EVALUATION OF TOBACCO CONTAINED COMPOST MIXTURE FROM LOCALLY AVAILABLE ORGANIC MATERIALS IN MONERAGALA DISTRICT

By

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DECLARATION

The work described in this thesis was carried out by me at the Faculty of Applied Sciences, under the supervision of Mr. Rukshan Gunatilaka and Mr. E.P.N. Udaya kumara. A report on this has not been submitted to any other University for another Degree.

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ABSTRACT

Tobacco has become a highly profitable commercial crop in Sri Lanka recently. Farmers in many parts of the country are now rapidly moving towards cultivating tobacco in their lands by replacing traditional food crops. During the processing of dry tobacco leaves large amount (nearly 0.6% of total yield) is wasted as dust. Thus cultivating tobacco in the long run causes depletion of soil nutrition and increases the soil erosion. Therefore it is suggested to apply compost fertilizer for tobacco cultivating lands, because compost can be applied to land as a fertilizer, soil conditioner or as a mulch.

This study was focused on to evaluate the composition of tobacco dust contained compost prepared using locally available organic materials such as rice straw, cow dung, Gliricidia leaves and kitchen waste. There were two different composting units used namely as tobacco dust contained composting unit and controlled composting unit (without tobacco dust) and three replicates from each unit. Heap method was selected to prepare compost and average temperature of the heaps was measured daily. All units were turned at 3 day intervals and moisture content determination was also carried out at the same time. Composting units were moisted if necessary. After 5 weeks of maturation period compost samples were subjected to chemical analysis.

From the temperature variation of the heaps, there were no marked difference between them and all heaps reached thermophilic conditions. According to the statistical analysis, macronutrients showed a significant difference between two treatments. Organic carbon, Nitrogen, Phosphorus, Potassium, Sulphur, Calcium and Magnesium in tobacco dust contained compost samples were significantly higher than controlled compost samples. There was no significant difference in micronutrients between two treatments except Boron.

From the findings of this study it can be concluded that tobacco dust contained compost produced using locally available organic materials, is nutrient rich, pathogen free organic manure and it can be used as an environmental friendly organic fertilizer for the tobacco cultivation with a minimum input.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Tobacco (mainly *Nicotina tabacum* and *Nicotina rustica*) although originated as a tropical crop, it is now cultivated in the subtropical regions of the world as well (Singh, 1988). It is a highly variable species, but typically it is a herbaceous, short lived perennial which belongs to the Family Solanaceae (Gibbon and Pain, 1985).

Now a days tobacco has become a highly profitable commercial crop in Sri Lanka, and farmers in many parts of the country are now rapidly moving towards cultivating tobacco. As a result thousands of rural farmers grow tobacco in their lands by replacing their traditional food crops (Perera, 1990). Districts like Nuwara Eliya, Kandy, Badulla, Kurunegala, Jaffna, Matale, Moneragala, Polonnaruwa, Ampara and Trincomalee can be identified as the areas where tobacco cultivation is widely spread (Gunasena, 1990). Where the Moneragala district is concerned nearly 100ha of land is covered with this crop and the production for Maha season reached 1500kg per ha, per year. Gonagan-Ara, Ulkanda, Handapanagala, Hulandawa, Suduwathura, Maharawa are some of the tobacco cultivating areas in the district.

However, cultivation of tobacco in the long run causes more harm than the short-term benefits to most of the tobacco cultivators in the country. Main adverse environmental consequence of tobacco farming is, it depletes soil nutrients at a much faster rate than any other crop. It also increases the soil erosion. Therefore land becomes infertile and finally crop yield and the quality of the product are decreased (Perera, 1990). In order to increase the productivity most of the farmers use chemical fertilizers. However, compared to the past, today the usage of fertilizers has become less due to the exorbitant prices of fertilizers and the deterioration in physical properties of soil (Webster and Wilson, 1980).

To curtail the above problem frequently it is suggested to apply compost fertilizer for above lands because there is a renewed interest in organic manures. To eliminate soil degradation introduction of a special low cost compost mixture which can be easily prepared by using the available raw materials in the area is suggested. Compost is valuable in reversing the deterioration in soil structure. It also plays an important role in stabilizing and increasing crop yield and enhancing the soil fertility. It also acts as a mulch which is a means of reclamation (Letitia and Fedrick, 1954).

Composting is a biological decomposition process that converts organic matters in to a stable, humus like product under controlled conditions (Sharma, 2001). It is a microbiological process that depends on the growth and activities of a mixed population of Bacteria and Fungi. Composting process can be stimulated, if optimum conditions of moisture, C:N ratio, Temperature and Oxygen levels of the compost heaps are properly maintained (Asian Productivity Organization, 1983). The nutrient value of compost varies with the nature of the material used in the preparation. It is important to have a mixture of materials of suitable average C:N ratio (Webster and Wilson, 1980).

During the processing of dry tobacco leaves large amount (0.6% of total yield) of tobacco is wasted as a dust. This dust mainly contains the tobacco leaves, stalks and stems. Nitrogen contents of tobacco leaves, stems and stalk are 4%, 2.5% and 3.7% respectively (Rodale et al., 1960). Therefore tobacco dust is a rich source of Nitrogen. Hence tobacco dust becomes a good source of a locally available raw material in composting to the farmers.

1.2 Objective

To evaluate tobacco dust containing compost mixture from locally available organic materials in Moneragala district.

CHAPTER 2

LITERATURE REVIEW

2.1 Composting

Production of compost is the heart of the organic method and it is a well known horticultural operation. It is an ancient practice whereby farmers have converted organic waste in to resources.

Composting is a biological decomposition process that converts organic matter to a stable humus-like product under controlled conditions. The organic residues of different nature and chemical composition can be convert in to good compost. It is a microbiological process depends on the growth and activities of mixed population of bacteria and fungi (Asian productivity organization, 1983).

Composting is an alternative system for solving some of the fertilizer problems existing on today's farm. Because it stimulates the growth of rich productive soil that provide nutrients to crops and enhances soil tilth, fertility and productivity (Grundey, 1980).

2.2 Compost

Compost is the dark brown crumbly material that is produce when a collection of plant and animal material is decompose in to fine organic matter and humus. Finished compost is full of nutrients essential for the healthy growth of crops. Mature compost contains trace and essential elements of which the most important are Nitrogen, Phosphorus and Potassium. Once the compost has been mix in to the soil, it will undergo the process of mineralization in which the humus releases minerals in to the soil making them available to the plants. It also improves soil quality by increasing the soils' ability to retain moisture. Therefore compost can be used in the same way as an inorganic fertilizer (Martin, 1982).

2.3 Advantage of compost farming

The finished product obtained from composting has some fertilizer value. It is an excellent soil conditioning agent. The general fertility level of the soil is greatly improved and it gives a stronger start to the crops.

Incorporating compost in to the soil increases the organic content and improves the texture, permeability and water holding capacity of the soil. It improves the soils' mechanical structure which includes it's granulation, tilth and increase of pore spaces.

When compost is added to the soil, it improve the humus content, hygroscopic moisture, water retention capacity and absorption capacity of the soil (Sharma, 2001).

Compost is an excellent material for litter or bedding. It is moisture absorbent, odorless and eliminates the need to purchase bedding from an outside source.

Compost can also be used as a mulch for nurserymen and vegetable farmers.

Compost also multiplies the microbial population of the soil. Bacteria and fungi increase tremendously when soil enriched organically aiding the growing process enormously. Better aeration and constant moisture greatly encourage their increase.

Applying compost to the soil it multiplies the earthworm greatly, because organic matter is it's natural food. The earthworm is one of the best friends of the farmer, aerating his soil and actually manufacturing top soil. Hardpan formation also gradually disappears.

By using compost on lands can prevent soil erosion, reduces runoff and increases the infiltration capacity of the soil.

Due to the use of chemical fertilizers, plant diseases and acid conditions can be occur and there is an occasional crop failure. This practically never happens where the soil is rich in humus-like compost. Plants are strong and healthy enough to stand when applying compost.

Compost has a humus-like quality that makes it even more useful especially in areas of the world where the humus content of soil is being rapidly depleted as a result of excessive cultivation and land erosion. Therefore compost can replace lost humus (Rodale et al., 1960).

2.4 Compost spreading

Compost cannot be spreads at some stages of crop growth. It is usually not possible to spread compost on crops near harvesting time. The pattern of agriculture determines when and where compost can be spreads. Traditionally most compost was spreaded on tilled land. To get a good response from compost application, good management practices should be follow. No more than 50 tonnes/ha should be applied in any one application and there should be at least 30 days between application. Lower application rates would be advise for wet soil conditions. Heavy rates of composts can block soil pores. The blocked soil pores will usually be clear within 30 days by microbes after breaking down the organic matter. This can be lead to anaerobic conditions and reduced infiltration capacity. If compost is applied at too frequent intervals, soil microorganisms will not be able to clear the blocked soil pores (Sharma, 2001).

2.5 Composting plants

Composting plants are less mechanized. Sophisticated machineries are not readily available in the composting plants. It also much labour oriented and therefore cost of the labour is low. It can be constructed onsite with minimal material cost. Because of that capital expenditure on the compost plant is minimum. So the cost of the final product will be within the reach of the consumer (Mann, 1962).

2.6 Classification of composting

Composting can be classify in several ways

2.6.1 Classification according to the Oxygen availability

By the amount of oxygen utilized composting can categorize in to two different ways either aerobic or anaerobic in nature.

2.6.1.1 Aerobic composting

Aerobic composting is governs by the activity of aerobic microbes and hence required the availability of atmospheric oxygen during the period of decomposition. If the environmental factors are optimal, aerobic composting is characterize by high temperature, the absence of foul odors and a short stabilization period. The high temperatures have a sterilizing effect by destroying weed seeds and pathogenic organisms. So it gives a pathogen free product. Aerobic composting is generally more rapid than anaerobic composting. Most modern compost processes are basically aerobic (Letitia and Fedrick, 1954).

2.6.1.2 Anaerobic composting

This is governs by anaerobic bacteria that operate in the absence of atmospheric oxygen. The process is characterizes by low temperatures, the production of odorous gases and longer stabilization time. Since anaerobic composting does not require atmospheric oxygen, the pile or bed can be seal to prevent the escape of foul smelling gases and left alone. It is generally proceeds at a slower rate than does aerobic composting. The major advantage of anaerobic composting is that the process can carry on with a minimum of attention and as such requires little or no energy once the compost bed is established (Wilson, 1928).

2.6.2 Classification according to the method of operation

Compost units can classify in several ways. They can construct in many ways.

2.6.2.1 Windrow method of composting

Compostable organic waste is heap in to piles under covered shed, which allows the beneficial microorganisms to decompose the organic waste efficiently. Shed protects the heap from rain and heat of the sun. Pile temperature of 55^0C-65^0C is optimum for aerobic composting. To enable the microorganisms to obtain sufficient oxygen, the pile is aerate using bamboo aerators. Turning along with the use of bamboo aerators is the method used to maintain the required pile temperature. Turning associated with watering maintains the conditions for rapid decomposition and moves the non-decomposable materials from exterior of the pile in to the interior thus providing new food source for bacteria. Temperature of the pile determines when to turn. The process of composting emits very little odor (Lampman, 2002).

2.6.2.2 Box method of composting

This method is very similar to windrow composting except that frequent turning is not required for aeration. Air is supply to the organic material through perforated box and perforated vertical pipes embedded in the pile. The vertical pipe provides chimney effect created by the warm gases rising out of the windrow causes air to flow through the pipes. Sorted organic waste is place in the perforated box, which decomposes aerobically (Lampman, 2002).

2.6.2.3 Barrel method of composting

The barrel composter is an excellent choice for a small yard. Clean barrel is use in this method. Paint barrels are good choice as the inside has a protective coating. Several rows of 1/2inch holes are drill over the length of the barrel and on the bottom to allow for air circulation and drainage of excess moisture. Barrel is place upright on blocks to allow air circulation. Moist, chopped or shredded waste materials are add until the barrel is 3/4 full. Waste decomposed aerobically in to compost within few weeks. Barrel wants rotate vigorously every two or three days. Plastic barrels are most commonly used (Nordstedt et al., 1991).

2.7 Kinetics of composting

The aerobic composting of all the plants are operate on aerobic process. The biochemistry or the rate at which organic matter decomposes is affect by the carbon-nitrogen relationship of the organic matter, moisture content, temperature, availability of oxygen and the p^H. The effects of these environmental factors on the decomposition of organic matter will help on to better composting process (Sharma, 2001).

2.7.1 Carbon-Nitrogen balance

Carbon to nitrogen ratio controls the rate at which composting proceeds. An ideal compost will have a good C:N ratio, which is said to be about 30:1. This balance can be achieved by simply mixing different organic materials. A low C:N ratio results in the loss of nitrogen as ammonia. A C:N ratio above this range results in a slow down of the composting process. The time required for composting can be lower by adding a nitrogen source such as manure.

As composting begins, for decomposers carbon is essential as it provides the energy source for them and nitrogen is crucial as it supplies protein to build their bodies.

C:N ratio can be varied according to how fresh the material is. As a example fresh green leaves have a lower carbon level (lower than 60:1) where dry, brown leaves have a higher carbon level (higher than 60:1).

As composting proceeds, the C:N ratio continuously decreases with time, since the nitrogen remains relatively constant and the carbon is released as carbon dioxide gas. The compost is considered ripened once the C:N ratio is lowered to a value between 12 and 20 (Roulae, 1992).

Table 2.1 C:N ratio of various ingredients

Ingredient	C:N ratio
Kitchen wastes	15:1
Leaves	60:1
Straw	80:1
Papers	180:1
Wood	700:1
Grass clippings	19:1
Urine	0.8:1
Food wastes	15:1
Fruit wastes	35:1

(Source: Roulae, 1992)

2.7.2 Moisture content

Moisture is essential for microbial activity of the process. To have fast compost going, the pile should be moist but not necessarily wet. An ideal compost pile said to be as moist as a "wrung out sponge". Therefore adding water where the climate is dry and sheltering the pile where the climate is extremely rainy becomes indispensable. Too much moisture is unlikely at the time of making the heap, but it should be protect from rain with polythene on top.

The biochemical reactions during composting are also influence by the moisture content of the organic matter. The optimum moisture content for greatest decomposition should be maintains between 50% and 60% (wet weight). Moisture content above 60% causes compaction of the material and fills the voids with water thus reducing the amount of air present. This may cause anaerobic conditions and slowing down the decomposition process. It is necessary to mix the compost inorder to supply oxygen. If the moisture content falls below 50%, high temperature occur in the center of the pile and begin to destroy the microorganisms, seriously curtailing the decomposition process. This problem can be correct by adding water to the organic matter to raise it's moisture content and restore the process to aerobic conditions (Sharma, 2001).

Table 2.2 Maximum permissible moisture contents

Type of waste	Moisture content (%)
Straw	75 – 85
Wood	75 – 90
Paper	55 – 65
Manures	55 – 65

(Source: Wilson, 1928)

2.7.3 Temperature

Temperature is a key environmental factor and it indicates the amount of biological activity taking place. Temperature within a compost pile is affect by moisture content, oxygen availability and microbial activity.

In general, each group of organisms has an optimum temperature and any deviation from the optimum is manifest by a decline in growth and activity of the organism. The total range of temperature at which life is possible divided in to three sub ranges cryophilic, mesophilic and thermophilic.

5^0C - 10^0C ⟶ Cryophilic range
10^0C - $40^0C/45^0C$ ⟶ Mesophilic range
45^0C - 70^0C ⟶ Thermophilic range

Mesophilic bacteria are more efficient than thermophilic bacteria and that composting therefore proceeds more rapidly. An important advantage of thermophilic composting is that pathogens and weed seeds are kill at this high temperature. Modern composting processes are design to operate within the mesophilic and thermophilic ranges (Sharma, 2001).

The composting process is at it's peak efficiency between 35^0C and 55^0C, because of the many organisms taking part in the process. As the process exceeds 55^0C, efficiency begins to drop abruptly and becomes negligible at temperature in excess of 70^0C. At temperature above 65^0C, sporeformers begin to lose their vegetative ability and form spores resulting in very little activity. Nonsporeformers simply die off. As the process cools from 65^0C or 70^0C back to 40^0C and lower, mesophilic organisms appear in large numbers establishing a high level of activity.

Temperature in anaerobic composting system, ranges from 38^0C to 55^0C, foul odors are given off and pathogens may survive (Wilson, 1928).

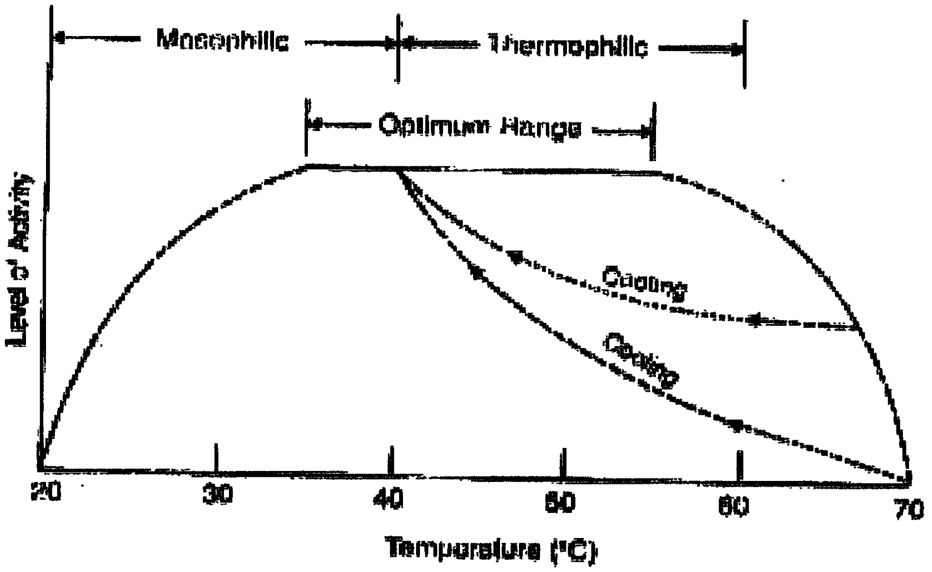

Fig. 2.1 Effect of temperature on microbial activity (Sharma, 2001)

2.7.4 Oxygen availability

Oxygen is essential to maintain aerobic conditions. An ample supply of atmospheric oxygen throughout the compost pile at all times is necessary. Oxygen can be incorporate in to windrows by turning or by thoroughly mixing. The windrow should be turn once every 3 to 4 days to maintain aerobic conditions. Oxygen is add to enclosed digester through continuous tumbling, stirring action or through forced aeration. It is difficult to determine the true oxygen requirement, because it is influence by temperature, moisture content and the bacterial population. It is done by using the chemical oxygen demand (COD) as a means of measurement.

At very low aeration rates, the oxygen supply is limiting and decomposition is anaerobic. Digestion under these conditions is relatively slow. If aeration rates are too high, heat will be remove faster than it is produce. This will lower the temperature below the thermophilic range thus making the process temperature limiting (Sharma, 2001).

2.7.5 pH

During the decomposition process, changes in pH occur. At initial stage, the material is slightly acidic, because as composting proceeds acid forming bacteria cause the compost to become more acidic thus lowering pH. The microbes in the compost then begin to metabolize the inorganic nitrogen to ammonium nitrogen causing the pH to rise rapidly. At this stage compost becomes alkaline. As decomposition continues, the ammonia may be release to the atmosphere or converted to nitrates. The nitrates are lost by leaching or by denitrifying bacteria rendering the compost nearly neutral or slightly alkaline (Sharma, 2001).

2.8 Microbes involved in composting

2.8.1 Bacteria

Both mesophilic and thermophilic bacteria play an important role in the composting process. The mesophilic bacteria predominate during the initial and final phase of decomposition when temperatures are below 40^{0}C. At initial stage large numbers of aerobic mesophilic bacteria are present and they generates heat and temperature within the composting pile increasing their biological activity. As the temperature rises above 40^{0}C, the mesophilic bacteria are replace by the thermophilic bacteria, which continue to generate heat. Thermophilic bacteria are capable of breaking protein, lipids, noncellulose carbohydrates and not capable of breaking down cellulose and lignin. At this stage temperature is raised up to 70^{0}C from 40^{0}C - 70^{0}C is known as the thermophilic range (Sharma, 2001).

2.8.2 Actinomycetes

They exist in the thermophlic region and utilize hemicellulose but not cellulose. Thermophilic actinomycetes are capable of decomposing cellulose. They can grow at temperature up to 72^{0}C and dominate the microbial population at the highest temperature level during the composting process (Wilson, 1928).

2.8.3 Fungi

They appear in both the mesophilic and the thermophilic stages of composting. The mesophilic fungi utilize the simple carbon substrates as their source of food. During the late stages they utilize some cellulose and hemicellulose. Thermophilic fungi are less temperature tolerant than the thermophilic bacteria or actinomycetes. They operate in the range of 40^{0}C to 60^{0}C. Above 60^{0}C thermophilic fungi will die off. As the compost heats up to above 40^{0}C the mesophilic fungi are replace by thermophilic fungi. As the temperature increases, both mesophilic and thermophilic fungi migrate to the outer edges of the compost pile where lower temperatures exist (Sharma, 2001).

2.9 Considerations in building a compost heap

2.9.1 Type and amount of compost

In order to build a managed compost heap sufficient organic materials must be collected together. It is possible to collect some of the material needed for the compost heap on the day of building the heap. Kitchen compost have to be collected on a regular or day-to-day basis. The materials collected before the day of composting need to be keep dry, cool and without ready air circulation. Putrescible material should be keep covered to prevent fly breeding. Suitable ways to keep the materials dry would be to cover with banana leaves or a grass thatch (Rodale et al., 1960).

2.9.2 Climate

Since temperature and moisture affect the composting process, climatic conditions must be taken in to account. If a composting pile fails to heat up it may be due to either too much or not enough moisture. In extreme case it may be desirable to add some sort of protective roof over the windrow. A protective cover will keep out the pile and retain much of the heat within the pile during cold weather (Sharma, 2001).

2.9.3 Land availability

The amount of land required depends upon the size of the operation and the size of the windrows constructed. It is required for windrowing, curing the compost and storing the finished product. Spacing of the piles may be determined from the proposed mixing procedures and the space required for maneuvering When turning and stacking (Sharma, 2001)

2.9.4 Water availability

During the process of composting water should be apply from time to time to avoid heap become dry. So it is extremely important to build the heap where water is easily accessible.

2.9.5 Size of the compost heap

A good basic size for a compost heap is 2m to 2.5m (about 6.5 to 8 feet) wide and 1.5m to 2m (about 5 to 6.5 feet) high. If the heap is too broad or too high, aeration will be poor. The minimum size of a compost heap is usually recommend to be $1 m^3$ (Rodale et al., 1960).

2.10 Practical method of making compost

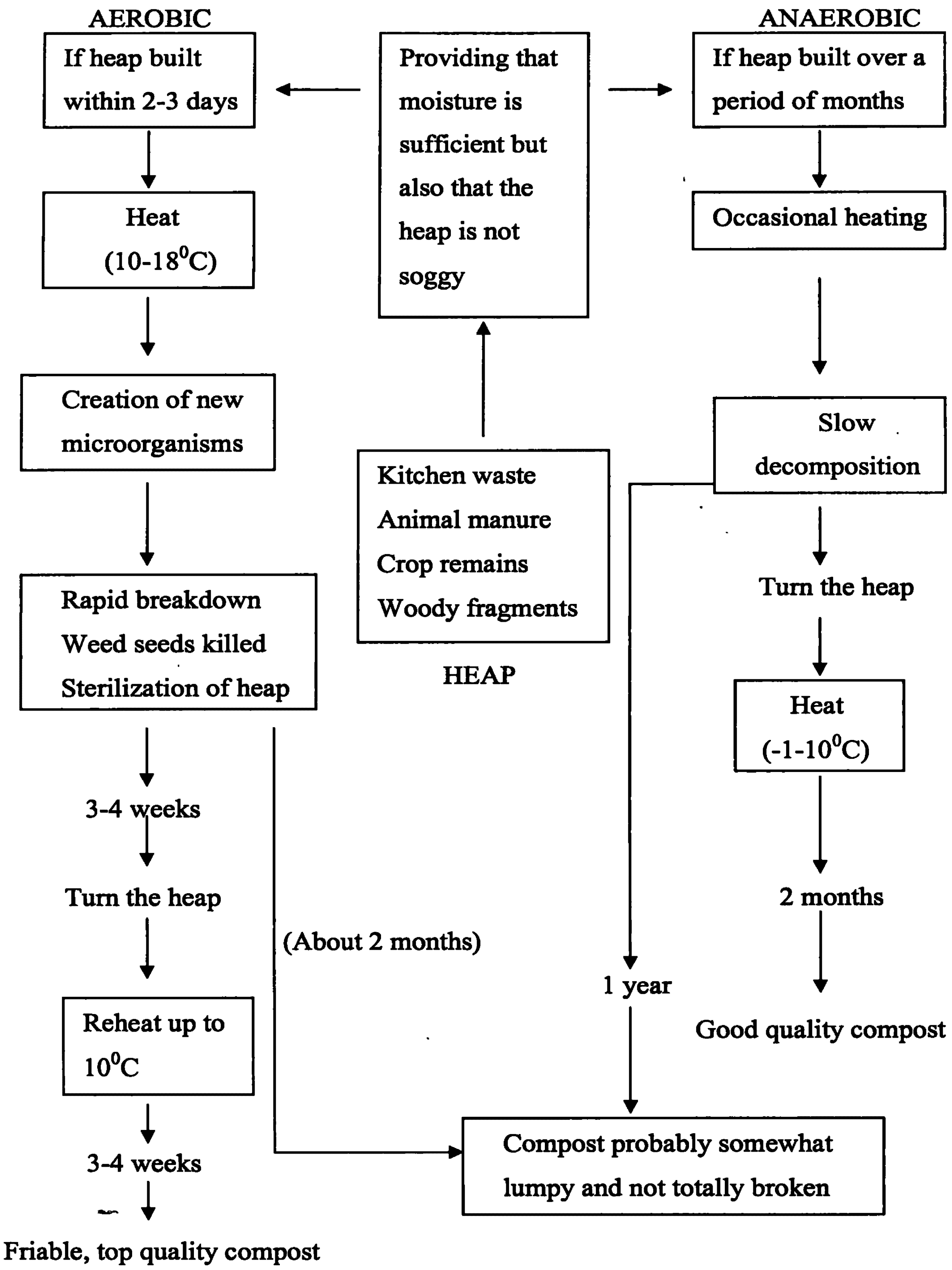

Fig. 2.2 The compost factory (Sharma, 2001)

Composting involves certain sequential steps, sorting, grinding, composting and storage.

2.10.1 Sorting

Waste is a collection of varied materials. Sorting is done to remove non biodegradable materials as well as materials, which are difficult to decompose, from the waste. Materials, which would normally require removal before grinding include tin cans, miscellaneous metals, glass and ceramic ware. Excess paper might be removed for salvage or in some cases to decrease the C:N ratio. Rags of natural fiber might be removed for salvage and synthetic fiber should be removed because of their adverse effect on the appearance of the compost product. Hand sorting as well as mechanical sorting (in large scale composting plants) can be done. Tin cans and other ferrous metal objects are commonly remove by a magnetic separator. Rags and non ferrous objects are presently removed by hand. Excess paper is removed by a blower with its suction intake located directly above the conveyor belt (Wilson, 1928).

2.10.2 Grinding

Grinding or shredding of materials produces a number of beneficial results, which hasten decomposition. The aim of grinding is to chop waste material in to small pieces. There are no special size requirements, but the materials must not be pulped test it become too soggy to compost. The ideal particle size would be the minimum size at which undue compaction of pulping does not occur. The larger the particle size, the slower will be the rate of decomposition. Particle size within the range range of one to two inches would be suitable. Because of the grinding the material is rendered more susceptible to bacterial invasion, made quite homogeneous and given a beneficial aeration (Wilson, 1928).

2.10.3 Composting

This is the step in which the procedures for making a compost heap.

2.10.3.1 Building the heap

In order to produce the conditions required by a compost heap it should be built in a particular way. First, a layer of coarse plant material such as straw to ensure good air circulation and drainage is needed. Following that organic material should be placed in layers altering between material that is easily decomposed with material that decompose slowly. A good thickness for each of these layers about 4 inches (10 cm). If manure is used it should be applied in layer of 1 inch (2 cm). Water should be applied after each sequence of layers. With each layer of organic material, the edges should be laid down first, followed by the center. This ensures that the heap edges will be firm and not collapse. The layers are repeated until the heap reaches a height of 5 feet. The main purpose of the layering is to assure that the proper amounts of the different materials get incorporated in the heap (Sharma, 2001).

To provide the aerobic conditions bamboo canes with holes cut in them and placed both vertically and horizontally throughout the heap. The heap should then be covered to protect it against moisture loss or heavy rain (Rodale et al., 1960).

2.10.3.2 Managing the compost heap

In dry conditions the heap will probably require water to be added. Moisture content can be tested in laboratory using oven dry method or it can be simply tested by placing a small bundle of straw in the compost heap. If moisture is acceptable then the bundle will damp when removed after 5 minutes. If the heap becomes too wet it should be opened up and mixed with more dry organic materials or allowed to dry in the sun (Sharma, 2001).

Temperature is the best single indicator of the progress of aerobic composting. Therefore measuring the temperature in the heap determines the degree of decomposition. Temperature of the compost heap can be checked using a thermometer. This is generally direct and accurate. Thermometer can mount on a end of a stick and can take daily readings. Digging in to the heap and feeling the material, is a simple way of checking the temperature (Rodale et al., 1960).

It is essential for obtaining a rapid, nuisance free composting action characteristic of the thermophilic aerobic process. In order to ensure a uniform and rapid decomposition, the compost must be thoroughly mixed. One method is to turn the outer edges in to the center of the pile. Under normal conditions, when the moisture content is between 50% and 60%, the windrow should be turned at 3 day intervals. If moisture level exceeds 60%, it should be turned at 2 day intervals to prevent the occurrence a aerobic conditions (Sharma, 2001).

2.10.3.3 Curing

After the compost has gone through a period of active decomposition, the composted material must be removed from the windrow and allowed to cure. Curing is a process that allows the compost to continue its stabilization process at a slower rate under mesophilic conditions. Curing can be done in a open place or placed under cover. After the compost is cured it is ready to be stored or utilized as a soil conditioner (Sharma, 2001).

2.10.3.4 Maturation of the compost

Once the compost heap has cooled down, the heap should be left to mature. In mature compost the original material is no longer recognizable and it has turned in to a brownish-black color powder. Pure black, smelly and soggy compost denotes an unfavorable fermentation with too much moisture and lack of air. A greyish, yellowish color indicates an excess of dead earth.

Awell produced mature compost is free from odor and easy to handle, store and transport. The material should be medium loose, not too tight, not packed, not lumpy and in crumbly like structure. Odor should be earthlike. Any bad smell is a sign that the fermentation has not reached its final goal and that bacteriological break down processes are still going on. A musty, cellar-like odor indicates the presence of molds, some times also a hot fermentation, which has led to losses of nitrogen (Rodale et al., 1960).

Table 2.3 Difference between mature and raw compost

Mature compost	Raw compost
Nitrogen as nitrate ion	Nitrogen as ammonium ion
Sulphur as sulphate ion	Sulphur still in part as sulphide ion
Lower oxygen demand	Higher oxygen demand
No danger of putrefaction	Danger of putrefaction
Higher water retention ability	Lower water retention ability
Clay-humus complexes are built	No clay-humus complexes are generated
Mineralization is about 50%	High proportion of organic substances not mineralized
Nutrient elements are in part available to plants	Nutrient elements not available
Higher concentrations of vitamins and antibiotics	Lower concentrations of vitamins and antibiotics
Higher concentrations of soil bacteria, fungi, which are decomposed easily degradable substances	Higher concentrations of bacteria and fungi, which decompose organic materials

(Source: Letitia and Fedrick, 1954)

2.10.4 Storage

After the material is adjudged sufficiently stable, it is stored without danger in a dry place until apply. Stored finished compost sort in to fractions on the basis of quality, usually by screening the material. The coarest material is destined for the rough applications, while the finest is reserved for the home gardeners for luxury crops (Wilson, 1928).

2.11 Time required to produce compost

Composting process can take from 2 months to 2 years depending on effort involved. To accelerate the process, the pile must be balance watered thoroughly, frequently turned and material should be shredded. It can be made in two or three weeks, if materials are finely ground or shredded, turned daily to provide good aeration and supplied with sufficient moisture and nitrogen (Roulae, 1992).

2.12 Health aspects of composting

Properly made compost heaps reach 55^0C-70^0C and the pile should be turned so that all materials are subjected to heat. It is best to dispose properly of weedy and diseased plant material rather than composting it, thereby eliminating any possibility of transmitting disease or weed in the finished product. Pathogens, parasites and disease causing organisms would not survive in a well managed compost operation. Properly managed windrow composting turns out a product, that is safe for agricultural and garden use (Nordstedt et al., 1991).

2.13 Tobacco waste as a composting raw material

Tobacco stems, leaf waste and dust are good organic fertilizer, especially high in potash. The nutrients contained in 100 pounds of tobacco wastes are 2.5 to 3.7 pounds of nitrogen, almost a pound of phosphoric acid and from 4.5 to 7 pounds of potassium.

After the tobacco leaves are stripped for market in the late fall, thousands of tobacco stalks are left on nearly every farm. Farmers use these to fertilize agricultural fields, chopping the stalks up and disking them in to the soil to raise grains and legumes.

Compost tobacco waste or use them in moderation in mulching or sheet composting, mixed with other organic materials. They should not be applied alone in concentrated amounts as a mulch because nicotine in tobacco will eliminate beneficial insects as well as harmful ones, earthworms and other soil organisms (Wilson, 1928).

CHAPTER 3

MATERIALS AND METHODOLOGY

At the initial stage of the research tobacco cultivated area in Gonaganara was visited and the raw materials which are commonly used in preparing compost were identified.

3.1 Location

The experiments were carried out at the premises of the Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka, Buttala, during the period of February to June 2005 under the normal climatic conditions.

Temperature, Relative humidity and Rainfall were measured daily using Thermometer, Dry and Wet bulb Thermometer, Rain guage respectively through out the experimental period (see appendix I).

3.2 Materials

Raw Materials

- Tobacco dust
- Rice straw
- Cow dung
- Gliricidia leaves
- Kitchen Waste (food waste, fruit waste and vegetable trimming)

Equipment

- Thermometer
- Wet and dry bulb thermometer
- Electrical balance
- Cabinet drier
- Rake

3.3 Experimental Design

Two different treatments were carried out with three replicates from each. One treatment was the controlled composting unit (with out tobacco dust) and the other was the tobacco dust containing composting unit.

Table 3 Design of composting units

Number	Type of Composting Unit
1	Tobacco Dust Containing composting unit
2	Tobacco Dust Containing composting unit
3	Tobacco Dust Containing composting unit
4	Controlled composting unit
5	Controlled composting unit
6	Controlled composting unit

3.3.1 Establishment of composting units

April is a slightly rainy season to the Buttala area and therefore to prepare compost, Heap Method was selected.

Size of a heap was $0.5m^3$ and they were built directly on the surface of a cleared ground area. Organic materials in the heaps were placed in layers, alternating between materials that are easily decomposed and the materials that are decomposed slowly. To make sure that the heaps will not collapse each layer was laid starting from the edge followed by the centre.

First straws were cut into small pieces and two inches layer of straws was placed on the ground to provide a base for the heap. Then one inch layer of cow dung was placed and the next three inches layer of Gliricidia leaves was placed. One inch layer on Kitchen waste was also placed at the top of the heap. The layers were repeated until the heap reaches a height of 0.5m. Six inches layers of tobacco dust was placed only in three heaps. Water was applied after each sequence of layer. After that all the layers were mixed with each other thoroughly. Finally all the heaps were covered with black polythene to protect them from moisture loss and heavy rain.

3.3.2 Temperature mensuration

Temperature is the best single indicator of the progress of aerobic composting process. Therefore it is important to measure the daily temperature in heaps. Thermometer was dipped into the heap at 3 different positions and average temperature was taken down. The same procedure was carried out daily at 9.00 am, 12.00 noon and 4.00 pm and the average daily temperature was calculated (see Appendix II).

3.3.3 Turning of the heaps

It is extremely important to aerate the compost heap to provide the aerobic conditions. So all heaps were turned in outer edges into the center of the heap, using a rake at 3 day intervals, to allow air to penetrate all parts of the heap.

3.3.4 Determination of moisture content

It is essential to maintain an appropriate range of moisture inside the heaps. To make sure the heap is always moist every representative sample from each heap was determined using the oven dry method after every turning (see Appendix III).

3.3.5 Watering

After the determination of moisture content in each heap, it was adjusted to a suitable moisture level by watering. If water level is lower than the suitable level, water was added to heaps as a gentle spray without disturbing the general arrangement of the heaps. Special attention was paid inorder to prevent waterlogged conditions. If the water level is higher than the required level the heap was uncovered to direct sunlight to make it dry.

3.4 Sample analysis

After the 5weeks (37 days) maturation period, representative samples from each completed compost heap were analysed to determine its' fertilizer value.

Sample analysis was carried out in the Soil and Plant Analytical Laboratory, CIC Agribusiness Centre, Pelwehera, Dambulla.

All the analysises were done using dry basis except pH and Electrical Conductivity (EC) tests. Following chemical tests were carried out to the determination of Moisture content, Organic Carbon (C), Electrical Conductivity (EC), pH, Total Nitrogen (N), Phosphorus (P), Potassium (K), Sulphur (S), Magnesium (Mg), Calcium (Ca) and micronutrients such as Copper (Cu), Zinc (Zn), Manganese (Mn), Boron (B) and total Iron (Fe). P, K, Ca, Mg, S, Cu, Fe, Mn, Zn and B were tested using $Hclo_4$: HNo_3 (1:2) acid digestion (see Appendix IV).

3.4.1 Analysis of chemical parameters

3.4.1.1 pH

10g of compost sample was put into a 25ml of distilled water and stirred thoroughly. Then the pH of the solution was measured using standard pH meter.

3.4.1.2 Electrical Conductivity (EC)

Electrical conductivity was measured using EC meter.

3.4.2 Analysis of macronutrients

3.4.2.1 Organic Carbon (C)

Organic Carbon was determined according to the Walky and Black method (Walky and Black, 1934) (see Appendix V).

3.4.2.2 Total Nitrogen (N)

The total Nitrogen content was determined according to the Kjeldahl method (Bremmer and Mulvany, 1992) (see Appendix VI).

3.4.2.3 Sulphur (S)

Sulphur was measured according to the Turbidimetric method after acid digestion of the samples (Deb, 1934) (see Appendix VII).

3.4.2.4 Phosphorus

Phosphorus was measured using Spectrophotometer after acid digestion of the samples.

3.4.2.5 Potassium (K)

Potassium was measured using Flamme photometer after acid digestion of the samples.

3.4.2.6 Calcium (Ca) and Magnesium (Mg)

Calcium (Ca) and Magnesium (Mg) were measured using Atomic Absorption Spectrometry (AAS) method.

3.4.3 Analysis of micronutrients

3.4.3.1 Boron (B)

Boron was measured using Spectrophotometer after acid digestion of the samples (see Appendix VIII).

3.4.3.2 Copper (Cu), Iron (Fe), Manganese (Mn) and Zinc (Zn)

Copper (Cu), Iron (Fe), Manganese (Mn) and Zinc (Zn) were measured using Atomic Absorption procedure after acid digestion of the samples.

3.5 Data analysis

Obtained data were analysed using Statistical Analysis System (SAS) software package. T test procedure was applied to observe whether there is a significant difference between treatments.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Variation of Temperature

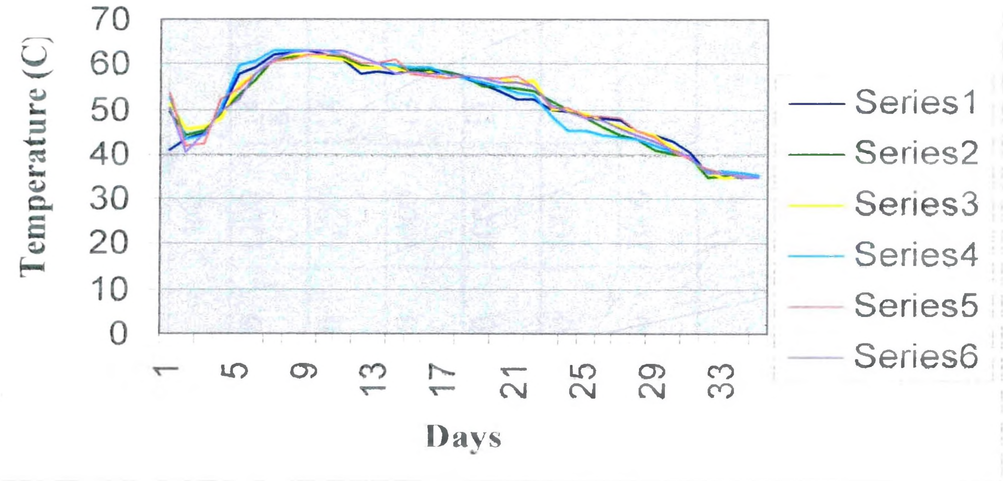

Fig. 4 Temperature variation of the compost heaps during the experimental period

In aerobic composting, temperature is the best single indicator of it's progress. According to the above graph there was no marked difference in temperature values of the composting heaps. Therefore microbial growth and their activity can be the same in all heaps throughout the experimental period.

Temperature gradually rose within the thermophilic range resulting in destroying weed seeds and most microbes of pathogenic.

4.2 Variation of Nutrients

According to the Analytical report, in general there was a significant difference in most of the nutrients between two different compost samples.

Table 4.1 Analytical Report of the compost samples

Sample	pH	EC	O.M	N	Ca	Mg	P	K	S	Cu	Fe	Mn	Zn	B
	1:25	us/cm	%	%	ppm									
		1:25		total	total									
S_1	8.9	1357	6.7	0.448	3800	1560	1000	3280	1200	14	9375	288	55	132
S_2	8.5	1734	4.8	0.420	4480	1640	1000	3120	1200	14	8951	282	42	78
S_3	8.5	1651	5.4	0.448	3620	1480	1000	3040	1400	13	8632	254	44	120
S_4	8.2	1246	1.9	0.252	2560	1100	600	1860	1000	11	8711	287	35	142
S_5	8.3	906	2.2	0.224	2160	1100	600	2080	1000	10	8917	260	39	102
S_6	8.2	819	2.2	0.308	3200	1140	600	2040	1000	10	8312	259	39	82

- All parameters tested as total

Sample S_1, S_2, S_3 = Tobacco dust contained compost samples

Sample S_4, S_5, S_6 = Control compost samples (without Tobacco dust)

4.2.1 Variation of chemical parameters

4.2.1.1 pH

Table 4.2 Treatment comparison of pH

Treatment	Mean value	Std. Dev
Tobacco dust contained compost	8.633	0.231
Control compost	8.233	0.057

There was a difference, in pH values between tobacco dust contained compost samples and controlled compost samples, which was not significant.

All the compost samples were slightly basic. This is due to the metabolizing of inorganic Nitrogen to Ammonium Nitrogen.

4.2.1.2 Electrical Conductivity (EC)

Table 4.3 Treatment comparison of Electrical Conductivity (EC)

Treatment	Mean value	Std. Dev
Tobacco dust contained compost	1581	198
Control compost	990	226

There was a difference in Electrical conductivity between tobacco dust contained compost samples and controlled compost samples and this indicated a significant difference. Higher EC values were observed in tobacco dust contained compost samples.

Increase of EC means the release of high amount of ions (plant nutrients). Hence the decomposition of litter with tobacco dust accelerates the release of plant nutrients.

4.2.2 Variation of Macronutrients

4.2.2.1 Organic Carbon (C)

Treatment comparison of Organic Carbon (C)

Treatment	Mean value	Std. Dev
Tobacco dust contained compost	5.633	0.971
Control compost	2.100	0.173

There was a significant difference for organic carbon percentage between tobacco dust contained compost samples and controlled compost samples. A high amount of organic carbon percentage was found in tobacco dust contained compost samples.

It may be due to the accelerated decomposition of litter in tobacco dust containing composting units.

4.2.2.2 Nitrogen (N)

Treatment comparison of Nitrogen (N)

Treatment	Mean value	Std. Dev
Tobacco dust contained compost	0.4387	0.0162
Control compost	0.2613	0.0428

There was a significant difference of Nitrogen between two treatments. Total Nitrogen in the tobacco dust contained compost samples was significantly higher than controlled compost samples.

4.2.2.3 Phosphorus (P)

There was a difference in Phosphorus values between tobacco dust contained compost samples and controlled compost samples. Higher values of Phosphorus were observed in the tobacco dust contained compost samples.

4.2.2.4 Potassium (K)

Table 4.6 Treatment comparison of Potassium (K)

Treatment	Mean value	Std. Dev
Tobacco dust contained compost	3147	122
Control compost	1993	117

Variation of Potassium in compost samples was significantly different between two treatments. Higher values of Potassium were observed in tobacco dust contained compost samples. Total Potassium was low in controlled compost samples.

4.2.2.5 Sulphur (S)

There was a difference in Sulphur values between tobacco dust contained compost samples and controlled compost samples. Higher values of Sulphur were observed in tobacco dust contained compost samples.

4.2.2.6 Calcium (Ca)

Treatment comparison of Calcium (Ca)

Treatment	Mean value	Std. Dev
Tobacco dust contained compost	3967	454
Control compost	2640	525

According to the values there was a difference in Calcium between tobacco dust contained compost samples and controlled compost samples. It was a significant difference. High amount of Calcium was found in tobacco dust contained compost samples.

4.2.2.7 Magnesium (Mg)

Treatment comparison of Magnesium (Mg)

Treatment	Mean value	Std. Dev
Tobacco dust contained compost	1560	80.0
Control compost	1113	23.1

There was a significant difference of Magnesium between two treatments. Higher values of Magnesium were observed in tobacco dust contained compost samples than controlled compost samples. So tobacco dust contained compost samples were rich in Magnesium.

4.2.3 Variation of Micronutrients

4.2.3.1 Copper (Cu)

Table 4.9 Treatment comparison of Copper (Cu)

Treatment	Mean value	Std. Dev
Tobacco dust contained compost	13.667	0.577
Control compost	10.333	0.577

There was a significant difference in Copper values between tobacco dust contained compost samples and controlled compost samples. Values of Copper in tobacco dust contained compost samples were higher than the values of controlled compost samples.

4.2.3.2 Iron (Fe)

Table 4.10 Treatment comparison of Iron (Fe)

Treatment	Mean value	Std. Dev
Tobacco dust contained compost	8986	373
Control compost	8647	308

There was a slight difference in Iron values between tobacco dust contained compost samples and controlled compost samples. But it was not a significant difference. So Iron values in both compost samples were nearly the same.

4.2.3.3 Manganese (Mn)

Table 4.11 Treatment comparison of Manganese (Mn)

Treatment	Mean value	Std. Dev
Tobacco dust contained compost	274.7	18.1
Control compost	268.7	15.9

There was no significant difference in Manganese between tobacco dust contained compost samples and controlled compost samples. Both treatment values were nearly the same.

4.2.3.4 Zinc (Zn)

Table 4.12 Treatment comparison of Zinc (Zn)

Treatment	Mean value	Std. Dev
Tobacco dust contained compost	47.00	7.00
Control compost	37.67	2.31

There was a difference in Zinc values between tobacco dust contained compost samples and controlled compost samples. But it was not a significant difference. Zinc values in tobacco dust contained compost samples were somewhat higher than values in controlled compost samples.

4.2.3.5 Boron (B)

Table 4.13 Treatment comparison of Boron (B)

Treatment	Mean value	Std. Dev
Tobacco dust contained compost	110	28.4
Control compost	108	30.6

There was no significant difference of Boron between tobacco dust contained compost samples and controlled compost samples. All the Boron values in the compost samples were nearly the same.

According to the above results of macronutrients and micronutrients, all the macronutrients Nitrogen, Phosphorus, Potassium, Sulphur, Calcium and Magnesium were significantly different between tobacco dust contained compost samples and controlled compost samples. Higher values were observed in tobacco dust contained compost samples. There was no significant difference in micronutrients such as Iron, Manganese, Zinc and Boron between two treatments. Only Copper showed a significant difference between tobacco dust contained compost and controlled compost.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study was focused on to evaluate the composition of tobacco contained compost produced using locally available organic materials.

Statistical analysis of the obtained nutritional values of the compost samples reveals that there is a significant difference between Tobacco dust contained compost and controlled compost (without tobacco dust).

Therefore according to the results it can be concluded that Tobacco dust contained compost, produced using locally available organic materials is a nutrient rich, pathogen free organic manure which can be used as an environmental friendly organic fertilizer in tobacco cultivation with a minimum input.

5.2 Recommendation

Microbiological test should be carried out to ensure whether it is free from pathogens and hazardous microbes.

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APPENDIX I

Meteorological observation at Buttala during the period of 21. 03. 2005 – 29. 04. 2005

Date	Maximum Temperature (^{0}C)	Relative Humidity (%)		Rainfall in past 24 hours (mm)
		9.00 am	4.00 pm	
25. 03. 2005	36.5	85.0	81.0	-
26. 03. 2005	35.5	95.5	66.0	-
27. 03. 2005	35.5	93.0	74.0	-
28. 03. 2005	36.5	88.0	60.5	-
29. 03. 2005	33.0	91.0	61.5	-
30. 03. 2005	32.4	94.0	64.0	-
31. 03. 2005	32.5	94.0	90.0	13.1
01. 04. 2005	34.2	95.5	91.0	-
02. 04. 2005	32.7	88.0	91.0	1.4
03. 04. 2005	32.5	95.5	85.0	7.8
04. 04. 2005	29.6	91.7	94.0	0.5
05. 04. 2005	29.5	95.5	88.7	27.9
06. 04. 2005	26.7	89.0	94.0	2.2
07. 04. 2005	31.8	87.5	56.5	23.7
08. 04. 2005	34.0	83.7	68.5	-
09. 04. 2005	-	-	-	-
10. 04. 2005	-	-	-	-
11. 04. 2005	35.0	84.0	62.5	11.0
12. 04. 2005	34.0	86.0	70.0	-
13. 04. 2005	36.0	80.5	85.0	64.0
14. 04. 2005	35.0	74.5	86.0	-
15. 04. 2005	34.5	78.0	71.0	1.0
16. 04. 2005	34.5	69.0	68.5	-

17. 04. 2005	32.5	67.5	63.0	-
18. 04. 2005	32.5	74.5	75.0	42.0
19. 04. 2005	35.0	81.0	78.0	5.2
20. 04. 2005	33.0	80.5	84.0	0.5
21. 04. 2005	32.5	82.5	70.5	-
22. 04. 2005	33.0	93.0	70.0	-
23. 04. 2005	35.0	74.5	53.5	-
24. 04. 2005	35.5	90.0	88.5	-
25. 04. 2005	35.0	81.0	85.3	-
26. 04. 2005	36.3	85.0	96.0	0.8
27. 04. 2005	36.0	84.0	84.0	11.5
28. 04. 2005	34.5	71.3	59.5	8.2

APPENDIX II

Temperature variation in composting units

Date	Daily average temperature (^0C)					
	S_1	S_2	S_3	S_4	S_5	S_6
25.03.2005	40.9	49.4	51.2	52.6	53.4	50.2
26.03.2005	43.1	44.1	45.5	43.0	41.8	40.25
27.03.2005	44.5	45.0	46.2	44.0	42.5	44.5
28.03.2005	49.2	48.7	48.0	50.0	52.0	49.5
29.03.2005	57.8	53.0	55.5	59.8	54.3	52.0
30.03.2005	59.0	56.2	57.7	60.7	58.0	57.7
31.03.2005	62.0	60.9	61.1	63.1	60.5	61.0
01.04.2005	62.5	61.5	62.0	63.0	61.0	62.5
02.04.2005	62.8	62.0	61.9	63.0	62.2	63.0
03.04.2005	62.1	61.7	61.5	62.9	62.2	63.1
04.04.2005	61.0	61.5	60.9	61.8	62.0	63.0
05.04.2005	58.0	59.7	59.0	60.0	60.2	61.6
06.04.2005	58.1	59.2	59.1	60.2	60.0	59.9
07.04.2005	58.0	59.0	59.1	59.7	61.0	58.0
08.04.2005	58.5	58.8	58.0	59.2	58.0	58.2
09.04.2005	58.4	58.6	58.2	59.0	57.5	58.0
10.04.2005	58.0	58.3	57.0	57.9	57.0	57.8
11.04.2005	57.0	57.1	57.1	57.0	57.1	57.5
12.04.2005	55.5	55.0	57.0	56.1	57.0	56.8

13.04.2005	54.2	54.9	56.9	54.9	56.9	56.1
14.04.2005	52.2	54.5	56.1	53.5	57.2	55.8
15.04.2005	52.0	54.0	56.2	53.2	55.0	55.2
16.04.2005	49.9	51.8	49.9	48.2	50.4	50.9
17.04.2005	49.5	50.0	50.0	45.0	50.2	49.5
18.04.2005	48.6	47.7	49.0	45.1	48.6	47.8
19.04.2005	48.1	46.0	47.5	44.0	48.5	47.5
20.04.2005	47.5	44.0	46.1	43.9	48.1	45.5
21.04.2005	45.0	43.2	45.0	43.1	45.0	44.1
22.04.2005	44.3	40.9	44.2	42.0	43.5	42.8
23.04.2005	42.8	40.0	41.5	40.2	40.5	41.0
24.04.2005	40.6	39.4	39.0	39.1	39.0	39.4
25.04.2005	35.5	35.0	35.9	36.2	36.7	35.8
26.04.2005	35.0	35.1	35.0	36.0	35.8	35.7
27.04.2005	35.2	35.0	35.1	35.5	35.2	35.0
28.04.2005	35.0	35.2	35.0	35.4	35.0	34.9

S_1, S_2, S_3 = Tobacco dust containing composting unit

S_4, S_5, S_6 = Control composting unit (without Tobacco dust)

APPENDIX III

Determination of moisture content

Date	Moisture content (%)					
	S_1	S_2	S_3	S_4	S_5	S_6
27.03.2005	100	102	103	106	99	102
30.03.2005	71	92	69	66	63	65
02.04.2005	103	98	101	105	100	102
06.04.2005	89	85	88	90	88	86
09.04.2005	68	69	68	67	67	66
12.04.2005	71	69	70	73	64	75
15.04.2005	65	67	68	67	65	71
18.04.2005	77	77	73	72	74	75
21.04.2005	72	74	69	69	71	73
25.04.2005	64	68	65	63	64	62
28.04.2005	65	69	67	65	68	66

S_1, S_2, S_3 = Tobacco dust containing composting units

S_4, S_5, S_6 = Control composting units (without Tobacco dust)

APPENDIX IV

Acid Digestion

Procedure

Oven dried (in 65^0C) compost sample was grind using porcelain pestle and motar and 0.5g of it's powder (particle size < 0.5mm) was put in to the 100ml conical flask.

10ml of diacid mixture (2 HNo_3 : 1 $HClo_4$) was added to the conical flask. It was kept overnight.

Then flask was put on a hot plate.

Funnel was put on the conical flask and temperature was increased slowly up to 200^0 C till all the organic matter was oxidized.

In case of more acid is required (as indicated by the color of digest) flask was cooled and 5ml of acid mixture (2:1) was added.

Process was repeated as before.

At the end of the digestion the dense white fumes of perchloric acid were started to condensing on the neck of the flask.

Flask was cooled and 6ml of 6N HCl was added.

HCl and water were boiled off till $HClo_4$ fumes started to condensing on the neck of the flask.

Then the flask was cooled, distilled water was added to the flask and contents were transferred to 50ml volumetric flask.

Final volume was filled with distilled water.

It was shaken well and left overnight for Silica to settle.

Blank digestion was also run with same amount of diacid mixture in identical manner (Deb, 1992).

APPENDIX V

Measurement of Organic Carbon

Procedure

10ml of 1/6N strength of Potassium dichromate ($K_2Cr_2O_7$) and 20ml of Conc. Sulphuric acid (H_2So_4) were added to 0.5g of oven dried powdered compost.

After shaking one minute, it was allowed to stand on a sheet of asbestos for one hour.

After one hour 200ml of distilled water, 10ml Phosphoric acid and 1ml of Diphenylamine indicator solution were added to above solution.

The solution was titrated against Ferrous ammonium sulphate solution drop by drop, until the color flashed to dark green.

Again 0.5ml of Potassium dichromate was added and titrated again until the color flashed to dark green.

A blank titration was done simultaneously (Walky and Black, 1934).

Calculation

$$2\,Cr_2O_7^{2-} + 3\,C + 16\,H^{+} = 4\,Cr^{3+} + 3\,CO_2 + 8\,H_2O$$

Volume of Potassium dichromate used = 10.5 ml
Molarity of dichromate = 1/6 N
Burette reading = V_1
Burette reading (blank) = V_2

$$2\,Cr_2O_7^{2-} + 6\,Fe^{2+} + 14\,H^{+} = 2\,Cr^{3+} + 6\,Fe^{3+} + 7\,H_2O$$

Moles of dichromate used = 1/6 * 10.5/1000 = X moles
Moles of Ferrous ammonium sulphate = 1/6 * 10.5/1000 * 6
Molarity of Ferrous ammonium sulphate = 1/6 * 10.5/1000 * 6/V_2 * 1000 = M_1
Moles of dichromate reacted with Ferrous = M_1 * V_1 * 1/6 = Y moles
Moles of dichromate reacted with Carbon = X – Y = Z moles
Grams of Carbon reacted with dichromate = 3/2 * Z * 12
Organic Carbon percentage (%) = 3/2 * Z * 12/2 * 100

APPENDIX VI

Measurement of total Nitrogen

Procedure

0.5g of oven dried powdered compost, 1g of catalyst mixture and 5ml of Conc. Sulphuric acid (H_2So_4) were added in to a digestion tube.

The sample was digested using a digestion unit until the solution becomes light blue in color.

After cooling to room temperature, it was transferred in to a 500ml conical flask using about 150ml distilled water.

20ml of 4% Boric acid was placed in a receiving flask and two drops of mixed indicator was added and receiving flask was kept beneath condenser.

Then 30ml of 10N Sodium Hydroxide (NaOH) was poured in to the conical flask containing sample and small quantity of Davadas alloy was also added to the sample.

Flask was connected to distillation apparatus.

Digest was distilled until the distillate in the receiving flask increased up to about 100ml.

It was titrated using 0.01N Hydrochloric acid (HCl) until color changes from green to pink (Bremmer and Mulvany, 1992).

Calculation

$NH_4^+ + OH^- = NH_3 + H_2O$

$NH_3 + H_3BO_3 = NH_4^+ + H_2BO_3^-$

$H_2BO_3^- + NH_4^+ + HCl = H_3BO_3 + NH_4Cl$

Volume of 0.01N HCl required = X ml

X ml of 0.01N HCl reacts with = 0.14 * X mg Nitrogen

Percentage of total Nitrogen in sample = 0.14 * X * 100%/1000

APPENDIX VII

Measurement of Sulphur

Procedure

1ml aliquot from acid digested compost filtrate was added to 19ml of water using a combination diluter-dispenser (Dilution 1).

Then 7ml of Dilution 1, 9ml of Acid seed solution and 4ml of Turbidimetric solution were mixed thoroughly and it was allowed to stand 10minutes (not longer than 30minutes).

It was read in turbidimeter at 535 nm wavelength (Hunter, 1988).

Reagents

Acid seed solution

130ml of Conc. Nitric acid (HNo_3) was added to 500ml of water.

400ml of glacial Acetic acid was added.

10g of Poly Vinyl Pyrolidone (PVP-k30) was added (which was dissolved in about 300ml of water).

6ml of 1000ppm So_4^{2-} solution was added.

Water was added to make final volume 2L.

Turbidimetric solution

37.5g of $BaCl_2 . 2H_2O$ was dissolved in 250ml of Acetic acid solution on the day it was used.

APPENDIX VIII

Measurement of Boron

Procedure

50ml Of acid digested compost filtrate and 3.5ml of Curcumin in HOAC were mixed thoroughly.

1ml of Conc. Sulphuric acid (H_2So_4) was added to it and mixed thoroughly again.

The mixture was allowed to stand at least 20minutes.

After 20minutes 15ml of Methanol was added and it was mixed thoroughly.

Whole mixture was read in Spectrophotometer at 555 nm wavelength before 90 minutes (Hunter, 1988).

Reagents

Curcumin solution

15ml of Glycerol and 1g of Curcumin were added to 1L of glacial Acetic acid. It was shaken to dissolve the Curcumin.

APPENDIX IX

Statistical Analysis

Two Sample T-Test and Confidence Interval

```
Two sample T for pH with t dust vs pH without t dust

          N      Mean     StDev   SE Mean
pH with   3     8.633     0.231      0.13
pH witho  3    8.2333    0.0577     0.033

95% CI for mu pH with - mu pH witho: ( -0.19,  0.991)
T-Test mu pH with = mu pH witho (vs not =): T = 2.91  P = 0.10
DF = 2
```

```
Two sample T for EC with t dust vs EC without t dust

          N      Mean     StDev   SE Mean
EC with   3      1581       198       114
EC witho  3       990       226       130

95% CI for mu EC with - mu EC witho: ( 39,  1142)
T-Test  mu  EC  with  =  mu  EC  witho  (vs  not  =):  T  =  3.41   P  =
0.042  DF = 3
```

```
Two sample T for C with t dust vs C without t dust

          N      Mean     StDev   SE Mean
C with t  3     5.633     0.971      0.56
C withou  3     2.100     0.173      0.10
```

```
95% CI for mu C with t - mu C withou: ( 1.08,  5.98)
T-Test mu C with t = mu C withou (vs not =): T = 6.20  P =
0.025  DF = 2
```

Two sample T for N with t dust vs N without t dust

```
           N      Mean     StDev   SE Mean
N with t   3    0.4387    0.0162    0.0093
N withou   3    0.2613    0.0428     0.025

95% CI for mu N with t - mu N withou: ( 0.0637,  0.291)
T-Test mu N with t = mu N withou (vs not =): T = 6.72  P =
0.021  DF = 2
```

Two sample T for K with t dust vs K without t dust

```
           N      Mean     StDev   SE Mean
K with t   3      3147       122        71
K withou   3      1993       117        68

95% CI for mu K with t - mu K withou: ( 842,  1464)
T-Test mu K with t = mu K withou (vs not =): T = 11.80  P =
0.0013  DF = 3
```

Two sample T for Ca with t dust vs Ca without t dust

```
           N      Mean     StDev   SE Mean
Ca with    3      3967       454       262
Ca witho   3      2640       525       303
```

```
95% CI for mu Ca with - mu Ca witho: ( 52,  2601)
T-Test mu Ca with = mu Ca witho (vs not =): T = 3.31   P =
0.045  DF = 3
```

Two sample T for Mg with t dust vs Mg without t dust

```
          N      Mean     StDev   SE Mean
Mg with   3    1560.0      80.0        46
Mg witho  3    1113.3      23.1        13

95% CI for mu Mg with - mu Mg witho: ( 240,  654)
T-Test mu Mg with = mu Mg witho (vs not =): T = 9.29   P =
0.011  DF = 2
```

Two sample T for Cu with t dust vs Cu without t dust

```
          N      Mean     StDev   SE Mean
Cu with   3    13.667     0.577      0.33
Cu witho  3    10.333     0.577      0.33

95% CI for mu Cu with - mu Cu witho: ( 2.02,  4.64)
T-Test mu Cu with = mu Cu witho (vs not =): T = 7.07   P =
0.0021  DF = 4
```

Two sample T for Fe with t dust vs Fe without t dust

```
          N      Mean     StDev   SE Mean
Fe with   3      8986       373       215
Fe witho  3      8647       308       178

95% CI for mu Fe with - mu Fe witho: ( -549,  1227)
```

```
T-Test mu Fe with = mu Fe witho (vs not =): T = 1.22  P = 0.31
DF = 3
```

Two sample T for Mn with t dust vs Mn without t dust

```
          N      Mean     StDev   SE Mean
Mn with   3     274.7      18.1        10
Mn witho  3     268.7      15.9       9.2

95% CI for mu Mn with - mu Mn witho: ( -38,  50.3)
T-Test mu Mn with = mu Mn witho (vs not =): T = 0.43  P = 0.70
DF = 3
```

Two sample T for Zn with t dust vs Zn without t dust

```
          N      Mean     StDev   SE Mean
Zn with   3     47.00      7.00       4.0
Zn witho  3     37.67      2.31       1.3

95% CI for mu Zn with - mu Zn witho: ( -9.0,  27.6)
T-Test mu Zn with = mu Zn witho (vs not =): T = 2.19  P = 0.16
DF = 2
```

Two sample T for B with t dust vs B without t dust

```
          N      Mean     StDev   SE Mean
B with t  3     110.0      28.4        16
B withou  3     108.7      30.6        18

95% CI for mu B with t - mu B withou: ( -75,  78)
```

```
T-Test mu B with t = mu B withou (vs not =): T = 0.06  P =
0.96  DF = 3
```

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