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Evaluating the incorporation method of crop residues and its impact on soil biological and chemical properties through decomposition

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Abstract
The preliminary research study was carried out in D block, Department of Agronomy, Tamil Nadu Agricultural University, Agricultural College and Research Institute, Madurai, to evaluate the role of surface area of crop residues through chopping and its impact on soil biological and chemical properties through decomposition. Four different crop residue such as paddy straw, maize stalk, cotton stalk and blackgram stalk along with absolute control was taken for the study. The experiment was laid out in randomized block design with three replications. The data computed during 0^{th}, 15^{th} and 30^{th} days were statistically scrutinised and expressed here as percentage increase in 30 days interval. The study revealed that blackgram stalk incorporation with chopping recorded higher percentage values on microbial load in soil, soil available N, P, K and organic carbon (OC) and also the dehydrogenase enzymatic activity followed by without chopping treatment. This was also followed by cotton stalk, paddy straw and maize stalk with chopping. The least activity was found with paddy straw and maize stalk treatment without chopping and no residue incorporation.

Keywords: crop residue, chopping, decomposition, microbial load and soil chemical properties

1. Introduction
Rice based cropping systems (RBCS) are the main source of food and income for millions of people in India, but crop productivity is either stagnating or declining despite the use of high yielding cultivars (Padre *et al.*, 2005) [9]. This raises major concern over the long-term sustainability of current farming practices and poses a threat to future food security against the background of climate change. Key factors responsible for deterioration in soil fertility and crop productivity include decline in soil organic matter (SOM) due to reduced inputs of bioresources and lack of an adequate rotation (Shibu, Van Keulen Leffelaar, & Aggarwal, 2010) [12], negative macro and micro-nutrient balances leading to depletion of soil fertility and nutrient deficiencies, declining water availability and poor quality water (Farooq, Kobayashi, Wahid, Ito, & Basra, 2009) [3], and deterioration in soil structure of continuously puddled soils in rice (Saharawat *et al.*, 2010) [11]. The decline in the soil fertility, mainly due to the inadequate organic carbon levels in soil, seems to be the most significant factor for decreased sustainability of the system.
Crop residues (CR) are one of the primary source of C inputs (Lal, 2004) [6], and the ways in which these are managed have a significant effect on physical, chemical and biological properties of soil (Kumar & Goh, 2000) [5]. Though CR are produced in larger quantities in India, they were burned by the farmer's due lack of proper management practices and also due to shortage in time for the succeeding crop. This leads to environmental pollution by the emission of green house gases, disturbs soil microfauna and also the nutritive values of residues were lost bounteously. Thus, effective and proper residue management practices have to be established for the benefit of farmer and also towards the concern on ecology.
Biological decomposition is the main and efficient decomposition method in which bacterial and fungal spores speed up the decomposition of waste under aerobic and anaerobic conditions. Microbial decomposition of incorporated crop residue alters the soil's physicochemical environment, (Prasad, 2011) [10] which in turn influences the microbial population/activity in the soil and also the subsequent nutrient transformations. In general, soil enzymes are good markers of soil fertility since they are involved in the cycling of the most important nutrients. Keeping the above facts in view, the objective of the present study was to

investigate the incorporation method of crop residues and its impact on soil biological and chemical properties as described by microbial load, dehydrogenase activity, soil organic carbon and nutrient addition status through decomposition.

2. Materials and Methods

The micro plot study was carried out by collecting various crop residues at Central Farm, Agricultural College and Research Institute, Madurai. The pre sowing composite soil samples from the experimental field were collected and analysed for physio – chemical characteristics. The soil physio chemical characters are depicted in Table 1.

The experiment was conducted during Aug – Sep, 2019. The trail was laid out in randomized block design with the treatments include T1 - Paddy straw incorporation with chopping, T2- Paddy straw incorporation without chopping, T3 - Maize stalk incorporation with chopping, T4 - Maize stalk incorporation without chopping, T5 - Cotton stalk incorporation with chopping, T6 - Cotton stalk incorporation without chopping, T7- Black gram stalk incorporation with chopping, T8 - Black gram stalk incorporation without chopping and T9 - No residue incorporation. The trail was conducted with three replications. Crop residues were quantified (Table 2.) and mixed up to 5 cm depth in the soil after cutting it into pieces to the respective plots. The moisture was maintained at 60 per cent during entire period of composting by sprinkling adequate amount of water.

2.1. Soil sampling & analysis

Soil samples were collected on 0, 15th and 30th days of the decomposition process from 0-20 cm depth at random from the experimental plots. The collected samples were shade dried, powdered and sieved through 0.5 mm sieve. The soil samples were analysed and the methods adopted are for soil texture (Bouyoucos, 1962) [1], pH and EC (Jackson, 1973) [4], microbial population count (Pramer and Schemidt, 1965), organic carbon (Walkley, 1934) [19], N (Subbiah and Asija, 1956) [17], P (Olsen, 1954) [7], K (Stanford and English, 1949) and dehydrogenase enzyme activity (Casida *et al.*, 1964) [2]. All the data was analysed by using ANOVA with 5 per cent level of significance. The statistical analysis was performed by AGRES.

Table 1: Initial Soil Sample Analysis

Particulars	Values
Texture	Sandy clay loam
soil pH	7.03
EC (ds m^{-1})	0.41
Microbes	
Actinomycetes (CFU/ml)	14 x 10^2
Fungi (CFU/ml)	6 x 10^5
Bacteria (CFU/ml)	10 x 10^7
Soil Available Nutrients	
Organic carbon (%)	0.394
Nitrogen (kg/ha)	208.2
Phosphorous (kg/ha)	10.8
Potassium (kg/ha)	274.5
Enzyme Analysis	
Dehydrogenase (µg of TPF g^{-1} of dry soil h^{-1})	0.103

Table 2: Quantification of Crop Residues

Crop Residues	Quantification (kg /m^2)
Paddy straw	0.5
Maize stalk	1
Cotton stalk	0.7
Black gram stalk	0.1

3. Results and discussion

3. 1. Effect of the treatments on microbial population (Table 3 and Fig. 1)

Among the treatments percentage increases of microbial population was higher in with chopping treatment over without chopping as a whole. Based on various crop residue, with its incorporation method, maize stalk incorporation with chopping recorded more bacterial population. Within fungal population maize stalk incorporation with chopping observed more colony percentage and it was found on par with blackgram stalk with incorporation treatments. The same treatment was found higher in population with actinomycetes. And the least was recorded with no residue incorporation treatment. Crop residue incorporation resulted in significantly higher soil microbial population and its biomass over control. All the crop residues management plots were having similar microbial biomass values except that in blackgram residue where significantly lower colonies were observed over the rest of crop residue incorporation treatments (Yusuf *et. al.*, 2009) [23]. Highest counts were evident in the treatments with incorporation of chopped residues with irrigation. In between direct incorporation and chopping plus incorporation treatments, there was a wide variation in microbial load while the differences was also more between different crop residues. But no such improvement was recorded in control plot (Singh *et. al.*, 2012) [14].

3.2. Effect of the treatments on dehydrogenase enzyme activity (Table 3 and Fig. 2)

With all of these treatments incorporated, the percentage increase of enzyme activity was found higher in blackgram stalk incorporation with chopping, followed by without chopping treatment. The least activity was found with no residue incorporation. Among the residue, the blackgram stalk was followed with cotton stalk, maize stalk and paddy straw. Yadvinder-Singh *et. al.* (2005) [22] stated that crop residues incorporation alters the soil environment, which in turn influences microbial population and activity in soil and subsequent nutrient transformations. Incorporation of residues of leguminous crops before sowing the next crop was reported to increase the soil microbial biomass and dehydrogenase activity (DHA) as compared to the control and also with the application of other crop residue treatment (Smitha *et. al.*, 2019) [15].

Table 3: Percentage increases on soil microbial population as influenced by incorporation methods of various crop residues through decomposition of 30 days interval

Treatments	Bacteria (10^{-7}) cfu/ ml	Fungi (10^{-5}) cfu/ ml	Actinomycetes (10^{-2}) cfu/ ml	Dehydrogenase enzyme activity (µg of TPF g^{-1} of dry soil h^{-1})
T1	120.0	116.7	71.4	176.7
T2	80.0	83.3	57.1	170.9
T3	130.0	183.3	78.6	197.1
T4	100.0	116.7	121.4	176.7
T5	90.0	83.3	92.9	276.7
T6	60.0	66.7	64.3	268.0
T7	100.0	183.3	135.7	496.1
T8	80.0	150.0	100.0	488.3
T9	50.0	16.7	42.9	11.7
SEd	3.87	5.03	3.59	11.29
CD (p=0.05)	8.02	10.67	7.61	23.92

T1 - Paddy straw incorporation with chopping, T2- Paddy straw incorporation without chopping, T3 - Maize stalk incorporation with chopping, T4 - Maize stalk incorporation without chopping, T5 - Cotton stalk incorporation with chopping, T6 - Cotton stalk incorporation without chopping, T7- Black gram stalk incorporation with chopping, T8 - Black gram stalk incorporation without chopping and T9 - No residue incorporation.

3.3. Effect of the treatments on soil available nutrient status (Table 4 and Fig. 3)

The higher percentage addition of soil available nutrients of nitrogen, phosphorous and potassium was found in blackgram stalk followed by cotton stalk, paddy straw and maize stalk with chopping treatment. This was followed by without chopping treatments and no residue incorporation. All the residue incorporation treatments gave significantly higher soil available NPK content over control. Among crop residues, incorporation of chopped straw + irrigation proved most beneficial in raising soil available N. The plots under crop residues removal (control) gave the lowest soil available N. The available P and K content in soil also increased in the same trend, due to different methods of residues incorporation over control (Singh *et. al.*, 2012) [14]. Incorporation of crop residues helps in enhancing soil fertility particularly of legumes. The legume straw incorporation enhanced the nutrient availability in soil which in turn resulted better growth and productivity of the subsequent crop (Padma *et. al.*, 2019) [8].

3.4. Effect of the treatments on soil organic carbon (Table 4 and Fig. 4)

With the soil organic carbon percentage, the value was higher with blackgram stalk incorporation with chopping followed by without chopping treatment of the same residue and paddy straw incorporation with chopping. From the crop residues incorporated, the higher percentage of organic carbon was found with blackgram stalk follows paddy straw, maize stalk and cotton stalk. The least was recorded with no residue incorporation. Different methods of residue management had a significant effect on final status of soil organic matter quantified through SOC. All the residue management treatments including control gave significantly higher SOC over its initial value. Legume stubbles contain 49% higher carbon and 133% higher N, and they add 60% more SOC compared to control plots (no residue incorporation) beyond 30 cm depth (Wang *et. al.*, 2004) [20]. But the highest increase in SOC was recorded in incorporation of blackgram residues with chopping over control. Since crop residues were recycled in incorporation treatments, an increase in soil available nutrients and SOC were evident (Singh *et. al.*, 2008) [13]. The increase in SOC over its initial value in a control plot could be attributed to the contribution from inevitable and unknown plant debris in soil. The legume-based residue incorporation ensures huge biomass production and confirms the net gain of soil carbon as compared to cereals (Tiemann *et. al.*, 2015) [18]

Table 4: Percentage increases on soil available nutrients and organic carbon status as influenced by incorporation methods of various crop residues through decomposition of 30 days interval

Treatments	Soil available nutrients (kg/ha)			SOC (%)
	Nitrogen	Phosphorous	Potassium	
T1	0.841	13.95	9.20	17.77
T2	-0.149	2.42	0.85	14.21
T3	0.110	9.67	2.98	17.01
T4	-0.403	1.77	0.32	12.94
T5	1.153	14.33	8.72	14.97
T6	0.250	3.81	0.99	8.63
T7	2.003	14.60	9.34	19.54
T8	1.263	5.02	5.12	18.78
T9	0.067	3.35	0.31	1.27
SEd	0.034	0.37	0.21	0.59
CD (p=0.05)	0.072	0.78	0.44	1.24

T1 - Paddy straw incorporation with chopping, T2- Paddy straw incorporation without chopping, T3 - Maize stalk incorporation with chopping, T4 - Maize stalk incorporation without chopping, T5 - Cotton stalk incorporation with chopping, T6 - Cotton stalk incorporation without chopping, T7- Black gram stalk incorporation with chopping, T8 - Black gram stalk incorporation without chopping and T9 - No residue incorporation.

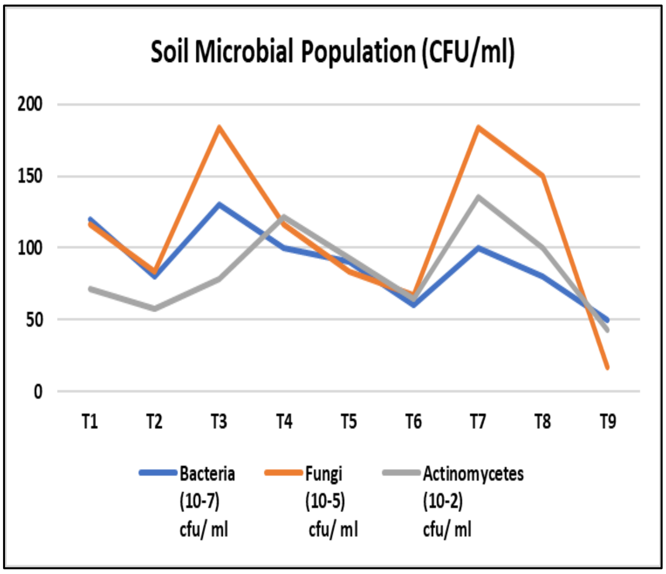

Fig 1: Percentage increase in microbial population

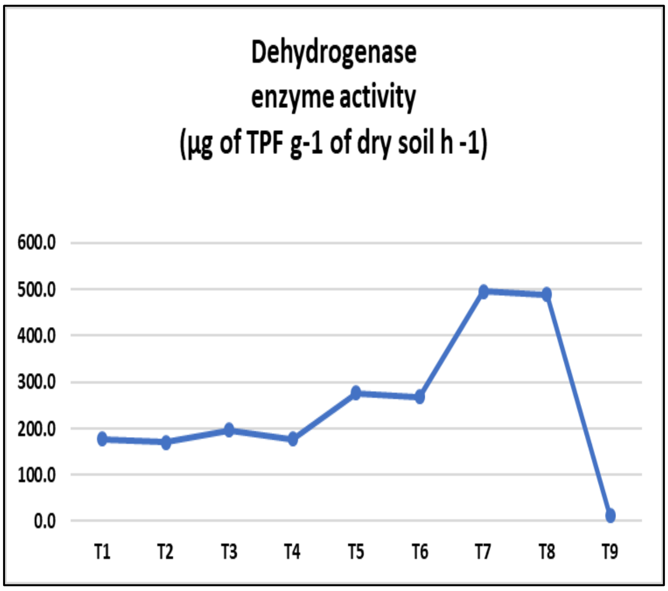

Fig 2: Percentage increase in dehydrogenase activity

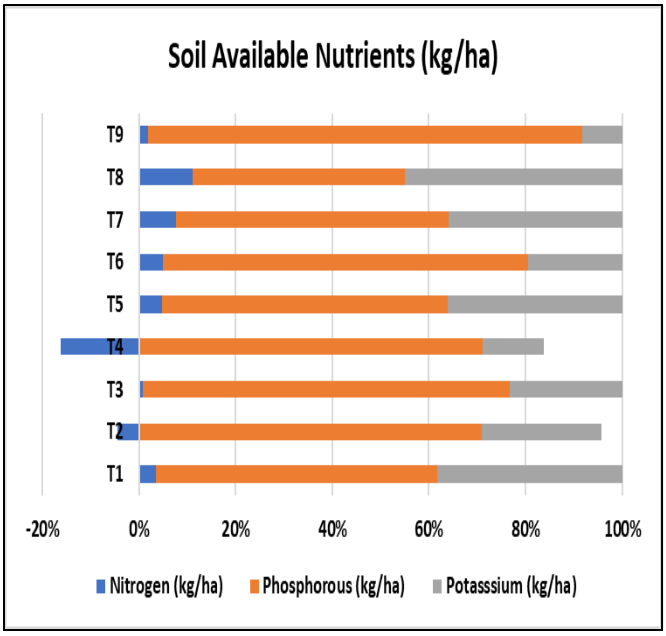

Fig 3: Percentage increase in soil available nutrients

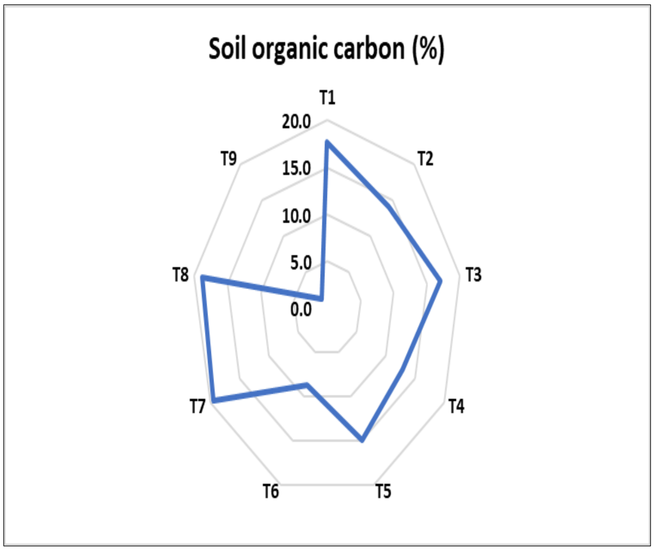

Fig 4: Percentage increase in soil organic carbon

4. Conclusion

From this study, it was concluded that the management practices comprising different crops residue incorporation of with and without chopping treatments have played an important role in decomposition process. This process contributed to a large extends in improving the soil available nutrients, organic carbon and also with the microbial population. Further, from the study it was implicit that the decomposition process mainly depends on the crop residue, method of incorporation and its chemical composition. Thus, it makes all needful nutrients available to plants from the unavailable organic sources. Among all the crop residues incorporated, black gram stalk performed well which was followed by cotton stalk, paddy straw and maize stalk in terms of available nutrients, organic carbon status, enzyme activity and also with the microbial population of the soil.

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