DYNAMICS OF ORGANIC CARBON POOLS DURING DECOMPOSITION OF CROP RESIDUES

THESIS

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Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
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By
AJIT KUMAR MEENA

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY
POST GRADUATE INSTITUTE, AKOLA

DR. PANJABRAO DESHMUKH KRISHI VIDYAPEETH,
KRISHINAGAR PO, AKOLA (MS) 444 104

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DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretations of the Thesis entitled **"DYNAMICS OF ORGANIC CARBON POOLS DURING DECOMPOSITION OF CROP RESIDUES"** or part there of has neither been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis / publication of any University or scientific organization. The source of materials used and all assistance received during the course of investigation have been duly acknowledged.

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Date: 04/ 06 / 2019 Enrolment No.-PP-3347

CERTIFICATE

This is to certify that thesis entitled **"DYNAMICS OF ORGANIC CARBON POOLS DURING DECOMPOSITION OF CROP RESIDUES"** submitted in partial fulfillment of the requirements for the degree of "Master of Science in Agriculture (Soil Science and Agricultural Chemistry)" of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, is a record of bonafide research work carried out by **AJIT KUMAR MEENA** under my guidance and supervision.

The subject of the thesis has been approved by the Student's Advisory Committee.

Place: Akola
Date: 04 / 06 / 2019

(Dr. D.V. Mali)
Chairman
Advisory Committee

Countersigned

Associate Dean
Post Graduate Institute
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola

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(D) Abbreviations

Abbreviations		Expanded form
%	-	Per cent
@	-	At the rate
$^{-1}$ or /	-	Per
^{0}C	-	Degree Celsius
ANR	-	Apparent Nutrient Recovery
CD	-	Critical Difference
AE	-	Agronomic Efficiency
cm	-	Centimeter
$CaCO_3$	-	Calcium Carbonate
Cu	-	Copper
CV	-	Coefficient of Variation
MBC	-	Microbial biomass carbon
DAD	-	Days After Decomposition
dS m^{-1}	-	Deci Siemens per Meter
DTPA	-	Diethylene Triamine Penta Acetic Acid
EC	-	Electrical Conductivity
et al.	-	*et alia* (and others)
EDTA	-	Ethylene Diamine Tetra Acetic Acid
etc.	-	*Et cetera*
Fe	-	Ferrous
Fig.	-	Figure
FYM	-	Farm Yard Manure
g	-	Gram
GL	-	Glyrisidia Leaves

FA	-	Foliar Application
h^{-1}	-	Per Hour
Ha	-	Hectare
i.e.	-	*id est* (that is)
INM	-	Integrated Nutrient Management
J	-	Journal
K	-	Potassium
L	-	Litre
M	-	Meter
m^2	-	Meter Square
Mg	-	Milligram
Mg m^{-3}	-	mega gram per cubic meter
Mm	-	Millimeter
Mha	-	Million hectare
Mn	-	Manganese
MW	-	Metrological week
N	-	Nitrogen
No.	-	Number
NS	-	Non significant
O.C.	-	Organic Carbon
P	-	Phosphorus
ppm	-	Parts Per Million
PSB	-	Phosphate Solubilizing Bacteria
PE	-	Physiological Efficiency
RP	-	Rock Phosphate
RDF	-	Recommended Dose of Fertilizer
Q	-	Quintal
S	-	Sulphur

SCS	-	Shredded Cotton Stalk
SE (m)±	-	Standard error of mean
SA	-	Soil Application
T	-	Tones
viz.	-	*Videlicet* (namely)
Wt.	-	Weight
Zn	-	Zinc
FYM	-	Farm yard manure
Mn	-	Manganese
WS	-	Wheat Straw

E) THESIS ABSTRACT

a.	Title of the thesis	:	**"DYNAMICS OF ORGANIC CARBON POOLS DURING DECOMPOSITION OF CROP RESIDUES"**
b.	Full name of student	:	**AJIT KUMAR MEENA**
c.	Name and address of major advisor	:	**Dr. D. V. Mali** Assistant Professor Department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola
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Head

Department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola.

ABSTRACT

The present study entitled "Dynamics of organic carbon pools during decomposition of crop residues " was conducted during 2018-19 to characterized the prepared enriched compost for various chemical, biological properties & organic pools at Research Farm, Department of Soil Science and Agril. Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth,

Akola. The enriched composts were prepared by using different crops residue along with various mineral sources. Various chemical, biological properties & organic pools were monitored during decomposing of crop residues up to 120 days. The experiment was laid in CRD with six treatments replicated three times.

The moisture content of compost was maintained at 60 to 70%. The crop residues used for preparation of compost were analyzed for various chemical parameters. The various chemical parameters were assessed during decomposition of crop residues at regular intervals.

The pH was decreased as the decomposition progressed. The significantly highest pH (8.20) was recorded at 15 days decomposition stage in compost prepared from 100% shredded cotton stalk. Whereas, least (7.18) was recorded at final stage of decomposition in compost prepared from 25% wheat straw + 25% shredded cotton stalk +25% glyricidia leaves + 25% sorghum stubbles.

The total organic carbon was decreased during decomposition. At 15 days stage the higher value (38.73%) were recorded where compost prepared by using 100 % wheat straw. At the end of composting the lower organic carbon content (24.90) was noted in compost of 25% wheat straw + 25% shredded cotton stalk + 25% glyricidia leaves + 25% sorghum stubbles.

The total N was increased during decomposition of crop residues. The total N was lowest in compost prepared from 100 % shredded cotton stalk. However, significantly highest total N (1.27%) was recorded in compost prepared from 25% WS + 25% SCS + 25% GL + 25% SS.

It is clearly evident that C:N ratio was gradually declined with throughout in period of decompositon in all treatment. At the end of decomposition, the compost prepared from 25% wheat straw +25% shredded cotton stalk +25% glyricidia leaves + 25 % sorghum stubbles recorded the lowest C:N ratio (19.63) (T_6) followed by (T_5). Whereas, the highest C:N ratio (26.55) was recorded in compost prepared from 100% shredded cotton stalk.

The very labile, labile pools of organic carbon, less labile was increased during decomposition of crop residues. At 120 days of decomposition significantly highest very labile, less labile was recorded in compost prepared from 25% wheat straw + 25% shredded Cotton stalk + 25% glyricidia leaves + 25% sorghum stubble, followed by in compost prepared from 30% WS + 30% SCS + 20% glyricidia Leaves + 20% sorghum stubbles.

The non-labile carbon pools was gradually decreased to 22.29% to 25.14% at 120 days. At the end of decomposition, the highest non-labile (25.14%) was recorded in compost prepared from 100% wheat straw. The lowest non-labile pool was observed in compost prepared from 25 % wheat straw + 25% shredded cotton stalk + 25% glyricidia leaves + 25% sorghum stubbles.

Among various crop residues used for preparation of compost use of 25% wheat straw + 25% shredded cotton stalks + 25% glyricidia leaves + 25% sorghum stubbles were found beneficial in improving CO_2 evolution and microbial biomass carbon.

CHAPTER I

INTRODUCTION

1.1 Background Information

Organic carbon is the fraction of carbon associated with organic matter in plant and soil. The organic carbon present in different fractions or pools in soil such as active pool, passive pool and slow pool etc. The active pool of C consists of labile or easily decomposed material and half-life of this pool is only a few days to one year. Organic matter in this pool has relatively high average C:N ratio (about 15-30) and included such organic matter fractions as living biomass, tiny pieces of detritus (POM), most of the polysaccharides and other non-humic substances. Active pool provides most of the readily accessible food for microbes and most of the readily mineralizable nitrogen. It can be readily increase by addition of fresh plant and animal residues into the soil and readily loss occurs if such additions are reduced or tillage is intensified. This pool rarely comprises >10-20 % of total soil organic matter. The slow pool of soil organic carbon has intermediate properties between the active and passive pools. Probably includes the finest fraction of particulate organic matter that are high in lignin and other slowly decomposable and chemically resistant components, half- life is typically measured in decades. This pool is an important source of mineralizable N and other plant nutrients as well as also responsible for structure stability, lead to enhance infiltration, resistance to erosion and ease of tillage practices. It also probably makes some contribution to the effects associated primarily with active and passive pools.

Passive pools of carbon consist of very stable material remaining in soil for hundred or even thousands of years. This includes most of the humus physically protected in clay-humus complexes. It accounts for 60-90% of the organic matter. The passive pool most closely associates with the colloidal properties of soil humus, and it’s responsible for most of the cation and water holding capacities contributed to the soil by organic matter.

Organic matter (OM) can be divided into three main pools: labile, stable and inert. Research over recent years has focused on the labile fraction (LF), as it is considered a quickly reactive indicator of soil productivity and health, and important as a supply of energy for soil micro-organisms.

Organic carbon is the main component of organic matter (OM). As an indicator for soil health, soil organic carbon is important for its contributions to food production, mitigation and adaptation to climate change, and the achievement of the Sustainable Development Goals (SDGs). Organic carbon is important as it determines ecosystem and agro-ecosystem functions influencing various soil properties.

Composting is natural process of decomposition of organic matter by micro-organisms under control conditions. It considered as a valuable soil amendment. Farm compost is poor in P content (0.4-0.8%). Addition of P through low grade rock phosphate makes the compost more balanced and supplies nutrient to micro–organisms for their multiplication and faster decomposition. The addition of P also reduces N loss. Enriched compost enhances the chemical properties of soil as well as improved physical and biological properties of soil.

Composting is the biological stabilization and decomposition of organic substrates by a mixed microbial population under the condition which allow for the development of thermophillic temperature as a consequence of biologically produced heat. The final product of composting is stable for the storage and application to the land without adverse environmental effects. Proper composting stabilizes organics destroys pathogens and provide significant drying of the substrates. These unique conditions are achieved when optimum moisture and proper aeration are maintained. Soil microbial population, a living phase of soil is predominantly influenced by the magnitude of soil organic matter in soil and hence quantification of their abundance and the species prevailing determines the overall biological processes and soil health at large. Soil microbial activity during the process of decomposition of residues is dependent on the availability of easily degradable carbon rather than mineral nitrogen (Das, 2004). Being a microbial mediated process decomposition of crop residues is accompanied by the changes in enzymes responsible for most of this transformation. The diversity and population of soil microorganism and the enzymes produced will depend on the chemical composition of crop residues. (Sajjad *et al*., 2002).

Composting process of rice, wheat straw enriched with rock phosphate decrease the concentration of total carbon, NH_4-N, C:N ratio, biomolecules and increase the total nitrogen, soluble phosphorous, and organic acid (Formic, Citric, Lactic and Acetic acids).Detection of these organic acids may indicate their role in P solubility. The phospho-composted produced with FYM enrichment can be considered a rich P fertilizer for increasing P solubility and crop production.

Different soil labile C pools usually positively correlate with each other and they function as good indicators for predicting minor changes in OC. Although Labile organic carbon (LOC) accounts for a small part of the OC pool, it is vital in regulating nutrient availability to plants and microbes, as well as catalyzing the transformations of these nutrients in the soil. Moreover, it is very sensitive to changes in the vegetation community and microclimate, which can result from environmental changes. Any changes in these factors would substantially alter LOC. It is well known that vegetation is a major factor in regulating soil LOC. Labile organic carbon (LOC), a group of dynamic chemical compounds, is important in global carbon (C) cycling due to its short turnover time and sensitivity to environmental changes.

On the basis of residue decomposability, added crop residues partition into various OM fractions. The fraction which is least decomposed (fresh input) and remains unprotected by physical mechanisms is referred as the free light fraction of SOM. The OM fraction that partially decomposes and is protected by physical mechanisms.

Direct increase in organic carbon (OC) content through adding a carbon source from compost. The carbon (C) content of applied compost will lead to a direct increase in organic carbon (OC) content of the grazed grasslands where the compost is applied. Even though the carbon added through compost additions will gradually decompose over time, a significant portion will end up in stable carbon pools. The portion of the compost carbon that will remain in the stable pools is likely to be greater than the portion that would be stabilized under baseline conditions. The labile organic compounds contained in compost are degraded relatively quickly, and the recalcitrant fractions remain in the soil. We recently reported on the decomposition of plant residues at different depths in mineral soil for 2 years. Here, we aim to apply the approach of characterize the changes in substrate quality during decomposition. Our interest will focus on the following points: (i) changes in the proportion of pools, mainly the proportion of unhydrolyzable pool relative to total; (ii) changes in the quality of the pools; (iii) how these changes are affected by the distinct pedoclimatic conditions at each depth (upper vs. deep layers); and (iv) the comparison of the behaviour of OC and N under this approach, paying special attention to the possible incorporation of N to the recalcitrant pool.

The viable strategy to control deterioration in soil quality is to add the organic matter in the form of compost. The conversion of agricultural residues into value-added compost and its incorporation in soil with cheap nutrient sources viz., rock phosphate improves the crops productivity as well as soil quality.

Carbon pools can be accomplished by management systems that add high amounts of biomass to the soil, cause minimal soil disturbance, conserve soil and water, improve soil structure and enhance soil fauna activity. Improved soil organic matter level will sequester CO_2, enhance stability and reduce soil erosion. Plant residues in agricultural soils do not represent a large storage pool. However, their management reinfluences water penetration, wind and water erosion and extent of formation of soil organic matter, thus affecting long term soil fertility and carbon storage.

1.2 Importance and need of study:

Organic carbon (OC), a key component of the global C pool, plays an important role in C cycling. SOC is derived from a complicated mixture of fresh organic materials from plants, soil fauna, root exudates, microbial residues and chemically or physically protected substrates, which generally consist of labile and recalcitrant pools. The soil labile organic carbon (LOC) pool is usually termed microbially available carbon (MAC), microbial biomass carbon (MBC), easily oxidation carbon (EOC), dissolved organic carbon (DOC), water-soluble organic carbon (WSOC), and light fraction carbon (LFC).

There is growing need in the society in disposing and recycling organic wastes either city or farm origin composting is the rotting down of the plant and animal remains in pits before the residues applied to the soil. Under the practical point of view, composting is the biological decomposition and stabilization of organic substances which increase soil fertility.

It is a matter of great concern that these crop residues left in the field are either burnt or used as fuel or thrown away as wastes. It can also a cause for pollution in different ways. In fact these crop residues can contribute and return to soil a significant portion of nutrient.

Composting is an environment friendly and less energy consuming process. It is a biological process in which organic wastes are converted into humus through the activities of complex soil micro-organism. This can be hastened on an organized manner in which crop residues are decomposed into simpler compound so as to make them available to plants. Microbes are responsible for such decomposition with addition of their decomposed material in soil, stimulate the living phase of soil and increase N-fixation, phosphate solubilisation and availability of other plant nutrients to crop.

1.3 Objective:

Looking to above thought and availability of crop residues proposed experiment was conducted with the following objectives

1. To assess the effect of crop residues on dynamics of organic carbon.
2. To assess the effect of various crop residues on changes in various biological properties during decomposition.

1.4 Hypothesis:

The organic carbon is the key parameter in soil which influences all the physical and chemical properties of soil. In recent days the content of organic carbon in the soils of semi arid areas is seriously declining. This has resulted into deterioration of soil health and emergence of multinutritional deficiencies in the soils. The shedding of leaves by the standing crops is having great potential to raise the organic carbon content in soil. Considering the changing climatic conditions and diversified cropping systems, it is necessary to monitor the changes in soil organic carbon levels. The magnitude of addition of organic carbon through crop residues is having good potential for improving soil organic carbon of soils. The harvested crop residues are usually burn in the field after harvesting. However, this should be discouraged and the crop residue recycling is for soil health point of view.

In India crop residues like wheat straw, cotton stalk, soybean straw, sorghum stubbles and farm wastes in huge quantity. Similarly with the increasing demand of food grain for ever increasing population of world increased the demand of manures particularly, FYM for crop production. The livestock population of India is decreasing day by day hence forth the FYM may also narrow down. In the context of demand of organic manures particularly FYM, use of crop residues, industrial wastes, city and farm wastes need to be utilized for preparation of compost. In this context several procedure for testing the stability or maturity of compost have been proposed.

1.5 Scope and limitation:

Composting is basically a microbiological process accomplished by thecombined activity of bacteria, actinomycetes, fungi, and protozoa which are either present in the composting material or are introduced externally to speed up composting and enrich the compost. Under proper moisture and aeration conditions, the diverse microflora attacks the organic matter to derive their energy, carbon and other nutrients. As a result the substrate is broken down to form an amorphous brown to dark brown mixture known as compost. The waste materials with adequate water content undergo intensive decomposition from low to high temperatures in heaps or pits for around 4 to 8 months. Compost is considered a valuable organic fertilizer, supplying nutrients for the crop and hence saving substantial amounts of mineral fertilizer.

All high intensity agricultural production systems are dependent on continual inputs of mainly nitrogen and phosphatic fertilizers derived from gaseous nitrogen and phosphate rock, respectively. Unlike nitrogen, phosphorus is relying on a finite resource and the current reserves could be depleted during end of this century. More concerning is that before that point is reached, similar to oil peak, we will see a global peak in rock phosphate reserves, estimated to occur in the next 30 years. While the exact timing may be disputed, it is clear that rock phosphate reserves are decreasing and the availability of cheap fertilizers will be a thing of the past.

Peak phosphorus is linked to peak oil. For example, the recent oil price shock and growing concern about climate change has stimulated a drastic increase in biofuel crop production globally, which in turn increases the demand for phosphate fertilizers, and hence the proximity of the phosphorus peak. However a key difference between peak oil and peak phosphorus, is that while oil can be replaced with other forms of energy once, it becomes too scarce, there is no substitute for phosphorus in food production.

More efforts in making use of low (non-premium) grade unreactive rock phosphate (RP) deposits are needed. Even under acid soil conditions, Indian rock phosphate are not very effective because of their poor reactivity. Thus, to match the P needs of India, indigenous rock phosphate need to be made more effective through modifications in the P release pattern of rock phosphate. Several techniques have been developed to modify low grade rocks phosphate to promote solubility of P in rock phosphate in different soils. But most of these techniques didn't reach the farmers' fields. Therefore, sincere and determined effort was made to implement the technologies of utilization by solubilizing rocks phosphate with organic residues to make phosphorus availability for crop plant in neutral and alkaline soil.

Therefore, recycling of crop residues is an integral part of the strategies of plant nutrient management for sustaining soil health and crop yields.

CHAPTER II

REVIEW OF LITERATURE

In this chapter, it has been attempted to summarize a brief review of the work done in respect of the project entitled "Dynamics Of Organic Carbon Pools During Decomposition of Crop Residues". The literature pertaining to the present study has been briefly cover the following heads.

2.1 Preparation of enriched compost

2.2 Changes in carbon pools during decomposition of crop residues

2.3 Changes in biological properties during decomposition of crop residues

2.4 Changes in chemical composition during decomposition of crop residues

2.1 Preparation of enriched compost

Asija *et al*. (1984) studied that rock phosphate enriched manures conserves the nitrogen. They also observed that there is increase in phosphorus content, nitrate nitrogen and decline in pH and with decomposition of compost.

Singh and yadav (1985) studied to prepare phospho-compost by composting varying amounts of low grade rock phosphate (RP) with mixture of different kinds of farm waste. All the levels of RP incorporation increased the loss of organic matter during the time of composting but maximum loss (41.1%) was found with the mixing of 1 kg RP per 3.65 kg waste on a dry weight basis. The water soluble P_2O_5 decreased with increasing the amount of RP while, organic and citrate soluble P_2O_5 increased significantly. The higher level of RP (2.5 kg per 3.65 kg dry waste) reduced the concentration of both organic and citrate soluble P. Phospho-compost prepared by enrichment with 1 kg RP per 3.65 kg waste was found to be as good as single superphosphate in micro-plot field experiments taking moong bean and wheat as the test crops.

Bangar *et al*. (1985) studied that rock phosphate was solubilized and transformed into available forms when rock incorporated during composting of organic wastes. The solubilization of phosphorus during composting has been attributed to the formation of humic substances.

Bangar *et al*. (1989) studied to prepare a nutrient rich compost from paddy straw using urea and Mussoorie rock phosphate (MRP). Inorganic N was partly conserved in the compost by the addition of pyrite. They have reported that the final compost contained about 1.6% total N and 3.3% total P. They have further reported an increase in the citric acid soluble P through the addition of pyrite.

Hajra *et al*. (1994) reported that phosphocompost made out of cow dung; alluvial soil: well rotted compost (1:1:0.5 dry weight basis) mixed with 5% low grade rock phosphate substantially improved the quality and crop response compared with pure paddy straw phosphocompost. The former phosphocompost at 10 t ha^{-1} performed to single super phosphate at 30, 40 or 50 kg P_2O_5 ha^{-1}.

Reddy and Reddy (2002) revealed that the use of different organic matter available at farm for composting like sugarcanes trash, paddy straw, weeds and other plants. The average nutrient contents of farm compost are 0.5% N,0.15% P_2O_5 and 0.5% K_2O. The nutrient value of farm compost can be increased with the application of single super phosphate or rock phosphate at 10 to 15 kg/t of raw material at the initial stage of filling the compost pit.

Manna *et al*. (2003) carried out three years field study to compare the performance of four sources of enriched phosphocompost (Soybean straw, wheat straw, mustard straw and city garbage) and inorganic fertilizer on soil chemical and biological properties. They noticed that continuous turnover of phosphocompost improved substantial quantity of soil microbial biomass C, activity of enzymes compared to chemical fertilizer. Citrate soluble P concentration of phospho-compost ranged in 2.31 to 7.85 g kg^{-1} the highest being in wheat straw and lowest in city garbage compost. The water soluble P was about 6 to 10 folds lower in all phospho-compost than citrate soluble P.

Lata and Pandey (2005) reported to rapid preparation of a highly nutrient enriched compost can be achieved by using efficient lignocellulolytic fungi (e.g*., Trichoderma*, *Aspergillus awamori, Polyporous versicolor, Penicillium funiculosum, Phanerochaete chrysosporium* etc.), as compost accelerators. Bioinoculants such as P-solubilizers and free-living N fixers can be employed to prepare phospho-compost by using rock phosphate 12.5% and pyrite 10% along with plant residues.

Sibi (2007) conducted experiment to evaluate the effect of phosphate solubilizing fungi *(Aspergillus awamori* and *Trichoderma viride*) in phosphocompost preparation along with low grade rock phosphate. Co-inoculation of phosphate-solubilizing fungi significantly increased the nutrient value of the compost that explores high P-solubilizing potential of *A. awamori* and *T. viride* which can be exploited for the solubilization of fixed phosphates thereby enhancing soil fertility and plant growth. Rock phosphate application along with phosphate solubilizing fungi increased 69.2% acid phosphatase and 65% alkaline phosphatase activity over ordinary compost. With co-inoculation, maximum P content (64.3%) was observed followed by single inoculation with *A. awamori* (62.2%).The present findings revealed that phosphate solubilizing fungi can interact positively in promoting nutrient content of compost and plant growth leading to improved yield.

Kumari *et al.* (2008) studied the production of organic acids and changes during decomposition of rice straw amended with tri calcium phosphate (TCP) and Udaipur rock phosphate (URP) under laboratory conditions. The pH decreased to acidic range (6.2) on day 15, but became alkaline gain later on. Zero days soluble P (9.0 µg g^{-1} straw) increased at 15 days after incubation (19.8 µg g^{-1} straw) declined later (14.8 µg g^{-1} straw) at 60 days of decomposition. Citric, oxalic, formic and maleic acids were detected during decomposition of rice straw and maximum amounts were present on day 15. Citric and oxalic acids were responsible mainly for P solubilization from TCP and URP; generally, citric acid was the most effective in P solubilization.

Banta and Dev (2009) prepared phosphocompost from green biomass of *Lantana camara* with 12.5 and 25.0% levels of rock phosphate. They observed that amount of citrate soluble P increased from 4.26 to 9.24 mg g^{-1} from 0 to 90 days of composting with total P 1.96%.

Rai *et al.* (2012) observed a significant enrichment of percent organic C and total N, Ca, Mg, K, Fe, Mn, Zn and Cu content in compost when prepared with rock phosphate @ 1% of total wheat/rice biomass.

2.2 Changes in carbon pools during decomposition of crop residues

Lal *et al. (*1995) studied that soil carbon is an important part of the terrestrial carbon pool and soils of the world are potentially viable sinks for atmospheric carbon.

Batjes (1996) studied that total soil carbon pools for the entire land area of the world is estimated of C in the upper 100 cm, whereas soil organic C is estimated of C in the upper 30 cm.

Rasal *et al*. (1996) studied that there is maximum reduction in organic carbon, increase in total and mineral nitrogen, water soluble-citrate soluble P, total P and phosphate solublizing microorganism were reported due to 5% P_2O_5 as rock phosphate, phosphocompost mixture, 1% urea, decomposing culture, 10% pyrite phosphocompost treatment which completely replace phosphatic fertilizers.

Rovira and Vallejo (2001) observed that the quality of organic matter (OM) depends on its distribution among labile and recalcitrant pools and the quality of each pools considered. OM quality is assumed to decrease as decomposition proceeds, but to verify this assumption it is necessary to define quality in operative terms. Chemical fractionation into three pools is a useful approach to characterize biochemical changes in C and N quality during plant residue decomposition..

Sleutelet *et al.* (2006) studied that soil organic pools using physical fractions in two long term field experiments and found that fertilization had a distinct influence on both the SOC amount present in two free particulate organic matter (POM) fractions and their relative proportion on the whole-SOC. This increase in SOC was equal or smaller for the POM occluded in micro aggregates (53–250 μm), and much smaller for the amount of OC present in the silt + clay sized fraction.

Ceske and Czech Republic (2010) studied that organic matter (OM) can be divided into three main pools: labile, stable and inert. Research over recent years has focused on the labile fraction (LF), as it is considered a quickly reactive indicator of soil productivity and health, and important as a supply of energy for micro-organisms. It is also suggested that future research should focus on the interactions among OM fractions and their better chemical and functional characterisation.

Campos *et al.* (2014) showed that stability of the final product was reached after 90 days and that the compost obtained presents substantial richness of stabilized organic matter and an absence of toxicity, so it may be considered as an organic fertilizer.

Kumar and Sharma (2014) studied that organic carbon (OC) can be classified into three main categories: labile, semi labile and refractory. The area of research is primarily focused on the labile organic carbon (LOC) as it is considered highly reactive indicator of soil quality and compost stability.

Naresh *et al.* (2018) concluded that residue and nutrient management on carbon stocks and labile organic carbon fractions increased dissolved organic carbon, microbial biomass carbon light and heavy fractions of carbon in soils at upper layers of the depths

2.3 Changes in biological properties during decomposition of crop residues

Bharadwaj and Gaur (1970) reported that increase in the reduction of carbon content was due to the increase in the microbial activities with the fineness of the materials and availability of oxygen during decomposition

Gaur *et al.* (1971) noticed the increased trend of bacterial and actinomycetes population at 30 and 90 days period followed by decline in their population at 60 and 120 days. However, again an increasing trend was observed after 120 days of incubation.

Guhe and Deshmukh (1973) found that crop residues like wheat straw incorporated with fertilizer N in soil favorably enhanced the soil microbial ecology, microbial biomass and yield of legume crop.

Balasubramanium *et al.* (1974) observed that the release of CO_2 by the soil amended with organic material was more in general as compared control.

Linko (1977) reported that cellulose is a prominent carbon constituent of higher plants. It is a carbohydrates composed of approximately 15,000 glucose units bound together by glucosidase linkage. It is decomposed by the cellulase enzymes produced by cellulolytic bacteria (Cytophaga spp. Cellulomonas spp., Cellovibrio spp., Pseudomonas spp., Bacillus spp. etc.); cellulolytic fungi (Aspergillus spp., Alternaria spp., Trichoderma spp., Fusarium spp., Fomes spp., Penicillium spp., Rhizopus spp. Cladosporium spp., Pyricularia spp. Nigrospora etc.) and cellulolytic actinomycetes (Micro *monospora spp*., *Nocardia spp*., *Streptomyces spp*. and *Strepto sporangium spp*.).

Gaur and Mukherjee (1980) recorded that significant increase in population of bacteria as compared to fungi and actinomycetes under the treatment receiving crop residues indicating the significance of organic recycling in microbial population.

Arya *et al*. (1981) observed that the maximum CO_2 evolution was noticed with cotton waste and least with saw dust up to 5^{th} day of inoculation. The slowest rate of decomposition of saw dust may be described to its wide C:N ratio and low nitrogen content.

Hadimani *et al.* (1982) studied the total C mineralized from residues and suggested that decomposition of organic material in soil initially proceeded at faster rate. The decomposition attained a slower rate after about 15 days. It was mineralized within 14 days and remaining plant materials decomposed at a slower rate. However, the CO_2 evolution and release of NH_4- N were significantly influenced by soil type and source of organic matter.The rate of CO_2 evolution release and NH_4^+-N and NO_2 + NO_3- N had a linear relationship with organic carbon content of the soil.

Mathur and Debnath (1983) estimated that the composting of dung with phosphate meal accelerated the decomposition of organic matter by increased microbial population during these stage of composting.

Reinertsen *et al*. (1984) observed that decomposition data for the various treatments indicate that the amount of microbial biomass produced and the overall the rate of decomposition in the early stages was largely dependent on the size of the soluble 'C' pools but decomposed within the first few days of decay.

Rasal *et al*. (1987) conducted a pot culture experiment to evaluate the effect of enriched compost on the growth of maize. He recorded that the carbon content of the compost was reduced significantly due to processing by amending with nitrogen fixing bacteria, mineral additive such as rock phosphate and phosphate solubilizers.

Harmon *et al*. (1990) reported that the decomposition index was inversely correlated with total CO_2 evolution from the decomposing roots of three grass species and predicted accurately the decomposition of other material, including legume residues.

Ingham and Horton (1990) recorded in high C:N ratio soils and materials, the fungal and bacterial ratio increased markedly, while the decomposition proceeds. The bacteria presumed to have peaked early in the process and probably had a diminishing role after first week.

Singh (1991) found that the nitrogen addition, which is known to accelerate the mineralization of easily degradable organic carbon, did not influence the rate of degradation of water insoluble organic carbon such as cellulose and lignin constituting about 60 to 70% of the total carbon present in trash.

Ladd *et al.* (1993) reported that under anaerobic condition decomposition and mineralization rate was slow and less completed than aerobic condition.

Karma (1994) reported white rot fungi as one of the most important group of lignolytic microbes existing in nature. According to him, major lignin degrading fungi were *phanerochaete*, *polyporus*, *pleurotus*, *ganoderma* and *stropharia*.

Shivaramu *et al.* (1994) pointed out that CO_2 evolution from soil was found to decrease with time. Maize stover @ 4 and 8 t ha^{-1} released CO_2 at higher rate during first 6 days than any other treatments. Whereas, paddy straw incorporation maintained relatively higher CO_2 evolution rate for longer period although initial rate was not as maize stover. The rate of CO_2 evolution was highest during the first week of incubation and FYM registered as steady evolution of CO_2 and found to be the best material for building up soil organic matter.

Potdukhe (1995) studied that percent loss in weight of three agricultural wastes via, sorghum stubbles, groundnut shell, cotton stalks by using eight different fungi. Among these fungi *Trichoderma viride* was good decomposer in loss in weight of organic substrate.

Singh *et al*. (1995) observed that about 24.8 to 39.5% of applied C through wheat straw decomposed in 60 days period. At 40 ± 2 C^0 incubation temperature, wheat straws were mineralized at faster rate and the application of N increased the process.

Atkinson *et al*. (1996) reported that microscopic organisms such as bacteria, fungi, actinomycetes, and protozoa are the chemical decomposers, while larger organisms such as worms, mites, snails, beetles, centipedes, and millipedes are mainly the physical decomposers. They are considered to be physical decomposers because they grind, bite, suck, tear, and chew materials into smaller pieces. Bacteria and worms are the powerhouse of chemical and physical decomposers, respectively.

Henning *et al.* (1996) reported that elevated CO_2 increase the C:N ratio and lignin content of sorghum stem and soybean leaves and had no impact on soil C turnover, relative nitrogen mineralization and cumulative C and N mineralization. Thus suggesting that increasing atmospheric CO_2 will have little effect on composition or decomposition of field crop residues.

Angers and Recous (1997) reported that in the first two days of incubation, decomposition rate of rye increased with decreasing particle size but there after the trend was reversed. For wheat straw, early decomposition was faster for the small sized particles. Thereafter, the largest size classes decomposed faster. It was hypothesized that great availability and accessibility of nitrogen was responsible for the higher rates of decomposition observed for finely ground wheat straw.

Sorensen *et al*. (1997) revealed that small particles may be decomposing faster than larger particles of crop residues because of the increased surface area and greater dispersion in soil increasing the susceptibility to microbial attack.

Wardle and Layelle (1997) observed that the species of microorganisms responsible for residues breakdown also depends on the temperature of substrate and type of substrates. Actinomycetes are responsible for residues breakdown mainly at high temperature, whereas species of bacteria and fungi are dominant at lower temperature.

Juma and McGill (1998) reported that fungi and bacteria were ultimately responsible for the biochemical processes in the decomposition of organic residues. Also suggested that the role of soil fauna was relatively greater in the decomposition of materials with a high C:N ratio, lignin and polyphenol content and less important on low C:N ratio residues as these residues were decomposed easily by microorganism.

Thakur and Sharma (1998) studied that effect of inoculation with Azotobacter and addition of varying level of rock phosphate was studied on nitrogen and phosphorus transformation during composting. Inoculation with *Azotobacter* at 30 and 60 days of composting increased ammonical, nitrate and total nitrogen contents and decreased water soluble P and C:N ratio.

Manna *et al*. (2000) studied that use of bio inoculum narrowed the C:N ratio from 29.5 to 21.5. The ash content and total N were significantly improved due to bio inoculums addition by about 6.7 to 19.6% and 16.7 to 31% respectively.

Manna *et al*. (2001) conducted experiment to prepare nutritionally enriched compost. It was ascertained that the composition process as compared to multiple microbial inoculants along with rock phosphate for compost in turn caused lowering of C:N ratio 12.2:1. Water soluble P and citrate soluble P increased significantly by the application of rock phosphate @ 1.25% P_2O_5 and further increase by 2.5% P_2O_5.

Vries and Visser (2001) reported that degradation of plant cell wall polysaccharides by the members of the *Aspergillus* this fungus is known to produce a wide spectrum of cell wall–degrading enzymes (cellulose, pectinase, hemicellulases and ligninase) and is responsible for complete degradation of the polysaccharides.

Gupta *et al*. (2004) evaluated organic matter degrading capacity of various microbes (*Trichoderma vride, Bacillus polymyxa, Pseudomonas striata and Azospirllus* spp.) on the basis of CO_2 evolved during different periods of incubation. They reported that among all the microbes tested in the study, *Bacillus polymyxa* and *Trichoderma viride* were the most efficient organic matter degrading microbes in legume and paddy straw respectively.

Kachave *et al*. (2004) reported that the total nitrogen, phosphorus, potassium and sulphur in cotton stalk was 0.54, 0.25, 0.87 and 0.05% and in paddy straw 0.56, 0.10, 0.3 and 0.04%, respectively. The amount CO_2 released was directly proportional to the amount of carbon present in crop residue.

Goyal *et al.* (2005) studied the enhanced population of introduced beneficial bacteria in treatments under study reflected appearance of nutritionally specialized microbial groups at the end of incubation, as should be with mature compost.

Paul (2007) reported that the any compound which is synthesized biologically is liable to destruction by soil inhabitants. The organic matter subjected to microbial decomposition comes mainly from plant source, which consist of 15-60% cellulose; 10-30% hemicelluloses; 5-

30% lignin; 0.5-5% fats, oils, wax and resins; 5-10% proteins; 1-13% minerals and a small part from animal sources.

Ghanbary (2010) studied the cellulose decomposition by different species of *aspergillus* on media containing 1% carboxy methyl cellulose (CMC) and reported that *A. niger* and *A. niveus* had highest in vitro cellulose degradation as compared to other species of *aspergillus*.

Chauhan *et al.* (2012) reported that compost was prepared from green biomass of *Lantana* supplemented with dung, soil, and FYM in the ratio of 8:1:0.5:0.5. The survival of *Azotobacter chroococcum* was monitored periodically at 60 and 90 days of composting with initial *Azotobacter* population of 88 × 106 cell/g. *Azotobacter* was inoculated only in treatment *Lantana camara* + *Azotobacter chroococcum* and *Lantana camara* + *Trichoderma viride* + *Azotobacter chroococcum* initially there was decrease up to 60 days and then it got stabilized subsequently up to 90 days.

Gogoi *et al.* (2013) recorded that microbial biomass carbon content increased and stabilized to a value of 4039.70 and 4424.61 µg/g/24hrs in the treatments *(Azotobacter* + *PSB*) and (*Azospirillum* + *PSB*), which may be credited to the initial inoculation of microorganisms in the ninety days old compost and rapid multiplication rates in presence of large amounts of readily decomposable substances.

2.4 Changes in chemical composition during decomposition of crop residues

2.4.1 Changes in C: N ratio during composting

The C:N ratio is an important factor to be considered while mixing the different kinds of materials for composting, On an average, microorganisms utilize 30 parts of carbon per one part of nitrogen. so C:N ratio of 30:1 is desirable for composting. In the composting material with high C:N ratios, carbon is present in excessive amounts relative to nitrogen, which leads to inefficient and slow composting process. In this case nitrogen availability is the limiting factor. With only limited nitrogen resources to use, microorganisms take longer to use the excess carbon.

Several life cycles of organisms are required to reduce the C:N ratio to a suitable level.

Wani (1975) obsereved that after adjusting C:N ratio of wheat straw incubated with Aspergillus spp. and other culture will help in obtaining good quality compost with a short period of 60 days.

Golueke (1977) reported that excessively higher C:N ratio resulted into slower decomposition rate than optimum C:N ratio. The stability of C:N ratio could be determined on part by the readiness with which the organic constituents of wastes were decomposed.

Pande (1978) studied that the loss in weight, C:N ratio and CO_2 evolution of organic matter viz., cotton stalk by eleven fungi and pointed out loss in weight of organic matter was significantly more over control. Per cent loss in weight of green gram trash was more over pigeon pea stalk but was at par with cotton stalk. The C:N ratio of decomposed organic materials reduced from 60:1 to 27:1 in cotton stalk, 56:1 to 26:1 in green gram trashed and 71:1 to 30:1 in pigeon pea stalk by activity of cellulolytic fungi.

Gawade (2001) studied that six cellulolytic fungi of decomposition in agricultural wastes viz. cotton stalks, pigeon pea, groundnut shells, sorghum stubbles and soybean trash. He observed that during decomposition process cellulose is used as energy source and was lost in the form of CO_2 during assimilation by microbes, nitrogen is not lost but mineralization in microbial cells, resulting in lowering down the C:N ratio.

Mishra *et al.* (2001) concluded that the rate of decomposition of the wheat straw was relatively faster in the beginning but it slowed down after four weeks and up to end of the 22^{nd} week, 82 to 86 per cent of the wheat straw has become decomposed. During decomposition of the wheat straw carbon content decreased, nitrogen content increased and C:N ratio decreased with time. There was practically no N-mineralization from the wheat straw during the 2^{nd} and 10^{th} week after straw incorporation, but there after N-mineralization proceed gradually.

Zayed and Motaal (2005) prepared compost from rice straw enriched with rock phosphate and microbial inoculants. They observed that the C:N ratio decreased from an initial 46:1 to 30:1 after 105 days of composting. The maximum amount of phosphorus solubilized by the un-inoculated rice straw was 250 ppm after 105 days, however, inoculation with phosphate solubilizing bacteria released about 1000 ppm of phosphorus after 75 days of composting with their total population ranged from 230 to 280 x 10^{-5} g^{-1} soil.

Hellal *et al.* (2012) conducted study to assess the effect of phospho-composting on increasing phosphorus solubility of inactive rock phosphate. The C:N ratios ranged between 35.2 and 52.2 at the beginning and decreased notably up to 12.1 to 15.6 at the end of composting cycle.

Khan and Sharif (2012) conducted the study during 2010 to determine the P solubilized from rock phosphate (RP) through composting with fresh poultry litter (PL). C:N decreased with the time in all the treatments.

2.4.2 Temperature

The natural composting processes produce heat due to microbial activities going on within composting material.The temperature falls composting can be successfully achieved throughout the year; however, due to the higher temperatures during summer, more moisture addition may be necessary in drier areas particularly in tropical country like India.

The thermophilic composting phase is an important phase to destroy various pathogens and weeds. High temperature also destroy pathogenic bacteria and protozoa, which are detrimental to health and agriculture when the compost is used in agricultural practices. While high temperature levels are desirable for pathogen destruction, they must be controlled to reduce the destruction of beneficial organisms and its subsequent effect on the completion of decomposition.

Acharya (1939) stated that the rise of temperature is proportional to the amount of decomposable organic matter present. Large amount of water (above 50 per cent) hindered rapid rise of temperature. The maximum temperature (65-70 per cent) was usually reached in about 3 to 5 days after which the temperature slowly fell.

Bell (1971) stated that the composting is a self heating thermophilic aerobic biological decomposition process which occurs naturally due to accumulation of biodegradable soil organic matter. During the process readily decomposable substances like hemicelluloses, cellulose and lignin are utilized by microbes ranged between 45 to 55 per cent but could occur over the wider range of 25 to 75 per cent moisture.

Briguvanshi (1988) prepared organic manure in pits using cattle shed waste, kudzu vine, kharif weeds and pine needles and enriched with fertilizers (urea, SSP) to improve their quality. The results showed that total nitrogen per cent was higher in all the manures and C:N ratio of the composting mixture narrowed down considerably. Phosphorus enrichment conserved nitrogen in the manures.

Beckmann and Schriefer (1989) observed that in the course of four months, temperature decreased from 70 to 30^0 C, rotting process was accelerated and temperature reached 60^0C.

2.4.3 Moisture

Moisture is necessary for the microbes in decomposing material to work efficiently, as it acts as a medium for chemical reactions, the transport of nutrients and the movement of the microorganisms. The composting material generally dries out with time. In turned systems, water is added regularly. In no-turn systems, moisture can be prevented from escaping using a thick layer of finished compost or bulking agent.

Poincelot (1974) stated that decomposition process of organic matter slowed down below 40 per cent and excess moisture the process become anaerobic and emits foul odour.

Vilgoen and Reinecke (1989) recorded that at initial stage activity of microbes were very less and the moisture requirement was also less and therefore moisture content in the compost at early period was naturally high.

2.4.4 Nutrient-composition of enriched compost

Enriched composts provide all nutrients in readily available forms, enhances uptake of these nutrients by the plants and play a major role in improving growth and yield of crops. Enriched composts or composts besides supplying plant nutrients, add a sufficient amount of organic matter to the soil, which helps in improving the physico-chemical properties of the soil.

Hajra *et al*. (1994) reported that phosphocompost made out of cow dung; alluvial soil: well rotted compost (1:1:0.5 dry weight basis) mixed with 5 per cent low grade rock phosphate substantially improved the quality and crop response compared with pure paddy straw phosphocompost. The former phosphocompost at 10 t ha^{-1} performed to single super phosphate at 30, 40 or 50 kg P_2O_5 ha^{-1}.

Biswas and Narayansamy (2006) reported that rock phosphate enriched compost were prepared by mixing four low –grade Indian rock phosphate with rice straw with and without Aspergillus awamori, rock phosphate compost had higher total P, citrate soluble P ,organic P ,acid and alkaline phosphatase activities and lower water souble P and microbial biomass C than normal compost. Inaculation with A.awamori increased total P, WSP, CSP, Organic P, SMBC and acid phosphatase activity. Rock phosphate compost recorded lower Olsen P at initial period of composting.

Reddy and Reddy (2002) used the different organic matter available at farm for composting like sugarcane trash, paddy straw, weeds and other plants. The average nutrient contents of farm compost are 0.5 per cent N, 0.15 per cent P_2O_5 and 0.5 per cent K_2O. The nutrient value of farm compost can be increased by application of single super phosphate or rock phosphate at 10 to 15 kg/t of raw material at the initial stage of filling the compost pit.

Kachave *et al*. (2004) revealed that the total nitrogen, phosphorus, potassium and sulphur in cotton stalk were 0.54, 0.25, 0.87 and 0.05 per cent and in paddy straw 0.56, 0.10, 0.3 and 0.04 per cent respectively. The amount CO_2 released was directly propotional to the amount of carbon present in crop residue.

Iqbal *et al*. (2010) reported that effect of enrichment on chemical properties of MSW compost. The efficiency of organic additives (Rock phosphate 5%, Ferrous sulphate 1% and Lime 0.63%) meant to perk up the municipal solid waste composting process and to examine the physico-chemical parameters during composting in mechanical composer. Swifty rise in temperature from mesophilic to thermophilic stage was accompanied by an increase in NH_4 -N that gradually decrease near the maturation phage. A significant correlation was found between total carbon, C:N ratio and increase in cation exchange capacity and humification rate, N mineralization is increase.It was briefly concluded that inorganic additives promote the decomposition rate and humification process.

Patra and Bandyopadhyay (2010) carried out experiment on phosphocompost and found that pH increases and percentage of total organic carbon, total nitrogen and total potash significantly and consistently decreased with the increased in rock phosphate levels of 2.5 per cent, 5 per cent and 7.5 per cent. Inoculation with locally isolated PSB and *Trichoderma viride* significantly increased pH, total nitrogen, phosphorus and organic carbon of the compost.

Sebi (2011) revealed that, phosphocompost prepared with low grade rock phosphates along with phosphrous solubilizing fungi (*Aspergillus awamori* and *Trichoderma viride*) can interact positively in promoting nutrient content of compost and plant growth parameters , leading to increased yield in tomato.

Moharana and Biswas (2016) reported on assessment of maturity indices of rock phosphate enriched compost using variable crop residues using crop having different C:N ratio .The result demonstrated that all the enriched compost had higher content of available nutrients and quality indices, indicating that enriched compost could be used to substitute costly chemical fertilizer for crop production.

CHAPTER III

MATERIAL AND METHODS

With a view to study the "Dynamics of organic carbon pools during decomposition of crop residues" the experiment was carried out at Research Farm, Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2018-19. The details of material used and methods adopted during the course of investigation are described below under appropriate heads.

3.1 Material required

3.2 Experiment details

3.3 Treatment details

3.4 Quantity of ingredient added in enriched compost

3.5 Methodology for preparation of enriched compost

3.6 Observation

3.7 Methods of analysis

3.8 Statistical Method

3.9 Location / Duration

3.1 Material required

3.1.1 Rock phosphate

Table 1: Chemical composition of rock phosphate

Sr.No	Chemical composition	Content
1	Total P (%)	20.0
2	Water soluble P (%)	0.003
3	Citrate soluble P (%)	1.10
4	Potassium (%)	0.13
5	Calcium (%)	9.0
6	Magnesium (%)	3.48

7	Sulphur (%)	0.40
8	Iron (mg kg^{-1})	5870
9	Manganese (mg kg^{-1})	904
10	Zinc (mg kg^{-1})	213
11	Copper (mg kg^{-1})	40

3.1.2 Crop residues

The wheat straw, shredded cotton stalk, glyricidia leaves, and sorghum stubbles available at Research Farm, Department of Soil Science and Agricultural Chemistry were utilized for preparation of enriched compost. The cotton residues are shredded into small pieces of approximately 2-3 cm length, and rock phosphate, PDKV decomposer, elemental sulphur, urea and cow dung slurry were added.

The chemical composition of crop residues used for preparation of enriched compost is as given below in Table 2.

Table 2. Chemical composition of Crop residues and Glyricidia leaves

Crop Residues	Chemical composition (%)					Micronutrients (mg kg^{-1})				C:N ratio
	Total C	N	P	K	S	Zn	Fe	Mn	Cu	
Sorghum stubbles	37.7	0.47	0.21	1.13	0.12	41	131	67	12.02	80.2
Wheat straw	40.1	0.51	0.18	0.89	0.14	45	124	56	9.55	78.6
Cotton Stalk	36.2	0.48	0.16	0.68	0.09	37	119	61	13.11	75.4
Glyricidia leaves	42.2	2.87	0.33	1.24	0.17	62	161	89	13.25	14.9

3.2 Experimental details

1. Location : Research Farm, Dept. of Soil Science and Agril. Chemistry. Dr. P D K V, Akola.
2. Year of study : 2018-2019
3. Design : Completely Randomized Design
4. Number of treatments : 6
5. Number of replications : 4
6. Method of composting : Pit method
7. Size of pit : 2 m x 3 m x 0.5 m
8. Turning : At 10 days interval upto 90 days

3.3 Treatment details

T_1 - 100% Wheat straw

T_2 - 100% Shredded Cotton Stalk

T_3 - 50% Wheat Straw + 50% Shredded Cotton Stalk

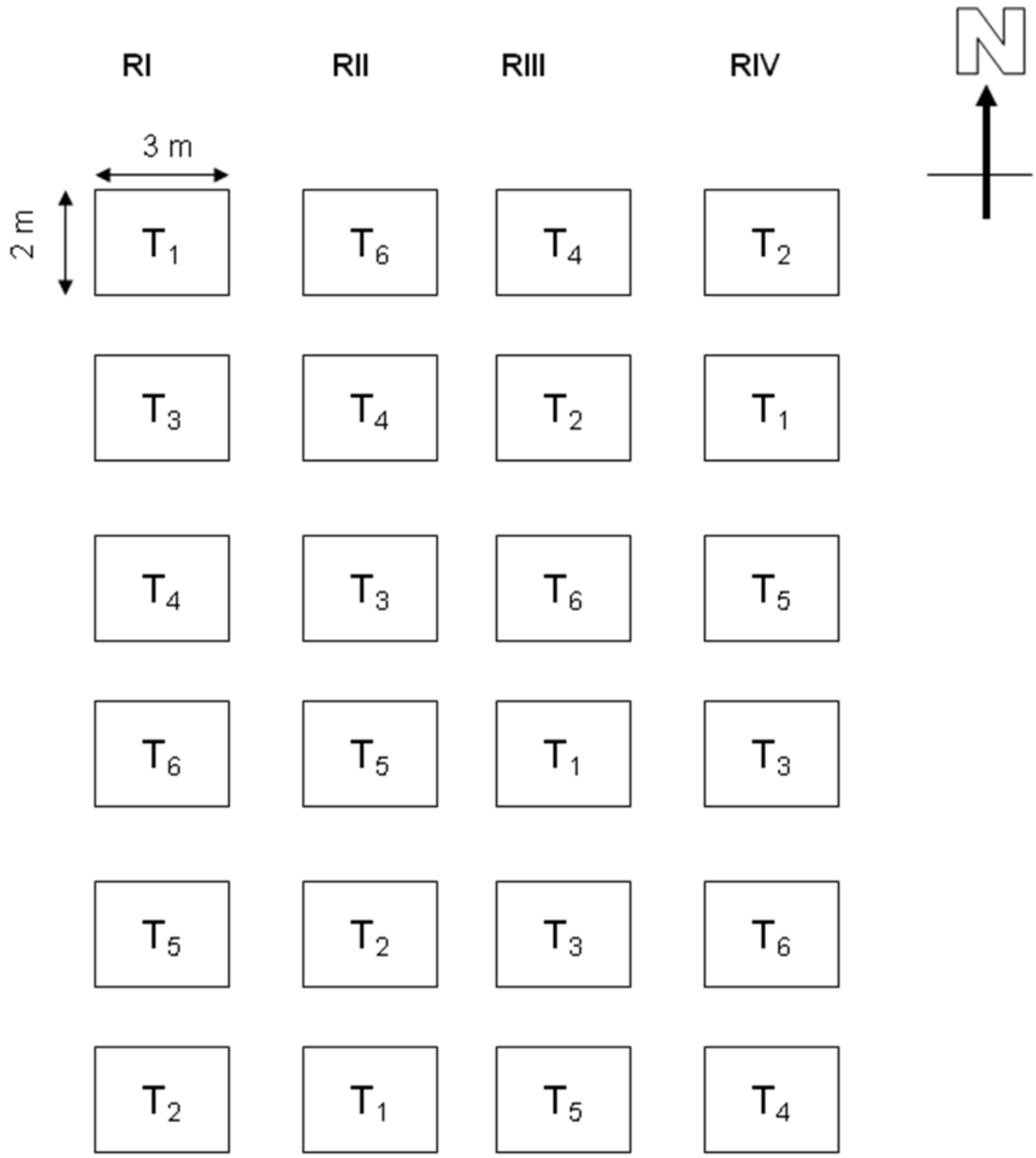
T_4 - 40% Wheat Straw + 40% Shredded Cotton Stalk + 20% Glyricidia Leaves.

T_5 - 30% Wheat Straw + 30% Shredded Cotton Stalk + 20% Glyricidia Leaves + 20% Sorghum Stubbles

T_6 - 25%Wheat Straw + 25% Shredded cotton stalk + 25% Glyricidia Leaves + 25% sorghum stubbles

3.4 Quantity of ingredient added in compost

1) Rock phosphate : @ 12% (120 kg per ton).
2) PDKV decomposer : @ 1 kg per ton.
3) Elemental Sulphur : @ 5% (50 kg per ton).
4) Urea : @ 1% (10 kg per ton).
5) Cow dung slurry : @ 1% (10 kg per ton)



Dimension of pit : 2 m x 3 m x 0.5m

Fig 1. Plan of Layout

3.5 Methodology for preparation of compost

1. The enriched compost was prepared by pit method with various crop residues (wheat straw, shredded cotton stalk, glyricidia leaves and sorghum stubbles) along with rock phosphate, urea, bentonite sulphur and PDKV decomposer and cow dung slurry.
2. Turnings were given at 10 days interval up to 90 days of decomposing.
3. After 90 days of decomposing, heaps of enriched compost were collected at one place as per treatment and allowed to cure for another 30 days.
4. The compost samples were collected at specific interval for analysis of various organic pools *viz.* very labile, labile, less labile, non labile and various chemical and biological properties.
5. Compost was watered regularly at 5–7 days of interval so as to maintain moisture content up to 60-70%.
6. Temperature was recorded at regular interval.

3.6 Observations

The following observations were recorded during composting and prepared enriched compost.

3.6.1 Proximate composition of different crop residues

1. Total N, P, K and Carbon
2. S, Zn, Fe, Mn and Cu.

3.6.2 Monitoring carbon pools and chemical and biological properties during composting

Pools of organic carbon (at 15, 30, 60, 90,120 days)

- Very labile
- Labile
- Less labile
- Non labile
- Total carbon

Plate 1 Flow chart of preperation of enriched compost

- Total nitrogen
- C:N ratio
- pH
- CO_2 evolution
- MBC (Microbial biomass carbon)

3.7 Methods of analysis

3.7.1 Organic carbon pools

Organic carbon (OC) was determined by modified Walkley and Black, (1934) using 36 N H_2SO_4 implying the recovery factor of 1.298 represents the total SOC pool. This fraction was sub-fractionated in to four different pools namely very lablie (pool I: C_{VL}), labile (pool II: C_L), less labile (pool III: C_{LL}) and non labile (pool IV: C_{NL}). Pools I and II together represent the active pool [Active pool=∑ pool I + pool II]; while pool III and pool IV together constitute the passive pool[Passive pool=∑(pool III + pool IV)] of organic carbon in soils (Chan *et al*. 2001) using 5, 10 and 20 ml of concentrated (36.0 *N*) H_2SO_4 that resulted in three acid-aqueous solution ratios of 0.5:1, 1:1 and 2:1 (corresponding to 12.0, 18.0 and 24.0 *N* of H_2SO_4, respectively). The amount of C, thus determined allowed the apportioning of total soil organic carbon into the following four different pools

According to their decreasing order of oxidizability

Pool I (C_{VL} very labile)	:	Organic C oxidizable by 12.0 *N* H_2SO_4
Pool II (C_L labile)	:	The difference in C oxidizable by 18.0 *N* and that by 12.0 *N* H_2SO_4
Pool III (C_{LL} less labile)	:	The difference in C_{tot} oxidizable by 24.0 *N* and that by 18.0 *N* H_2SO_4
Pool IV (C_{NL} non labile):	:	The difference between C and oxidizable by 24.0 *N* H_2SO_4.

The pool I and II together represent the active pool [active pool = Σ (pool I + Pool II)] while pool III and pool IV together constitute the passive pool [Passive pool = Σ (pool III + Pool IV)] of organic C in soils (Chan *et al*. 2001).

3.7.2 Total Carbon

The total carbon from plant sample was estimated by taking known quantities of dried samples in a pre-weighed silica crucible. The samples were kept in a muffle furnace at a temperature of 600^0C for 2 hours. The crucible were later transferred to desiccators, cooled and immediately weighed to a constant weight (ash weight).The total presence of organic matter was calculated by taking difference of dry weight of samples and ash weight of the samples. Then total carbon was calculated by dividing the per cent organic matter by the factor 1.724 (Jackson 1973).

$$\% \text{ Organic Carbon} = \frac{(100 - \% \text{ Ash})}{1.724}$$

$$\% \text{ Organic matter} = 100 - \% \text{ ASH}$$

3.7.3 Total Nitrogen

Total nitrogen was estimated by using Micro Kjeldahl's method as described by Piper (1966).

3.7.4 C: N ratio

The extent of decomposition of organic substrate was determined by its C:N ratio. Undecomposed substrates have wider C:N ratio and on decomposition the C: N ratio is reduced. With this view the oven dried samples were analyzed for their organic carbon and nitrogen content by using Ignition method (Jackson, 1973) and Micro Kjeldahl's method (Piper, 1966) respectively.

3.7.5 pH

It was determined by pH meter using 1:4 to 1:5 (according to straw used for preparation of compost) straw to water ratio (Jackson, 1973). Briefly accurately weighted quantity of samples were mixed using 1:4 to 1:5 ratio. The centrifuged & the pH of the suspension was determined by pH meter.

3.7.6 CO_2 evolution

The Co_2 evolution at was determined by alkali trap method as described by Anderson and Flanagan (1989).

3.7.7 MBC

The MBC of soil was determined by Chloroform Fumigation Extraction method as described by Jenkinson and Powlson (1976)

3.8 Statistical Methods

Experimental data were analysed by adopting standard statistical method of analysis of variance as given by Gomez and Gomez (1984).

3.9 Location / Duration

The experiment was conducted at Research Farm, Department of Soil Science and Agricultural Chemistry, Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2018-2019.

Mixing of ingredient

Turning

Covering of pit

Monitoring

Plate 2 Preparation and monitoring of the compost

CHAPTER IV

RESULTS AND DISCUSSION

Organic inputs are useful for land improvement and crop productivity. The most important need is the production of nutritionally enriched compost with shortest possible time. The use of organic matter may help to improve soil carbon content, biological health of soil and crop production. Although, most of these materials contain significant amount of nitrogen and contain little phosphorus. The use of low grade rock phosphate, elemental sulphur, urea as well as PDKV decomposer found to be increased the effectiveness of compost by enhancing availability of nutrients in compost.

In present study the focus was given on "Dynamics of organic carbon pools during decomposition of crop residues" was conducted at Research Farm, Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2018-19.

The results obtained discussed under the following heads.

4.1 Changes in chemical composition during decomposition of crop residues.

4. 2 Changes in carbon pools during decomposition of crop residues.

4.3 Changes in biological properties during decomposition of crop residues.

4.1 Changes in chemical composition during decomposition of crop residues

4.1.1 pH

4.1.2 Total carbon

4.1.3 Total N

4.1.4 C:N ratio

4.2 Changes in carbon pools during decomposition of crop residues

4.2.1 Very labile

4.2.2 Labile

4.2.3 Less labile

4.2.4 Non labile

4.3 Changes in biological properties during decomposition of crop residues

4.3.1 CO_2 evolution

4.4.2 MBC (Microbial biomass carbon)

4.1.1 pH

The negative logarithm of hydrogen ion activity which indicates the acidic or alkaline nature. It is usually expressed as pH value.

The results pertaining to the periodical changes in pH during composting prepared from different crop residues are presented in Table 3 and fig 2. Decline in pH values was observed with the advancement of decomposition period.

During composting period the pH values remained declining irrespective of the treatments and the time span. At 15 days of composting the pH values ranged between 7.74 to 8.20 which were gradually falls and at 120 days it ranged between 7.18 to 7.49. At the end of composting, the lowest pH (7.18) was observed in treatment (T_6) i.e. 25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles. The highest pH (7.49) was noted in treatment (T_3) 50% WS + 50% SCS. Drastic variation in pH value were observed upto time span of 90 days, thereafter the pH value were almost static or slightly declined.

The present findings are in accordance with those of Singh and Amberger (1998). They pointed out that the initial pH of decomposing straw increased slightly because of addition of cow dung and rock phosphate of high $CaCO_3$, but it decreased gradually with decomposition of organic matter which resulted in the release of organic acids in all treatments. Similar declining trend was noticed by Kumari *et al.* (2008) and Khan and Sharif (2012). Hellal *et al.* (2012) prepared rice straw phosphocompost and they stated that decrease in pH may be caused by increased production of organic acids or increased nitrification.

Table 3. Periodical changes in pH during decomposition of crop residues

Treatments		pH				
		Days after decomposition				
		15	**30**	**60**	**90**	**120**
T_1	100% WS	8.12	7.82	7.69	7.54	7.46
T_2	100% SCS	8.20	7.81	7.61	7.44	7.35
T_3	50% WS + 50% SCS	8.13	7.79	7.61	7.55	7.49
T_4	40% WS + 40% SCS + 20% Glyricidia Leaves	7.82	7.72	7.54	7.37	7.24
T_5	30% WS + 30% SCS + 20% Glyricidia Leaves + 20% Sorghum Stubbles	7.81	7.62	7.50	7.33	7.19
T_6	25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles	7.74	7.61	7.49	7.24	7.18
	SE(m)±	0.01	0.02	0.01	0.06	0.07
	CD at 5%	0.03	0.05	0.02	NS	NS

4.1.2 Total Carbon

The total carbon content was decreased with the increase in the decomposition time. The results pertaining to the periodical changes in total carbon during composting prepared from different crop residues are presented in Table 4 and Fig 3.

At 15 days of decomposition total carbon ranged from 34.78 to 38.73%, whereas, it varied from ranged 29.20 to 34.38% at 30 days, 28.85 to 33.25% at 60 days, 26.60 to 29.83% at 90 days and 24.90 to 27.47 percent at 120 days.

The significantly highest value of total carbon (27.47%) was observed in 100% wheat straw. the lower value (24.90%) of total carbon was found in compost 25% wheat straw + 25% shredded cotton stalk +

25% glyricidia leaves + 25%. followed by 50% wheat straw + 50% shredded cotton stalk. The addition of glyricidia Leaves in combination of

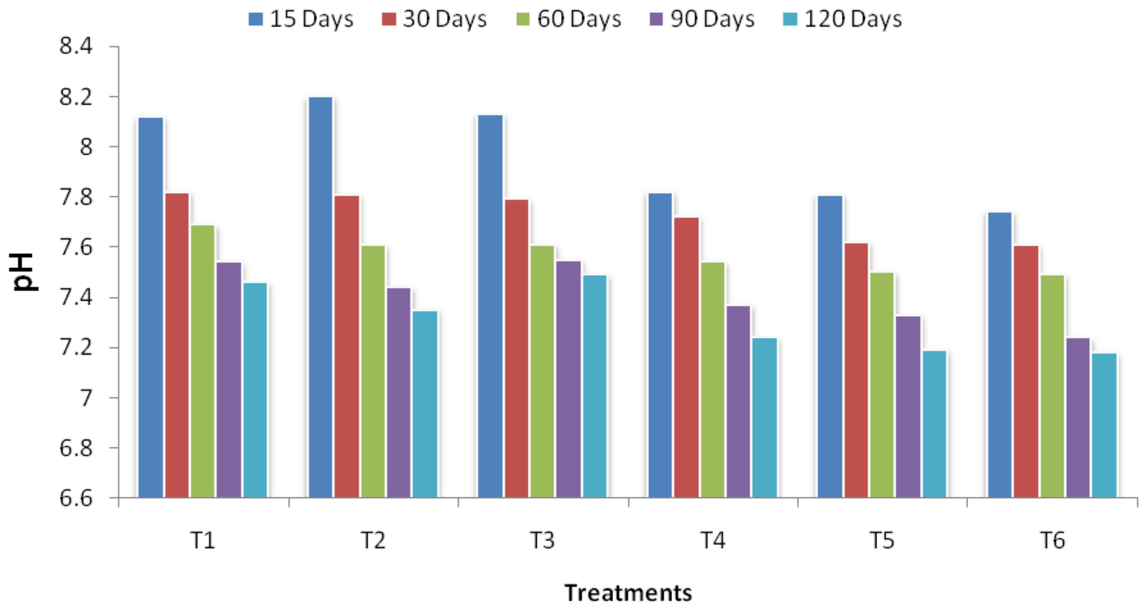


Fig 2: Periodical changes in pH during decomposition of crop residues

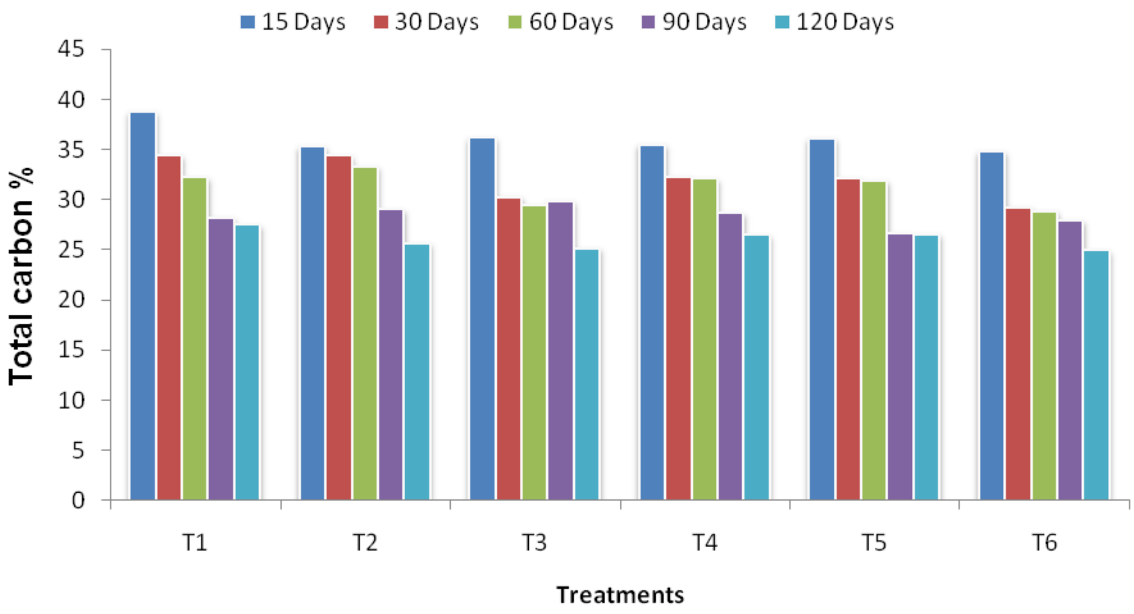


Fig 3. Periodical changes in total carbon during decomposition of crop residues

other crop residues resulted to lower the total carbon content at 120 days of decomposition period.

Gradually and consistent decrease in total carbon content during composting was also noticed by Manna *et al.* (2001), Khan and Sharif (2012). The total carbon content decreased as the decomposition proceeds from 0 to 90 days was noted by Banta and Dev (2009), which may be due to the carbon degrading activity by microbes or due to the stimulating effect of added N on microbial activity during decomposition.

Table 4. Periodical changes in total carbon during decomposition of crop residues

Treatments		Total Carbon (%)				
		Days after decomposition				
		15	30	60	90	120
T_1	100% WS	38.73	34.38	32.18	28.18	27.47
T_2	100% SCS	35.28	34.35	33.25	29.00	25.65
T_3	50% WS + 50% SCS	36.14	30.25	29.38	29.83	25.14
T_4	40% WS + 40% SCS + 20%	35.48	32.20	32.05	28.63	26.44

	Glyricidia Leaves					
T_5	30% WS + 30% SCS + 20% Glyricidia Leaves + 20% Sorghum Stubbles	36.10	32.08	31.85	26.60	26.55
T_6	25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles	34.78	29.20	28.85	27.90	24.90
	SE(m)±	0.66	0.99	0.80	0.96	0.29
	CD at 5%	1.95	2.94	2.37	NS	0.86

4.1.3 Total Nitrogen

Changes in total nitrogen content during composting of crop residues is presented in Table 5 and illustrated in Fig 4.

The decrease in total N in compost prepared from 50% WS + 50% SCS may be due to execution of gliricidia leaves during preparation of compost which contains appreciably higher quantity of N.

The total nitrogen content was increased with the advancement in the decomposition period. The results pertaining to the periodical changes in total nitrogen during composting of crop residues are presented in Table 3 and Fig 3, The total N content at 15, 30, 60, 90 & 120 days of decomposition varied from 0.49 to 0.69%, 0.59 to 0.75%, 0.73 to 0.93%, 0.85 to 1.15% and 1.02 to 1.27% respectively among various treatment at 120 days of decomposition of crop residues. The significantly highest value of total nitrogen content (1.27%) was found in compost prepared from 25% wheat straw + 25% shredded cotton stalk + 25% glyricidia leaves + 25% sorghum stubbles and it was found to be on par with compost prepare from 30% wheat straw + 30% shredded cotton stalk + 20% glyricidia leaves + 20% sorghum stubbles followed by with compost prepare from 40% wheat straw + 40% shredded cotton stalk + 20% gyricidia leaves. Significantly lower total nitrogen content (1.02) was observed in 50% wheat straw + 50% shredded cotton stalk.

The compost prepared from various crop residues along with glyricidia leaves in total nitrogen content. This effect was might be due to higher concentration of nitrogen in glyricidia leaves.

The results of the present investigation are in congruence with those of Manna *et al.* (2001) and Khan and Sharif (2012). They found that the total N content of compost treatments were in increasing trend with increase in decomposition period. The similar findings were also reported by Banta and Dev (2009). They stated that addition of microbial inoculants in rock phosphate lead to increase in N content of mature compost and addition of rock phosphate accelerates the mineralization of N. Similarly, Sibi (2011) concluded that apparent increase in total nitrogen content in compost is not only due to enrichment but also due to the reduction in weight because of decomposition.

Table 5. Periodical changes in total nitrogen during decomposition of crop residues

Treatments		**Total Nitrogen (%)**				
		Days after decomposition				
		15	**30**	**60**	**90**	**120**
T_1	100% WS	0.56	0.63	0.78	0.91	1.19
T_2	100% SCS	0.49	0.61	0.73	0.85	1.05
T_3	50% WS + 50% SCS	0.52	0.59	0.75	0.89	1.02
T_4	40% WS + 40% SCS + 20% Glyricidia Leaves	0.64	0.74	0.87	1.03	1.21
T_5	30% WS + 30% SCS + 20% Glyricidia Leaves + 20% Sorghum Stubbles	0.66	0.71	0.90	1.09	1.25
T_6	25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles	0.69	0.75	0.93	1.15	1.27
	SE(m)±	0.03	0.02	0.02	0.02	0.05
	CD at 5%	0.09	0.05	0.05	0.06	0.13

4.1.4 C: N ratio

Changes in C:N ratio was recorded at regular interval during decomposion of crop residues and presented in Table 6 and graphically depicted in Fig 5.

The C:N ratio of the substrate is the most important factor in the process of decomposition. Wider the C:N ratio slower will be the decomposition. *viz*. Narrower C:N ratio attack more rapidly by decomposing microorganisms.

The C:N ratio of various crop residues used for the preparation of compost varied widely as the days of decomposition proceeds. During the initiation of composting i.e. after 15 days the C:N ratio was wider. The C:N ratio of the various treatments ranged between 50.77 to 72.75 at 15 days of decomposition, 39.19 to 56.78 at 30 days, 31.00 to 45.63 at 60 days, 24.33 to 34.12 at 90 days and 19.63 to 24.77 at 120 days of decomposition respectively .

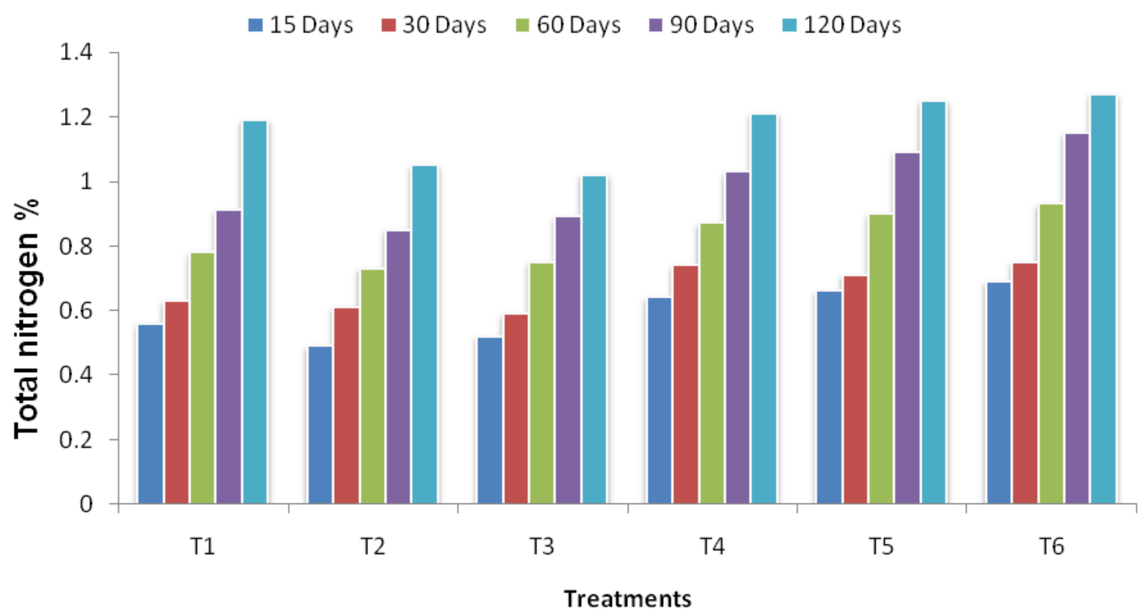


Fig 4. Periodical changes in total nitrogen during decomposition of crop residues.

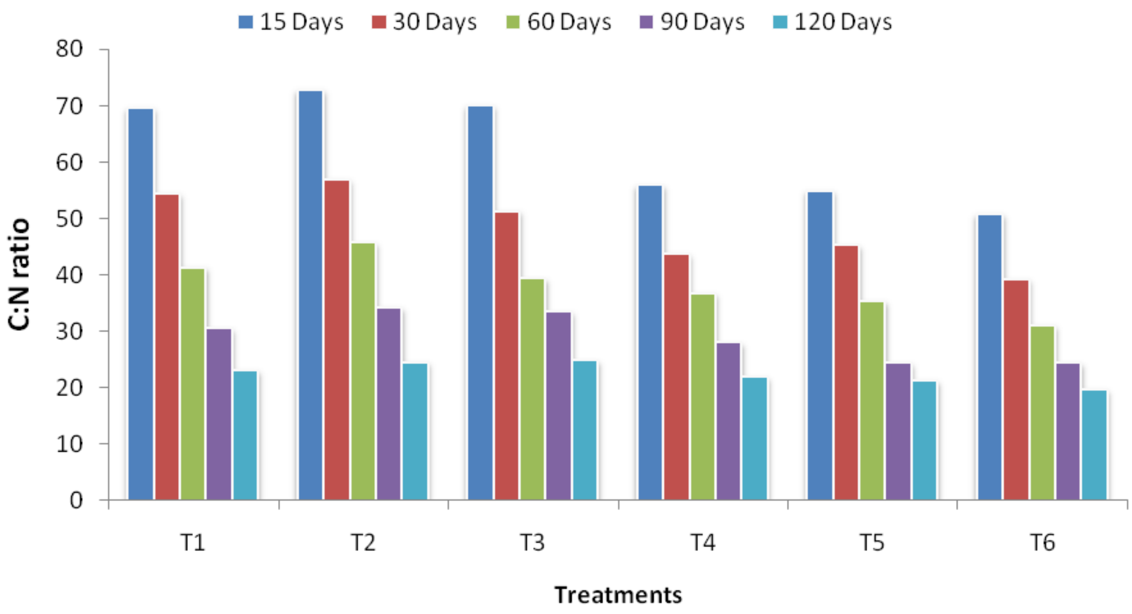


Fig 5. Periodical changes in C:N ratio during decomposition of crop residues.

The significantly highest C:N ratio i.e. 24.77 at 120 days stage was recorded in the treatment of composting prepared from 50% wheat straw + 50% shredded cotton stalk and significantly lower values (19.63) of C:N ratio was obtained in the compost prepared from wheat straw, shredded cotton stalk, glyricidia leaves and sorghum stubbles.

The decrease in C:N ratio with time span might be due to decrease in carbon content which absorbed due to loss of organic carbon through oxidation and simultaneously increase in the total nitrogen.

Table 6. Periodical changes in C:N ratio during decomposition of crop residues

Treatments		C:N Ratio				
		Days after decomposition				
		15	30	60	90	120
T_1	100% WS	69.50	54.30	41.30	30.44	23.04
T_2	100% SCS	72.75	56.78	45.63	34.12	24.49

T_3	50% WS + 50% SCS	69.97	51.27	39.30	33.42	24.77
T_4	40% WS + 40% SCS + 20% Glyricidia Leaves	55.87	43.66	36.67	27.93	21.85
T_5	30% WS + 30% SCS + 20% Glyricidia Leaves + 20% Sorghum Stubbles	54.90	45.18	35.33	24.36	21.24
T_6	25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles	50.77	39.19	31.00	24.33	19.63
	SE(m)±	0.68	0.41	0.65	0.83	0.91
	CD at 5%	2.02	1.21	1.92	2.48	2.71

The results are in confirmity with the finding of by Banta and Dev (2009), they noticed that the C:N ratio at the initiation stages of composting was higher, which was narrowed down at maturity of compost. This reduction may be due to carbon degrading activity of microbial inoculents. Khan and Sharif (2012) also concluded that reach of C:N ratio with the time span might be due to escape of CO_2 after decomposition. While, mostly nitrogen remain in the system. Similar observation was reported by Hellal (2012).

4.2 Changes in carbon pools during decomposition of crop residues

4.2.1 Very labile carbon

The periodical changes during composting that is after 15, 30, 60, 90, 120 days decomposition stage is presented in Table 7 and graphically depicted in Fig 6.

The very labile carbon content during decomposition of crop residues varied among treatments and days after decomposition. The very labile carbon at 15 days of decomposition ranged from 6.01 to 9.95 g kg^{-1}, at 30 days of decomposition ranged from 6.47 to 10 g kg^{-1}, at 60 days of decomposition ranged from 8.45 to 11.63 g kg^{-1}, at 90 days of decomposition ranged from 10.42 to 14.88 g kg^{-1} and at 120 days of decomposition it was ranged from 13.01 to 18.64 g kg^{-1}.

The significantly highest value of very labile carbon content i.e. 18.64 g kg^{-1} was recorded in compost prepared from 25% WS + 25% SCS + 25% glyricidia geaves + 25% sorghum stubbles and it was found to be on par with decompost prepared from 30% WS + 30% SCS + 20% glyricidia leaves + 20% sorghum stubbles, and followed by (T_4) 40% WS + 40% SCS + 20% glyricidia leaves and 50% WS + 50% SCS ,followed by (T_1) 100% WS. The significantly lower value i.e. 13.01 g kg^{-1} was recorded in compost prepared from 100% shredded cotton stalk.

The compost prepared from various crop residues in combination with glyricidia leaves resulted in higher content of very labile carbon. The very labile pool of carbon is a active pool of carbon. The turnover period range from few days to one year. The addition of glyricidia leaves during preparation of compost resulted accumulation of very labile pool of carbon. The degradation of glyricidia leaves occurs within a very short span of time due to narrow C:N ratio which ultimately accumulated the very labile pools of carbon. The results are similarly with finding reported by Das *et al*. (2016) that NPK+FYM treatment encouraged the accumulation of very labile carbon pool. The similarly findings Naresh *et al.* (2018) concluded that residue and nutrient management on carbon stocks and increased labile organic carbon fractions increased dissolved organic carbon, microbial biomass carbon light and heavy fractions of carbon.

Table 7. Periodical changes in very labile carbon during decomposition of crop residues

Treatments		Very Labile carbon (g kg^{-1})				
		Days after decomposition				
		15	30	60	90	120
T_1	100% WS	6.84	7.82	8.85	11.95	16.35
T_2	100% SCS	6.01	6.47	8.45	10.42	13.01
T_3	50% WS + 50% SCS	7.38	8.66	9.55	10.58	15.84
T_4	40% WS + 40% SCS + 20% Glyricidia Leaves	8.59	9.23	10.10	12.51	16.72
T_5	30% WS + 30% SCS + 20%	8.79	9.50	11.04	14.68	17.99

	Glyricidia Leaves + 20% Sorghum Stubbles					
T6	25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles	9.95	10.00	11.63	14.88	18.64
	SE(m)±	0.68	0.58	0.57	0.88	0.91
	CD at 5%	2.03	1.73	1.70	2.61	2.69

4.2.2 Labile carbon

The periodical changes in labile carbon during composting of crop residues at 15, 30, 60, 90, 120 days are presented in Table 8 and graphically depicted in Fig 7.

The labile carbon content in compost prepared from various crop residues at 15 days of decomposition ranged from 0.28 to 0.56 g kg^{-1}, at 30 days of decomposition ranged from 0.45 to 0.90 g kg^{-1}, at 60 days ranged from 1.04 to 1.49 g kg^{-1}, at 90 days ranged from 1.90 to 3.40 g kg^{-1} and 2.51 to 5.65 at 120 days of decomposition.

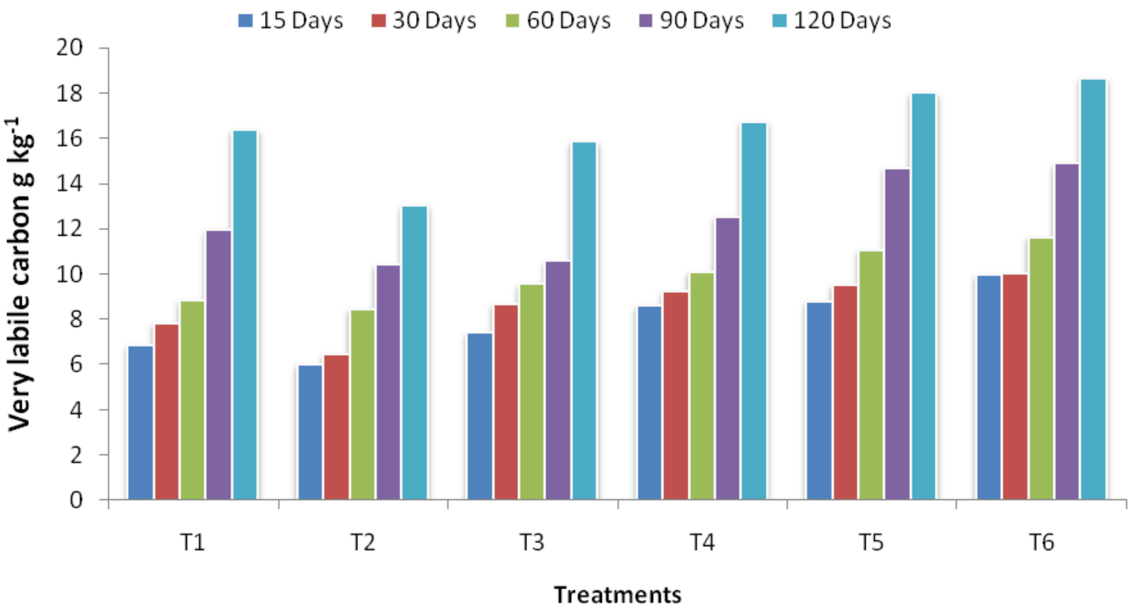


Fig 6. Periodical changes in very labile carbon during decomposition of crop residues.

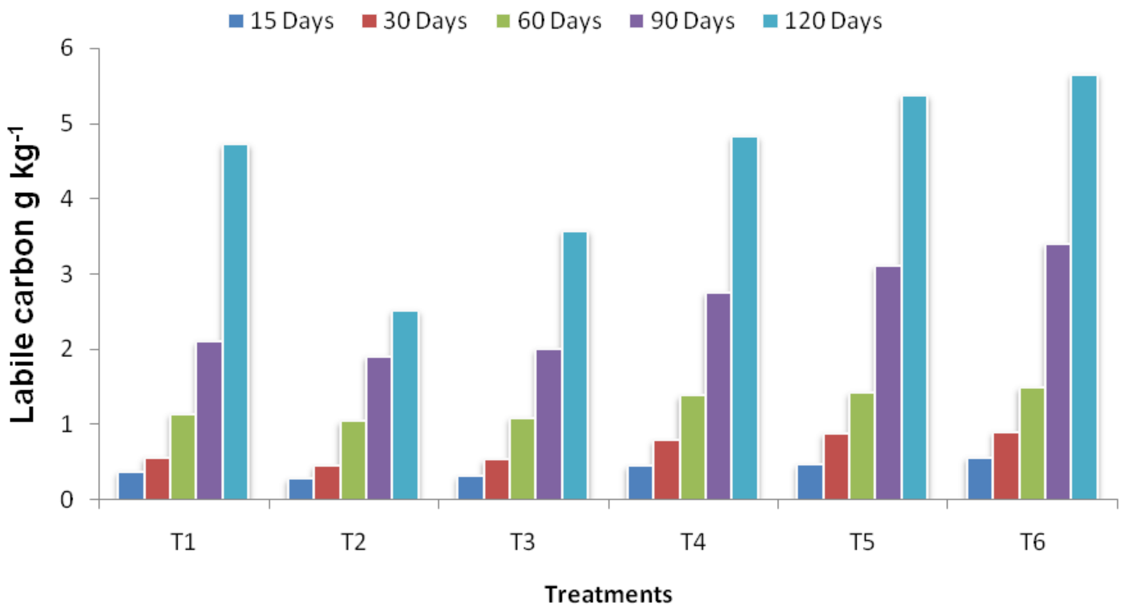


Fig 7. Periodical changes in labile carbon during decomposition of crop residues.

The significantly highest labile carbon content (5.65 g kg^{-1}) was recorded in compost prepared from 25% WS + 25% SCS + 25% glyricidia geaves + 25% sorghum stubbles and it was found to be on par with compost from 30% WS + 30% SCS + 20% glyricidia leaves + 20% sorghum stubbles followed by compost from 40% WS + 40% SCS + 20% glyricidia leaves and 50% WS + 50% SCS followed by compost from 100% WS. The significantly lower value labile carbon (2.51 g kg^{-1}) was recorded in compost prepared from 100% shredded cotton stalk during decomposition.

Table 8. Periodical changes in labile carbon during decomposition of crop residues

Treatments		Labile carbon (g kg^{-1})				
		Days after decomposition				
		15	**30**	**60**	**90**	**120**
T_1	100% WS	0.37	0.56	1.14	2.10	4.72

T_2	100% SCS	0.28	0.45	1.04	1.90	2.51
T_3	50% WS + 50% SCS	0.31	0.53	1.09	2.00	3.57
T_4	40% WS + 40% SCS + 20% Glyricidia Leaves	0.45	0.79	1.38	2.75	4.82
T_5	30% WS + 30% SCS + 20% Glyricidia Leaves + 20% Sorghum Stubbles	0.47	0.88	1.42	3.10	5.37
T_6	25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles	0.56	0.90	1.49	3.40	5.65
	SE(m)±	0.01	0.02	0.09	0.11	0.58
	CD at 5%	0.03	0.06	0.27	0.34	1.71

The compost prepared from combination of glyricidia leaves along with other crop residues resulted in higher content of labile carbon pools this might be due to easily de gradation of glyricidia as compare to other crop residues which ultimately resulted in accumulation of labile pools of carbon. Similarly, it was reported by Das *et al*. (2016) that NPK+FYM treatment encouraged the accumulation of very labile carbon pool. The similarly findings Naresh *et al.* (2018) concluded that residue and nutrient management on carbon stocks and increased labile organic carbon fractions increased dissolved organic carbon, microbial biomass carbon light and heavy fractions of carbon.

4.2.3 Less labile carbon

The periodical changes in less labile carbon pools at 15, 30, 60, 90, 120 days of decomposition are presented in Table 9 and graphically depicted in Fig 8.

The less labile carbon content at 15, 30, 60, 90 & 120 days of decomposion ranged from 0.31 to 0.45, 0.58 to 0.85, 0.66 to 0.90, 0.69 to 0.98 and 1.66 to 2.28 g kg^{-1} respectively. The significantly highest less labile cabon content (0.45 g kg^{-1}) was recorded in compost prepared from 25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles. The relatively lower value of less labile carbon (0.31 g kg^{-1}) was recorded in compost prepared from 100% shredded cotton stalk.

Table 9. Periodical changes in Less labile carbon during decomposition of crop residues

Treatments		Less Labile carbon (g kg^{-1})				
		Days after decomposition				
		15	**30**	**60**	**90**	**120**
T_1	100% WS	0.34	0.62	0.79	0.92	1.83
T_2	100% SCS	0.31	0.58	0.66	0.69	1.66
T_3	50% WS + 50% SCS	0.33	0.61	0.71	0.88	1.82
T_4	40% WS + 40% SCS + 20% Glyricidia Leaves	0.40	0.73	0.82	0.93	1.83
T_5	30% WS + 30% SCS + 20% Glyricidia Leaves + 20% Sorghum Stubbles	0.42	0.81	0.88	0.95	1.92
T_6	25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles	0.45	0.85	0.90	0.98	2.28
	SE(m)±	0.01	0.01	0.04	0.03	0.27
	CD at 5%	0.04	0.03	0.11	0.10	NS

The gradual decrease in less labile carbon was observed with the advancement of decomposition period. At 120 days of decomposition the lower value of less labile carbon (1.66 g kg^{-1}) was recorded in compost prepared from 100% shredded cotton stalk during decomposition. The compost prepared from combination of glyricidia leaves along with other crop residues resulted in higher content of less labile carbon. Similarly, it was reported Das *et al*. (2016) that NPK+FYM treatment under long term fertilization with FYM was significant. The similarly findings Naresh *et al.* (2018) concluded that residue and nutrient management on carbon stocks and increased labile organic carbon fractions increased dissolved organic carbon, microbial biomass carbon light and heavy fractions of carbon.

4.2.4 Non- labile carbon

The periodically changes in non-labile carbon during decomposition is presented in Table 10 and graphically depicted in Fig 9.

The non-labile carbon content in compost prepared from different crop residues ranged from 33.68% to 37.98% at 15 days of decomposition, 38.03% to 33.60% at 30 days, 27.45% to 32.24% at 60 days, 24.73% to 28.48% at 90 days, 22.29% to 25.14% at 120 days of decomposition. The non-labile carbon content was gradually decreased with advancement of time span of decomposition. The decline in non-labile carbon was observed under almost the treatments, However the lower value are observed in the compost prepared from all combination of crop residues.

The significantly highest non- labile carbon content (37.98%) was recorded in compost prepared from 100% WS. The lower value of non-labile carbon pools i.e. (22.29%) was recorded in compost prepared from 25% WS + 25% SCS + 25% glyricidia leaves + 25% sorghum stubbles at 120 days after decomposition. The lower values of non-labile carbon pools under such treatments would be due to addition of glyricidia leaves which accelerate to convert non-labile fracfions of carbon to very labile carbon & active pools of carbon. Similarly, it was reported Das *et al*. (2016) that NPK+FYM treatment under long term fertilization with FYM was significant. The similarly findings Naresh *et al.* (2018) concluded that residue and

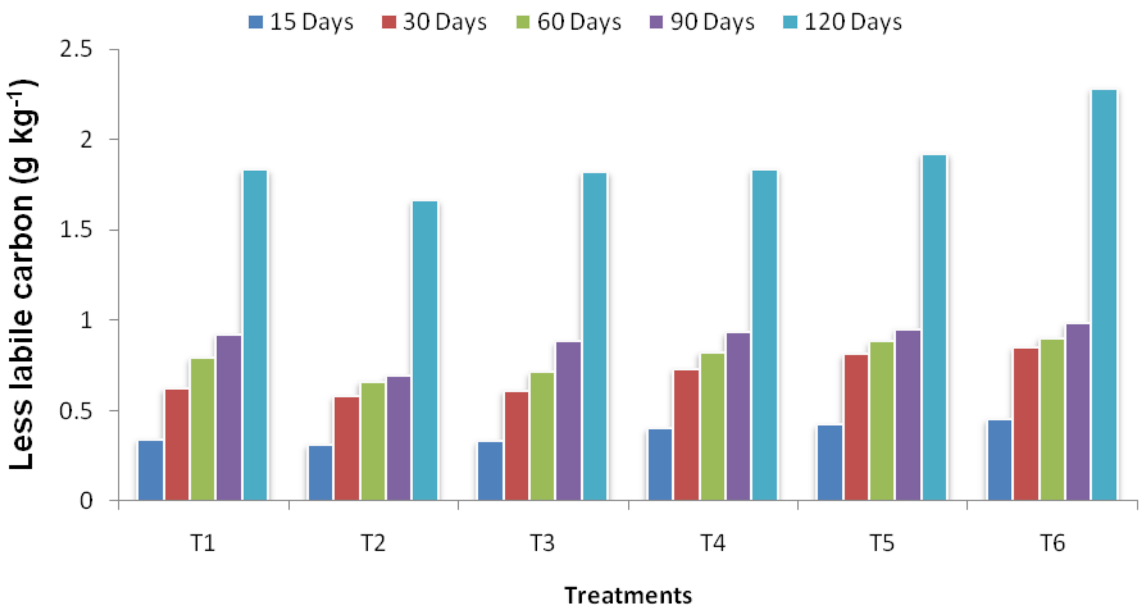


Fig 8. Periodical changes in Less labile carbon during decomposition of crop residues.

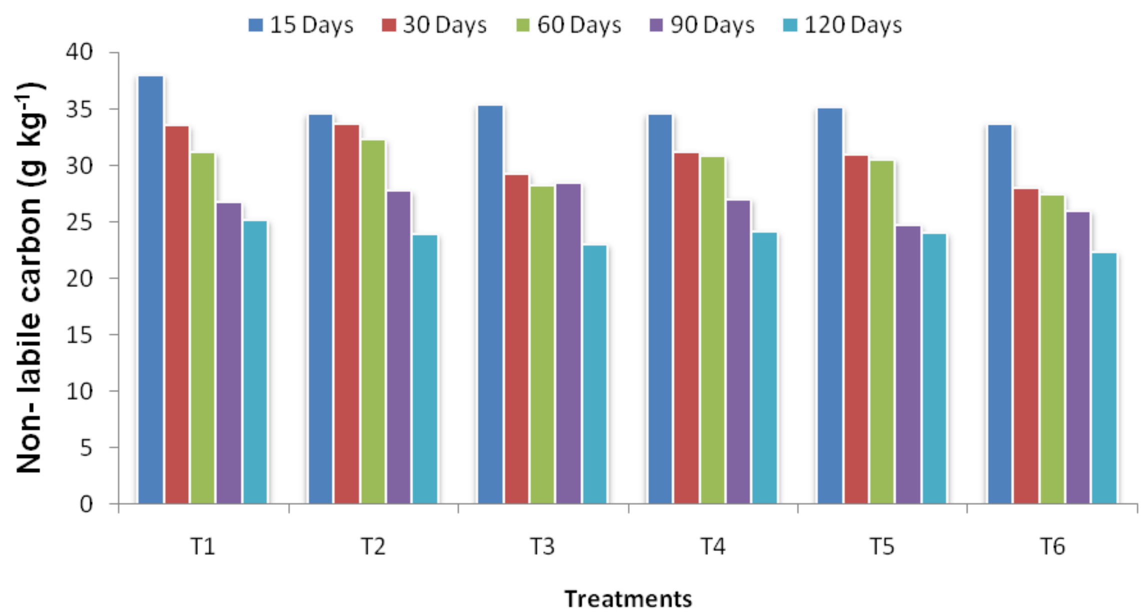


Fig 9. Periodical changes in Non- labile carbon during decomposition of crop residues.

nutrient management on carbon stocks and increased labile organic carbon fractions increased dissolved organic carbon, microbial biomass carbon light and heavy fractions of carbon.

Table 10. Periodical changes in Non- labile carbon during decomposition of crop residues

Treatments		Non-Labile (%)				
		Days after decomposition				
		15	30	60	90	120
T_1	100% WS	37.98	33.48	31.10	26.68	25.14
T_2	100% SCS	34.54	33.60	32.24	27.70	23.93
T_3	50% WS + 50% SCS	35.34	29.27	28.24	28.48	23.02
T_4	40% WS + 40% SCS + 20% Glyricidia Leaves	34.54	31.13	30.82	27.01	24.10
T_5	30% WS + 30% SCS + 20% Glyricidia Leaves + 20% Sorghum Stubbles	35.13	30.96	30.52	24.73	24.02
T_6	25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles	33.68	28.03	27.45	25.97	22.29
	SE(m)±	1.28	0.75	1.36	0.76	0.49
	CD at 5%	3.80	2.24	4.05	2.24	NS

4.3 Changes in biological properties during decomposition of crop residues

4.3.1 CO_2 evolution

The data pertaining to periodical changes in CO_2 evolution are presented in Table 11 and graphically represented in Fig 10. The CO_2 evolution studies which determined the O_2 consumption or CO_2 evolution under aerobic conditions. The mineralization of the organic matter by microbes during decomposition CO_2 evolution is an important feature that determines compost quality and relates to the degree to which the rate of microbial active and organic matter has been stabilized.

The respiration rate increased up to 60 days of composting, thereafter, the respiration rate was decreased at 90 and 120 days of composting in respect of various treatments.

Table 11. Periodical changes in CO_2 evolution during decomposition of crop residues

Treatments		CO_2 evolution (mg CO_2 per 100 g 24 h^{-1}) Days after decomposition				
		15	**30**	**60**	**90**	**120**
T_1	100% WS	27.50	36.30	51.85	44.55	40.15
T_2	100% SCS	24.75	34.10	47.15	40.95	38.08
T_3	50% WS + 50% SCS	25.85	35.20	48.95	43.45	39.05
T_4	40% WS + 40% SCS + 20% Glyricidia Leaves	32.78	42.15	54.45	47.85	41.25
T_5	30% WS + 30% SCS + 20% Glyricidia Leaves + 20% Sorghum Stubbles	36.35	44.35	58.85	50.05	42.35
T_6	25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles	38.00	47.65	63.25	52.25	43.45
SE(m)±		0.36	0.50	0.32	0.37	0.33
CD at 5%		1.07	1.49	0.94	1.09	0.99

At 15 days of decomposition, the CO_2 evolution was varied between 24.75 to 38.00 mg CO_2 per 100 g 24 h^{-1}. The higher CO_2 evolution i.e. 38 mg CO_2 per 100 g 24 h^{-1} was recorded in compost prepared from 25% WS + 25% SCS + 25% glyricidia leaves + 25% sorghum stubbles (T_6) and minimum CO_2 evolution i.e. 24.75 mg CO_2 per 100 g 24 h^{-1} was recorded in compost prepared from 100% Shredded Cotton Stalk (T_2), At 30 day the CO_2 evolution ranged between 34.10 to 47.65 (mg CO_2 100 g 24 h^{-1}), at 60 days, the CO_2 evolution ranged between 47.15 to 63.25 mg CO_2 per 100 g 24 h^{-1} and at 90 days of decomposition, the CO_2 evolution ranged between 40.95 to 52.25 mg CO_2 per 100 g 24 h^{-1}.

At 120 days, the CO_2 evolution ranged between 38.08 to 43.45 mg CO_2 100 g 24 h^{-1}. The higher CO_2 evolution 43.45 mg CO_2 per 100 g 24 h^{-1} was recorded with 25% WS + 25% SCS + 25% glyricidia leaves + 25% sorghum stubbles (T_6). The minimum CO_2 evolution 38.08 mg CO_2 per 100 g 24 h^{-1} were recorded in treatment of 100% SCS (T_2).

The higher CO_2 evolution was observed in compost prepared from 25% WS + 25% SCS + 25% glyricidia leaves + 25% sorghum stubbles, suggesting that higher rate of CO_2 evolution associated with higher decomposition rate and relatively less C:N ratio. Similar time of work was reported by Bharadwaj and Gaur (1970). They reported that increase in the reduction of carbon content was due to the increase in the microbial activities with the fineness of the materials and availability of oxygen during decomposition.

Similar findings were observed by Patil (2012) and Kumar (2015).

4.3.2 MBC (Microbial biomass carbon)

The data pertaining to periodical changes in microbial biomass carbon are presented in Table 12 and graphically represented in Fig 11.

The microbial biomass carbon was increased with the increase in the days of decomposition. At 15, 30, 60, 90 and 120 days of decomposition MBC is varied from 65.18 to 96.91, 127.06 to 143.95, 209.8 to 279.03, 222.60 to 282.62 and 151.10 to 196.20 μg g^{-1} respectively.

The higher microbial biomass carbon i.e. 196.29 μg g^{-1} was recorded in the compost prepared from 25% WS + 25% SCS + 25% glyricidia leaves + 25% sorghum stubbles (T_6) and it was found to be on par with 40% WS + 40% SCS + 20% Glyricidia Leaves. and minimum microbial biomass carbon 151 μg g^{-1} were recorded in treatment of 100% SCS (T_2). The gradual increase in the microbial biomass carbon during decomposition of crop residues is associated with rate of decomposition which enhances the activity of microbial acting on substrates. therefore

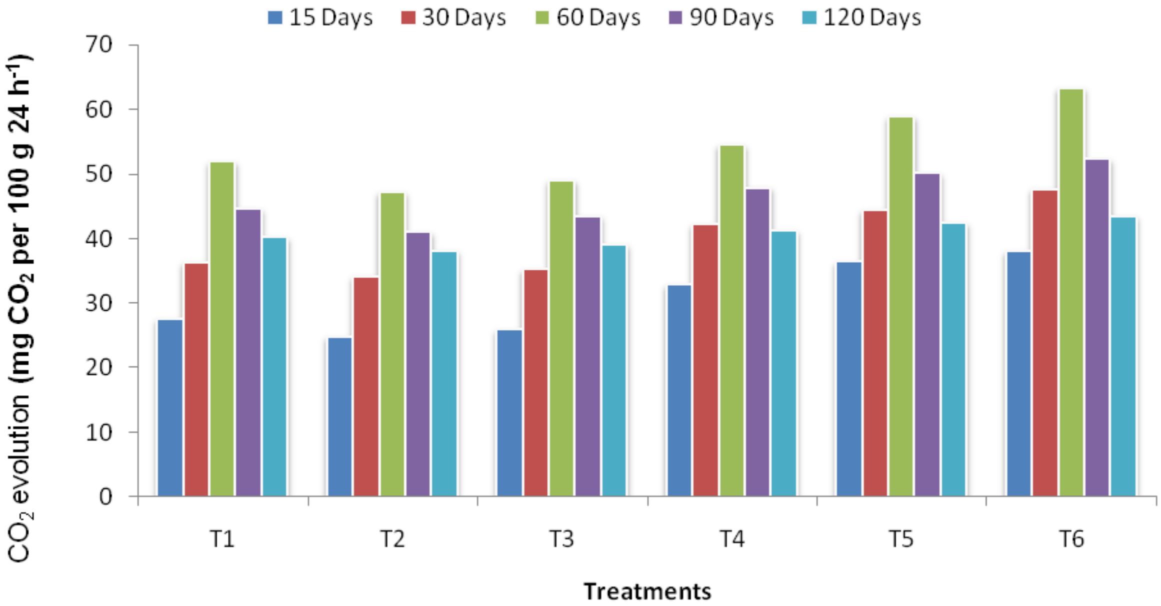


Fig 10. Periodical changes in CO_2 evolution during decomposition of crop residues.

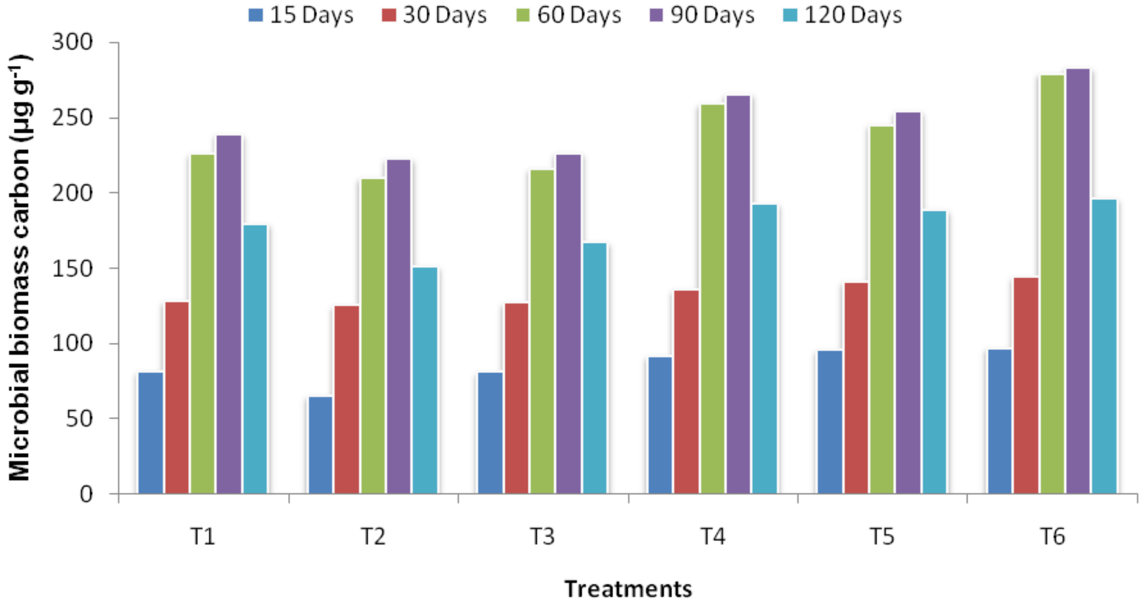


Fig 11. Periodical changes in Microbial biomass carbon during decomposition of crop residues

reflected in improving the microbial biomass carbon during decomposition. Similar findings were reported by Manna *et al*. (2001).

Table 12. Periodical changes in Microbial biomass carbon during decomposition of crop residues

Treatments		MBC (µg g^{-1})				
		Days after decomposition				
		15	30	60	90	120
T_1	100% WS	81.38	128.11	225.96	238.78	179.43
T_2	100% SCS	65.18	125.18	209.80	222.60	151.10
T_3	50% WS + 50% SCS	80.93	127.06	215.99	226.39	167.16
T_4	40% WS + 40% SCS + 20% Glyricidia Leaves	91.50	135.74	258.87	265.50	192.84
T_5	30% WS + 30% SCS + 20% Glyricidia Leaves + 20% Sorghum Stubbles	95.48	140.80	244.90	253.77	188.28
T_6	25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles	96.91	143.95	279.03	282.62	196.29
SE(m)±		0.87	1.05	1.20	0.95	1.02
CD at 5%		2.54	3.07	3.81	2.87	3.24

CHAPTER V

SUMMARY AND CONCLUSIONS

The present investigation entitled “Dynamics of organic carbon pools during decomposition of crop residues" was conducted during the year 2018-19 at Research Farm, Department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola. The experiment was laid out in Completely Randomized Design with six treatments replicated four times. The treatments comprised wheat straw, shredded cotton stalks, glyricidia leaves and sorghum stubbles along with rock phosphate, elemental sulphur, urea, as well as PDKV decomposer and cow dung slurry were mixed with different proportion to study the organic carbon pools and chemical and biological changes during decomposition of crop residues.

The compost samples were collected treatment wise respectively at 15, 30, 60, 90 and 120 days of decomposition and analyzed for chemical properties and organic carbon pools and biological properties during the composting. The crop residues used for composting were analyzed for proximate composition. The salient findings emanated during the course of investigation are summarized and the conclusions emerged are briefly presented in this chapter.

5.1. Changes in chemical composition during decomposition of crop residues

5.1.1 pH

Decline in pH values was observed with the advancement of decomposition period. At 15 days of composting the pH values ranged between 7.74 to 8.20 which were gradually falls and at 120 days it ranged between 7.18 to 7.49. At the end of composting, the lowest pH (7.18) was observed in treatment (T_6) i.e. 25% WS + 25% SCS + 25% glyricidia leaves + 25% sorghum stubbles. The highest pH (7.49) was noted in treatment (T_3) 50% WS + 50% SCS.

5.1.2 Total Carbon

At 15 days of decomposition total carbon ranged from 34.78 to 38.73%, whereas, it varied from ranged from 29.20 to 34.38% at 30 days, 28.85 to 33.25% at 60 days, 26.60 to 29.83% at 90 days, 24.90 to 27.47 percent at 120 days.

The significantly highest value of total carbon (27.47%) was observed in 100% wheat straw. the lower value (24.90%) of total carbon was found in compost 25% wheat straw + 25% shredded cotton stalk + 25% glyricidia Leaves + 25% sorghum stubbles followed by 50% wheat straw + 50% shredded cotton stalk.The addition of glyricidia leaves in combination of other crop residues resulted to lower the total carbon content at 120 days of decomposition period.

5.1.3 Total Nitrogen

The total nitrogen content was increased with the advancement in the decomposition period. Total N content at 15, 30, 60, 90 & 120 days of decomposition varied from 0.49 to 0.69%, 0.59 to 0.75%, 0.73 to 0.93%, 0.85 to 1.15% & 1.02 to 1.27% respectively. Among various treatment at 120 days of decomposition of crop residues. The significantly highest value of total nitrogen content (1.27%) was found in compost prepared from 25% wheat straw + 25% shredded cotton stalk + 25% glyricidia Leaves + 25% sorghum stubbles.

5.1.4 C: N ratio

During the initiation of composting i.e. after 15 days the C:N ratio was wider. The C:N ratio of the various treatments ranged between 50.77 to 72.75 at 15 days of decomposition, 39.19 to 56.78 at 30 days, 31.00 to 45.63 at 60 days, 24.33 to 34.12 at 90 days and 19.63 to 24.77 at 120 days of decomposition respectively . The lower value of C: N ratio (19.63) was obtained in the compost prepared from equal quantity of wheat straw, shredded cotton stalk, glyricidia leaves and sorghum stubbles.

5.2 Changes in carbon pools during decomposition of crop residues

5.2.1 Very labile carbon

The very labile carbon at 15 days of decomposition ranged from 6.01 to 9.95 g kg^{-1}, at 30 days of decomposition ranged from 6.47 to 10 g kg^{-1}, at 60 days of decomposition ranged from 8.45 to 11.63 g kg^{-1}, at 90 days of decomposition ranged from 10.42 to 14.88 g kg^{-1} and 13.01 to 18.64 g kg^{-1} at 120 days of decomposition.

The significantly highest value of very labile carbon content i.e. 18.64 g kg^{-1} was recorded in compost prepared from 25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles.

5.2.2 Labile carbon

The labile carbon content in compost prepared from various crop residues at 15 days of decomposition ranged from 0.28 to 0.56 g kg^{-1}, at 30 days of decomposition ranged from 0.45 to 0.90 g kg^{-1}, at 60 days ranged from 1.04 to 1.49 g kg^{-1}, at 90 days ranged from 1.90 to 3.40 g kg^{-1} and 2.51 to 5.65 at 120 days of decomposition.

The significantly highest labile carbon content (5.65 g kg^{-1}) was recorded in compost prepared from 25% WS + 25% SCS + 25% glyricidia leaves + 25% sorghum stubbles.

5.2.3 Less labile carbon

The less labile carbon content at 15, 30, 60, 90 & 120 days of decomposition ranged from 0.31 to 0.45, 0.58 to 0.85, 0.66 to 0.90, 0.69 to 0.98 and 1.66 to 2.28 g kg^{-1} respectively. The significantly highest less labile carbon content (0.45 g kg^{-1}) was recorded in compost prepared from 25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles.

5.2.4 Non- labile carbon

The non-labile carbon content in compost prepared from different crop residues ranged from 33.68% to 37.98% at 15 days of decomposition, 38.03% to 33.60% at 30 days, 27.45% to 32.24% at 60 days, 24.73% to 28.48% at 90 days, 22.29% to 25.14% at 120 days of decomposition. The decline in non-labile carbon was observed under almost treatments, however, the lower value were observed in the compost prepared from all combination of crop residues.

5.3 Changes in biological properties during decomposition of crop residues

5.3.1 CO_2 evolution

The respiration rate increased up to 60 days of composting, thereafter, the respiration rate was decreased at 90 and 120 days of composting in respect of various treatments.The higher CO_2 evolution i.e. 38 mg CO_2 per 100 g 24 h^{-1} was recorded in compost prepared from 25% WS + 25% SCS + 25% glyricidia leaves + 25% sorghum stubbles (T_6).

5.3.2 MBC (Microbial biomass carbon)

At 15, 30, 60, 90 and 120 days of decomposition MBC was varied from 65.18 to 96.91, 127.06 to 143.95, 209.8 to 279.03, 222.60 to 282.62 and 151.10 to 196.20 μg g^{-1} respectively. The higher microbial biomass carbon i.e. 196.29 μg g^{-1} was recorded in the compost prepared from 25% WS + 25% SCS + 25% glyricidia leaves + 25% sorghum stubbles.

5.4 Conclusion

- From the above study, it can be concluded that, the compost prepared from 25% WS + 25% SCS + 25% glyricidia leaves + 25% sorghum stubbles was found beneficial to increase the concentration of total N and very labile, labile, less labile pools of carbon.
- Similarly, the CO_2 evolution and microbial biomass carbon was higher in the compost prepared from 25% WS + 25% SCS + 25% glyricidia leaves + 25% sorghum stubbles.

CHAPTER VI

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VITA

1. **Name of student** : **AJIT KUMAR MEENA**

2. **Date of Birth** : 07/08/1994

3. **Name of the College** : Post Graduate Institute,
Dr. PDKV, Akola

4. **Residential Address** : Village-Veergaon,Post-Dholkhera,
Teh.-Mahuwa,Dist.-Dausa
Rajasthan.
Mobile No. 9509984928,9079200462
Email – ajitkumarmeena907@gmail.com

5. **Academic Qualification** :

Sr. No.	Name of Degrees awarded	Year in which obtained	Division/ Class	Name of awarding University	Subjects
1	B.Sc. (Agriculture)	2016	first	MPUAT, Udaipur (Rajasthan)	Agriculture

6. **Research papers published(if any)** : NIL

7. **Field of Interest (in which you desire to work)** : Research

Place: **Akola**

Date: /06/2019 **Signature of Student**