# TEMPERATURE CHANGES DURING COMPOSTING CHICKEN LITTER WITH BAGASSE AND EM AND FERTILIZER VALUES OF COMPOST

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**Abstract**

The litter of broiler chicken consists of a mixture of manure, wood shaving and waste food. This was mixed with bagasse in a 1:1 ratio and composted with EM under aerobic and anaerobic conditions. The rise in temperatures under aerobic conditions in compost heaps of 10 and 40 Kg were 34 and 56 degrees celsius in 5 and 2 days respectively. The temperature did not rise in compost heaps kept under anaerobic conditions. The testing of fertilizer value of the compost in pot and field studies using vegetables illustrated the improvements in growth and yields. The potential of composting with EM for making organic fertilizers is presented.

## Introduction

Ten thousand tons of chicken broiler litter are annually produced in Mauritius and cause disposal problems in large enterprises. The litter has high nitrogen content (Brake et al., 1992). It can be air-dried or composted to prevent losses of ammonia and development of unpleasant odors and used as an organic fertilizer. Air-dried poultry manure can have as much as three times more nitrogen content that composted poultry manure (Mondini et al.,1996). However composting ensures killing of potential pathogens such as *Salmonella*, stabilizes the organic matter with a high degree of humification and improve its quality as a soil amendment as well (Ciavatta et al., 1994; Collins et al., 1993; Mondini et al., 1996). A decrease in self-heating capacity with cooling to ambient temperatures indicates maturity. Composting with added plant material provides additional carbon to achieve optimum degradation and retention of nitrogen through more microbial biomass formation (Atkinson et al., 1996) besides further improving soil physical conditions and nutrient holding capacity. Chicken litter containing wood shavings as bedding material when composted with wheat straw, peanut hulls, pine bark and paper mill sludge in $0.33m^3$ quantities developed peak temperatures of 40 $^oC$, 66 $^oC$, 66 $^oC$ and 45 $^oC$ respectively (Flynn and Wood, 1996). Ideal temperatures should be in the range of 60-65 $^oC$ as temperatures above 70 $^oC$ kill the microorganisms most active in composting.

Composting with Effective Microorganisms (EM) inoculation is encouraged in organic farming practice in many countries that constitute the Asia-Pacific Natural Agriculture Network and elsewhere with significant agricultural benefit (Anon., 1996). Effective Microorganisms is a mixed culture of photosynthetic and lactic acid bacteria, actinomycetes, yeast and fermenting fungi developed in Japan to improve organic matter composting (Higa and Parr, 1994). In addition, EM is reported to have several other beneficial effects such as better germination and plant establishment, enhanced flowering, fruiting and ripening, and weed, pathogen and pest control.

The main objective of this investigation was to study the composting of chicken broiler litter containing wood shavings as bedding material with added bagasse and with EM inoculation to determine the temperatures developed during composting and the effects of the compost on plant growth and yield.

**Materials and Methods**

The EM1 liquid bio-fertilizer was obtained from EM Laboratory, Shizuoka-Shi, Shizuoka-ken, Japan. It was activated by diluting at the rate of 1 cc per liter of water containing 1 g of raw sugar and kept for 24 hours before use.

The chicken litter containing wood shavings as bedding material and waste feed was obtained from broiler pens in which the broilers had been raised for 60 days. The litter was thoroughly air dried.

The bagasse obtained as compressed blocks was manually shredded to enable uniform mixing and thoroughly air dried.

In one experiment chicken litter and bagasse were mixed in 5 kg quantities each and wetted with 30 liters of EM suspension. Two replicates were placed in thick gauge transparent polythene bags and tightly closed to maintain anaerobic conditions. The depth in the bag was 60 cm. Two replicates were spread on tarpaulin in an open room in a heap 150 cm diameter and height 30 cm and lightly covered with gunny bags to minimize moisture and heat loss. Temperature was regularly recorded at a depth of 15 cm from the top in both the bags and the heaps over a period of 25 days.

The experiment was repeated under aerobic conditions using chicken litter and bagasse mixed in 20 kg quantities each, wetted with 120 liters EM1 solution and spread on tarpaulin in a heap of diameter 165 cm and height 75 cm. Temperature was regularly recorded at a depth of 15 cm and the heap was aerated by mixing whenever the temperature exceeded 50 $^{o}$C. The NPK values of the compost were determined after 25 days.

The efficacy of the compost to promote plant growth and yield was determined in a pot study on bean (*Phaseolus vulgaris*) cv. Long Tom, and in the field on bean, onion (*Allium cepa*) cv. Local Rodrigues and potato (*Solanum tuberosum*) cv. Spunta

**Pot Study**

The experiment was carried in plastic pots with saucers each containing 3 kg of sieved garden soil. The soil is a silty clay having a pH of 6.2 and 0.42, 0.098 and 0.051 % of NPK respectively. The treatments were

1. Control
2. 200 g compost added per pot
3. 400 g compost added per pot
4. 600 g compost added per pot
5. 3 g of complex fertilizer 13:13:20:2 per pot

The experiment was laid as a randomized complete block with four replicates. Five pots formed one experimental unit. The compost or the fertilizer was thoroughly mixed with the soil. The pots were thoroughly wetted by capillary and allowed to equilibrate for 1 week before bean seed ware sown. After germination one seedling was maintained per pot. The plants were harvested at maturity after all the plants had dried and dried bean yield was recorded.

**Field Studies**

The three crops were concurrently grown on separate blocks on the University Farm at Reduit. The treatments were

1. Control
2. Compost added at the rate of 1 kg per $m^2$
3. NPK Fertilizer at the rates of 300 and 600 kg/ha of 13:13:20:2 for bean and onion respectively, and 250, 175 and 125 kg/ha of ammonium sulphate, triple superphosphate and muriate of potash respectively for potato.

The experiment was laid out as a randomized complete block with four replicates. Plot size was 1.8 m x 1.2 m. Spacing was 45 cm x 60 cm, 10 cm x 30 cm and 10 cm x 15 cm for potato, bean and onion respectively. The plots were watered as and when required. No pesticide applications were applied. All plants in the compost treatments also received twice weekly sprays with EM 5 solution prepared by diluting 100 cc of EM1 in a mixture of 100 cc each of molasses, vinegar and 50 percent ethanol in 600 cc of water (Anon., 1995) as a plant protection measure.

All plots were harvested at maturity and the yield of potato, bean and onion recorded.

**Results and Discussion**

The experiments using 10 kg and 40 kg compost mixtures were started on 3lst January 1997 and 13th March 1997 respectively. Initial temperature at mixing was 25 °C. The temperatures recorded over the 25 day period is presented in Table 1. The temperature in the anaerobic treatment increased slightly to 28 °C and remained constant at this temperature during the whole period. Decomposition was extremely slow or negligible with strong unpleasant odor. There was hardly any darkening of the mixture to indicate fermentation. After day 25 the bag was emptied and the mixture heaped as for the aerobic compost. Within a day the temperature increased to 45 °C and remained so for 2 days and then gradually dropped to 28 °C. This indicated that it was lack of oxygen that was hindering decomposition. In the aerobic heap the maximum temperature reached was 36 °C. This is low to kill pathogenic microorganisms. The small heap size does not permit build up and retention of heat.

In the 40 kg aerobic compost heap the highest temperature reached was 56 °C and stayed above 50 °C until day 5 when the compost was mixed and aerated. The temperature rose again to 50 °C after mixing. Self-heating after day 19 produced lower temperatures indicating decrease in microbial activity. Flynn and Wood (1996) found similar effects after day 21 with other organic substrates. The temperature gradually decreased to 37 °C in 25 days. These temperatures are similar to those recommended in the APNAN Application Manual (Anon.,

1995) for successful composting but may still not be adequate to kill potential pathogens (Flynn and Wood, 1996). Further experimentation is needed to determine manageable heap size and mixing frequency for optimal heat retention.

The NPK values for the compost at day 25 were 1.35, 0.83 and 0.52 % on a dry matter basis respectively. Dry matter content was 28 %.

**Pot Study**

The bean seeds were sown on the 14th May 1997. Germination was uniform in all treatments. The first floral primordia appeared on 9th June and 100 % flowering was achieved on 12th June. There was no indication that the compost had any effect on earliness of emergence or flowering. The first pods appeared on 18th June. All treatments were harvested on 15th August. The number and dry weight of seeds are presented in Table 2. All treatments produced significantly higher number and dry weight of beans per plant than the control. However there were no significant differences between the compost treatments or between the compost treatments and the fertilizer treatment. This suggests that nitrogen was the nutrient influencing growth and that there were no added benefits in applying quantities of compost greater than 200 g.

**Field studies**

The plots were prepared as raised beds. The fertilizer and the compost were applied and raked in before planting. The onion, potato and bean were planted on 11th April 1997. Uniform emergence occurred within 6 days. Visual observation showed that fertilizer treated plots had the highest weed infestation and compost treated plots the lowest. The fertilized plots produced larger and greener potato and onion plants. No differences were observed on the bean plots. Plants receiving the EM treatment initially showed lower disease and pest incidence. All plots showed similar disease and pest incidence later during the growth cycle. The bean plants flowered on 15th May. Flowering scapes appeared in onion on 3rd June. The bean plots were harvested on 30th June and the onion and potato on 15th July. The yields are presented in Table 3. In the potato and onion crops fertilizer treatments produced yields which were significantly better than the control. The compost treatment improved yields over the control but they were not statistically different. This indicated that the NPK supplied by the compost were not adequate. In the bean trial the fertilizer and the compost treatments produced no benefit over the control. This was unexpected and it indicated that the soil probably had enough NPK for bean plant growth or the effects were being confounded by nitrogen-fixing root nodules.

The purpose of inoculating EM is to introduce beneficial microorganisms to improve the plant environment for better plant growth and yield (Higa and Parr, 1994). These effects were apparent in this study. Continued inoculation with EM will enhance such effects probably.

**Conclusion**

Chicken litter mixed with bagasse and inoculated with EM does not compost under anaerobic conditions. Small heaps under aerobic conditions generate insufficient heat to kill potential pathogenic microorganisms and can be a serious concern to health. Heaps containing 40 kg of air-dried mixture produced a maximum temperature of 56 $^{o}$C which may not be safe enough. Application of the compost to soil at the rate of 200 g per 3 kg soil in a pot experiment produced as much growth and yield as pots receiving 3 g of 13:13:20:2 fertilizer and was significantly better than the unfertilized control. Under field conditions application of the compost at the rate of 1 kg per $m^2$ improved growth and yield of onion and potato over the unfertilized control but was much lower than in plots receiving inorganic fertilizers at the recommended rates. A higher rate of compost application may further improve yield. The effect of EM5 as a plant protection measure was slight. Continued use may improve its effect.

**References**


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**Table 1. Temperature changes in 10 and 40 kg compost mixtures (°C).**

| Day | 10 kg | 10 kg | 40 kg |
|---|---|---|---|
| | Anaerobic | Aerobic | Aerobic |
| 0 | 25 | 25 | 25 |
| 1 | 27 | 25 | 56 |
| 2 | - | - | - |
| 3 | 28 | 30 | - |
| 4 | 28 | 33 | 52 |
| 5 | 28 | 34 | 52*45 |
| 6 | 28 | 34 | 47 |
| 7 | - | - | - |
| 8 | 28 | 35 | 47 |
| 9 | - | - | 50*40 |
| 10 | 28 | 36 | - |
| 11 | 28 | 35 | - |
| 12 | 28 | 35 | 45 |
| 13 | 28 | 35 | 48*35 |
| 14 | 30 | 35 | 48 |
| 15 | 30 | 35 | 50 |
| 16 | - | - | 50 |
| 17 | 28 | 32 | - |
| 18 | 28 | 33 | - |
| 19 | 28 | 33 | 43*35 |
| 20 | 28 | 30 | 43 |
| 21 | 28 | 30 | 44 |
| 22 | - | - | 42 |
| 23 | - | - | 39 |
| 24 | 28 | 28 | 37 |
| 25 | 28 | 28 | 37 |

X*Y : X: temperature before mixing

*: mixing and aeration

Y: temperature after mixing and heap formation.

**Table 2. Pot study – number and dry weight (g/plant) of bean seeds.**

| Treatment | No of seeds | Seed dry weight |
|---|---|---|
| Control | 5.6 | 3.4 |
| Fertilizer | 16.4 | 8.6 |
| 200g compost | 16.2 | 11.0 |
| 400g compost | 14.5 | 8.0 |
| 600g compost | 16.0 | 9.4 |
| LSDT 5% | 7.7 | 3.2 |
| LSDT 1% | 10.8 | 4.5 |

**Table 3. Field studies – yield of bean, onion and potato.**

| Treatment | Bean seeds dry weight (g/plot) | Onion fresh weight (kg/plot) | Potato fresh weight (kg/plot) |
|---|---|---|---|
| Control | 35.7 | 0.475 | 1.200 |
| Fertilizer | 35.0 | 0.948 | 2.644 |
| Compost | 38.6 | 0.613 | 1.563 |
| LSDT 5% | ns | 0.362 | 0.895 |
| LSDT 1% | ns | 0.549 | 1.355 |