad B.A.M. (1995). Response of wheat to irrigation frequency and maturing in a salt affected semi-arid environment. J. of Agric Environment (13): 115-125.
[12] Eltilib, A.M., Ali, A. M., and Abdullah A. (1994). Effect of Chicken manure and salinity on growth and leaf nitrogen, phosphorus and potassium contents on okra grown in two soil type Khartoum, U., J, Agric, Sci, I(2): 16-36.
[13] Abdelgani, M.E., (1997). Effect of Rhizobium on N Dilatation, yield and seed quality of Fenugreek (Trigonellafoenumgraecum L), PhD. (Agric) thesis, University of Khartoum, Sudan.
[14] Elsheikh, A. E.andEkhlas, M.M. (1998). Effect of biological organic and chemical fertilizer on yield, hydration coefficient, cook ability and mineral composition of groundnut seed. Food Chemistry, (36) No 2PP: 253-257.
[15] Dewes, T. D. and L. S. Schmitt. (1994). Deposition of nitrogen and potassium from farmyard manure heaps in the soil under long-term manure storage areas. Agrobiological Research 47:115-120.
[16] Gobo1, 2, J.G.; Barrio2, 3, S; Kass, D.C.L. and Thomas2, R.J (2002). Decomposition and nutrient release by green manure in a tropical hillside agro-ecosystem. Plant and soil 24: 33-1342.