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Incubation Study on Effect of Incorporation of Crop Residue along with Microbial Consortium on MBC and soil microbial population

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ABSTRACT

An incubation experiment was conducted to study the decomposition and its influence on soil health in polyhouse with residue incorporation along with microbial consortium for 90 days to find out the influence of crop residues on MBC and microbial populations..The MBC and microbial populations assayed at different intervals were significantly increased by the application of crop residue along with microbial consortia in residue treated pots either alone or in combination with microbial consortia and starter dose of N and P fertilizers as decomposition accelerators than in treatment that received RDF. Among the treatments, the highest MBC and microbial population were recorded with the treatment $T_{7,}$ which received crop residue @1.5 t ha^{-1} + Microbial consortium@2 kg t^{-1}+ urea 3 kg t^{-1} + SSP 15 kg t^{-1} of residue incorporated was at par with T_6 and T_3 during both the years of the experimentation.

Keywords: *Crop residue, microbial biomass carbon, microbial consortium and soil micro flora.*

In India, crop residues are mostly used as cattle feed but the widespread use of combine harvesters makes crop residues to largely remain in the field and interfere with tillage and seeding operation for the next crop. Hence, farmers are forced to take away the crop residue from field or prefer to burn the residues in order to take next crop immediately. Out of 140 Mt surplus crop residues in India 92 Mt are burned each year (NPMCR, 2019). The burning of 1 ton of paddy straw release 1460 kg carbon dioxide (CO_2), 60 kg carbon monoxide (CO), 3 kg particulate matter (PM), 200 kg ash, and 2 kg sulfur dioxide (SO_2). Moreover, residue burning results in the loss of entire carbon (C), 80 per cent of nitrogen (N), 25 per cent of phosphorus (P), 20 per cent of potassium (K), and 50 per cent of sulfur (S).(Kumawat *et al.*,2021). Loss of carbon from soil will result in reduced microbial activity, affect soil nutrient cycling potential, soil detoxifying capacity and other soil functions in long term. The recycling of crop residues has the advantage for converting the surplus residues into useful product for meeting the nutrient requirement for soil microorganism as well as succeeding crops.

Degradation of organic matter in soil is mainly biochemical in nature involving hydrolysis and oxidation brought about by various hydrolytic enzymes liberated by microorganisms. N-immobilization occurs due to incorporation of crop residue. In soil, the N availability mainly depends on the mineralization of organic- N into inorganic-N forms from soil organic matter, crop residues and urea-based fertilizers. Conservation of soil N depends on the maintenance of a balance between the rate of mineralization of organic N to ammonia and the rate of ammonia consumption by plant uptake, heterotrophic microbial assimilation,NH_3 – oxidising bacteria. The presence of large amounts of nitrates will eventually lead to leaching and denitrification.The objective of this study was how the microbial consortium and N and P fertilizers applied together with korra crop residue with wider C:N ratio has affected the microbial population as well as microbial biomass carbon in soil.

MATERIALS AND METHODS

An incubation study was conducted at green house of Agricultural Research Station, Amaravathi of The Acharya N.G.Ranga Agricultural University of Andhra Pradesh during 2017-18. The bulk surface

soil collected from field no 4 was used for incubation experiment. The soil was processed and filled in 20 kg capacity cement pots. The korra crop residue was used for incorporation in soil @1.5 t ha^{-1} after chopping in to 3-4 cm size the except in control (T_1) and RDF (T_8). Total eight treatments including control were employed and each treatment was replicated thrice by following completely randomized block design. Turnings at weekly intervals were given and the residue was allowed for aerobic decomposition for 90 days and maintained at 60 per cent water filled pore space throughout incubation. Soil samples were collected at *15* days interval after incubation were analysed for assessing the decomposition dynamics of korra crop residue with respect to MBC and microbial population in each treatment. The details of the treatment are as follows.

Treatments

T1: Control (No Crop residue-farmers practice)

T2: Crop residue @1.5 t ha^{-1} alone

T3: Crop residue @1.5 t ha^{-1} + Microbial Consortium @2 kg t^{-1} of crop residue

T4: Crop residue @1.5 t ha^{-1} + Urea 1 kg+ SSP 5 kg t^{-1} of crop residue

T5: Crop residue @1.5 t ha^{-1} + Urea 2 kg+ SSP 10 kg t^{-1} of crop residue

T_6: Crop residue @1.5 t ha^{-1} + Microbial Consortium + Urea 1 kg+ SSP 5 kg t^{-1} of crop residue

T7: Crop residue @ 1.5 t ha^{-1} + Microbial Consortium + Urea 2 kg+ SSP 10 kg t^{-1} of crop residue

T8: RDF

Microbial consortium consists of decompo.A (fungal consortium of *Pleurotus ostreatous*, *Phanerochaete chrysosporium*, yeast and *Trichoderma*), decompo.B(bacterial consortium of *Bacillus sp*, *Lactobacillus sp* and *Pseudomonas sp*) developed at Agricultural Research Station,Amaravathi.Microbial biomass carbon was determined by fumigation-incubation method (Beck *et al.,* 1997). Plate counts of bacteria, fungi and actinobacteria were made at intervals of 15 days during incubation.The soil samples collected at 15 days interval were assayed for MBC and microbial population by following standard methods of AOAC and the initial soil properties and population of bacteria, fungi and actinobacteria were presented in Table 1 and composition of korra crop residue was given in table 2.

Table. 1 Initial soil properties

Soil property	value
pH	8.1
Electrical conductivity(dSm^{-1})	0.23
Organic carbon (%)	0.21
Microbial biomass carbon(µg/g)	148
Bacteria (CFU g^{-1} soil)	10×10^6
Fungi(CFU g^{-1} soil)	10×10^4
Actinobacteria(CFU g^{-1} soil)	20×10^5

RESULTS AND DISCUSSION

The present incubation study entitled was conducted during 2017-18 at Agricultural Research Station, Amaravathi. The results of the incubation experiment were statistically analysed, presented and discussed with appropriate scientific research findings under different sub- heads as detailed below.

Microbial biomass carbon

The microbial biomass carbon content estimated at different intervals of incubation is presented in table 3. The microbial biomass carbon content was significantly influenced up to 60 DAI. The non significant influence at 75 and 90 DAI might be due to slow down in microbial population growth. This was evidenced by existence of a significant positive correlation between microbial biomass carbon and microbial population (r= 0.0923**) at 60DAI. The data (Table 3) revealed an increase in biomass carbon content up to 45 days of incubation and then decreased in all the treatments. Among the treatments, the treatments which received crop residue along with microbial consortia recorded higher microbial biomass content than the treatments which received only crop residue (T_2) and crop residue along with starter dose of inorganic N and P fertilizers (T_4 and T_5). Similarly higher MBC was recorded in crop residue treated plots than untreated plots were observed by Choudhary *et al*. (2018).

Significantly the highest microbial biomass carbon was recorded in T_7 treatment and it was at par with T_6 and T_3 treatments at 15, 30, 45 and 60

DAI. The lowest was recorded in absolute control (T_1) at all intervals and it was at par with T8 at 15DAI. At 45 DAI, the treatment T_7 recorded higher MBC by 31.78 per cent when compared to control. The soil microbial biomass carbon reflects soils ability to store and cycle nutrients and organic matter. The main effect of treatment T_7 on MBC content over time is due to incorporation of korra crop residue along with microbial consortium indicating an increase in beneficial biological functions in soil.

The results are in agreement with Peruci *et al*. (1997) who emphasised the importance of crop residue management in determining soil microbial biomass carbon and recorded greater amount of soil microbial biomass carbon in soils where residues were buried.

Table 2 Chemical composition of crop residue

S.No.	Composition(%)		Method of analysis
1	Cellulose	31.80%	Acid hydrolysis by Van Soest *et al* .(1991)
2	Hemi cellulose	20.80%	
3	Lignin	6.80%	
4	Total carbon	43.40%	Dumas method of combustion technique, Dumas (1831) using CN Analyser
5	Total nitrogen	0.66%	
6	C:N ratio	65:01:00	
Micronutrients (mg kg^{-1})			
7	Fe	112	Di acid digestion and determined using AAS, Tandon (2013)
8	Mn	56	
9	Cu	13	
10	Zn	13.9	

Soil micro flora

The influence of incorporation of korra crop residue along with chemical fertilizers on microbial population viz., bacteria, fungi and actinobacteria estimated at 15 days interval during incubation is presented in table 4 and illustrated in figure 1. The perusal of the data revealed that there was an improvement in soil microbial population *viz.*, total bacteria, fungi and actinobacteria over the initial population after incubation except in T_1. The lowest population in T_1 was apparently due to lack of food for rapid multiplication of microbes. Significantly the highest number of soil microbial population was found in treatment T_7 which received integration of crop residue, microbial consortium and higher doses of starter dose of N and P fertilizer at all intervals. This was followed by T_6 and T_3. The improvement in soil microbial population might be due to the addition of crop residue which might have added a fair quantity of organic matter to the soil, which in turn acted as a substrate for the multiplication and development of microbes either over the initial and absolute control. Similarly, increased trend in soil microbes due to incorporation of residues was also reported by Nagar *et al*. (2016).

At 60 DAI, the maximum bacterial population was recorded in treatment T_7 which was at par with T_6 and T_3 and then decreased with duration of incubation. The activity and growth of microorganisms in earlier and later stages of incubation were limited by the availability of N due to application of korra crop residue with low N content. The higher bacterial population in T_7, T_6 and T_3 was apparently due to external addition of microbial consortium culture dominated by bacterial isolates. Residue retention promotes the microbial abundance compared to residue removal Govaerts *et al*. (2006) and Noya *et al*. (2013). Bacteria dominate in early stages but fungi increased in population at the end of decomposition.

At 75 DAI fungal population was highest in treatment T_7 and then decreased with duration of incubation. This might be due to the action of fungi on decomposed products of bacteria. The fungal population in the soil was relatively less efficient metabolically than the bacteria and actinobacteria in all the treatments throughout the incubation. This also

implies that compared with the fungal population, the bacterial population is probably more active metabolically under the semi-arid conditions. Similar increase in population of bacteria was also reported earlier by Singh (2019) in residue applied treatments. Many researchers have come to the conclusion that the rate of the decomposition of crop residues is affected by the composition and activity of the soil microbiome, especially proteobacteria and actinobacteria, as well as the composition of plant debris. According to Strickland *et al.* (2009), the percentage of proteobacteria, acidobacteria, actinobacteria, and fungi Ascomycota changes with the time of plant residue decomposition. During the process, a decrease in the number of bacteria has been observed, with a simultaneous increase in the number of fungi.

According to Abbasi *et al.* (2015), decomposition increases the surface of mineralized plant debris. As a consequence, it can be conveniently colonized by other types of microorganisms, and get easy access to hydrolyzed polymer compounds (cellulose, lignin, and protein). Plant residues are broken down by successive groups of microorganisms. Easily decomposable compounds are rapidly consumed by bacteria and the recalcitrant fraction increases, resulting in an increase in the fungal community. In the initial stage, bacteria with proteolytic and cellulolytic enzymes dominated but in later stages, nitrifiers dominated. Fungi feed on simple, soluble components (sugars) then, followed by fungi that are specialized polymer degraders. In the last stage of decomposition, the most resistant fraction is broken down by fungi (Ruess, and Ferris, 2004)

The actinobacterial population has increased with duration of incubation up to 45 DAI and decreased later with the days of incubation. The highest population of actinobacteria was recorded in treatment T_7 and it was at par with treatments T_6 and T_3. The increase in actinobacterial population might be due to availability of substrate as food simple sugars, which decreased later due to competition from bacterial groups.

Table 3. Effect of incorporation of korra crop residue on microbial biomass carbon of soil during incubation

Treatment details	Microbial biomass carbon (mg kg^{-1}) of soil					
	15DAI	30DAI	45 DAI	60 DAI	75 DAI	90 DAI
T_1: Absolute control	149	150	151	150	149	149
T_2:Crop residue @1.5 t ha^{-1}	169	170	171	156	154	150
T_3:T_2+MC@2 kg t^{-1} of residue	180	183	184	180	162	154
T_4:T_2+Urea 1.5kg+SSP 7.5 kg t^{-1} of residue	170	172	174	163	160	152
T_5:T_2+ Urea 3.0 kg+ SSP 15 kg t^{-1} of residue	172	174	176	166	161	153
T_6:T_3+ Urea 1.5 kg+ SSP 7.5 kg t^{-1} of residue	189	186	189	181	163	155
T_7: T_3+ Urea 3 kg+ SSP 15 kg t^{-1} of residue	195	197	199	190	164	156
T_8:RDF(20:50:0:40)	154	167	169	160	153	150
SE(m)+	5.05	4.82	4.54	5.49	4.6	5.5
CD(0.05)	15.14	14.46	13.6	16.45	NS	NS
CV(%)	5.3	4.81	4.48	5.65	5.03	5.53

Table 4. Effect of incorporation of korra crop residue on microbial population of soil during incubation

Treatment details	Bacteria ($CFUx10^6$)						Fungi ($CFUx10^4$)						Actinobacteria ($CFUx10^5$)					
	15 DAI	30 DAI	45 DAI	60 DAI	75 DAI	90 DAI	15 DAI	30 DAI	45 DAI	60 DAI	75 DAI	90 DAI	15 DAI	30 DAI	45 DAI	60 DAI	75 DAI	90 DAI
T_1: Absolute control	10	12	13	15	10	8	8	8	8	8	7	7	18	17	17	17	17	17
T_2:Crop residue @1.5 t ha^{-1}	12	18	20	22	12	11	11	12	15	16	18	9	19	24	23	22	21	20
T_3:T_2+MC@2 kg t^{-1} of residue	23	32	34	37	32	15	16	17	24	25	26	12	23	26	25	24	23	24
T_4:T_2+Urea 1.5kg+SSP 7.5 kg t^{-1} of residue	21	23	24	26	18	12	12	14	17	18	20	11	21	25	24	23	21	20
T_5:T_2+ Urea 3.0 kg+SSP 15 kg t^{-1} of residue	22	25	26	28	20	13	13	15	20	21	22	12	22	24	23	22	22	21
T_6:T_3+ Urea 1.5 kg+SSP 7.5 kg t^{-1} of residue	26	33	35	38	33	16	17	19	25	26	27	14	24	27	26	25	24	23
T_7: T_3+ Urea 3 kg+SSP 15 kg t^{-1} of residue	29	34	36	39	34	17	18	20	27	28	29	15	25	28	27	26	25	24
T_8:RDF(20:50:0:40)	14	16	18	19	12	10	10	10	10	10	10	9	23	21	20	20	19	18
SE(m)±	0.54	1.05	0.84	0.94	0.68	0.54	0.54	0.58	0.65	0.87	0.65	0.54	0.85	0.74	0.82	0.89	0.74	0.79
CD(0.05)	1.62	3.14	2.52	2.8	2.03	1.62	1.62	1.73	1.94	2.6	1.94	1.62	2.26	2.21	2.45	2.67	2.21	2.37
CV(%)	4.8	7.51	5.66	5.79	5.49	7.34	7.13	6.96	6.13	7.89	5.63	8.41	6.09	5.31	6.12	6.89	5.83	6.33

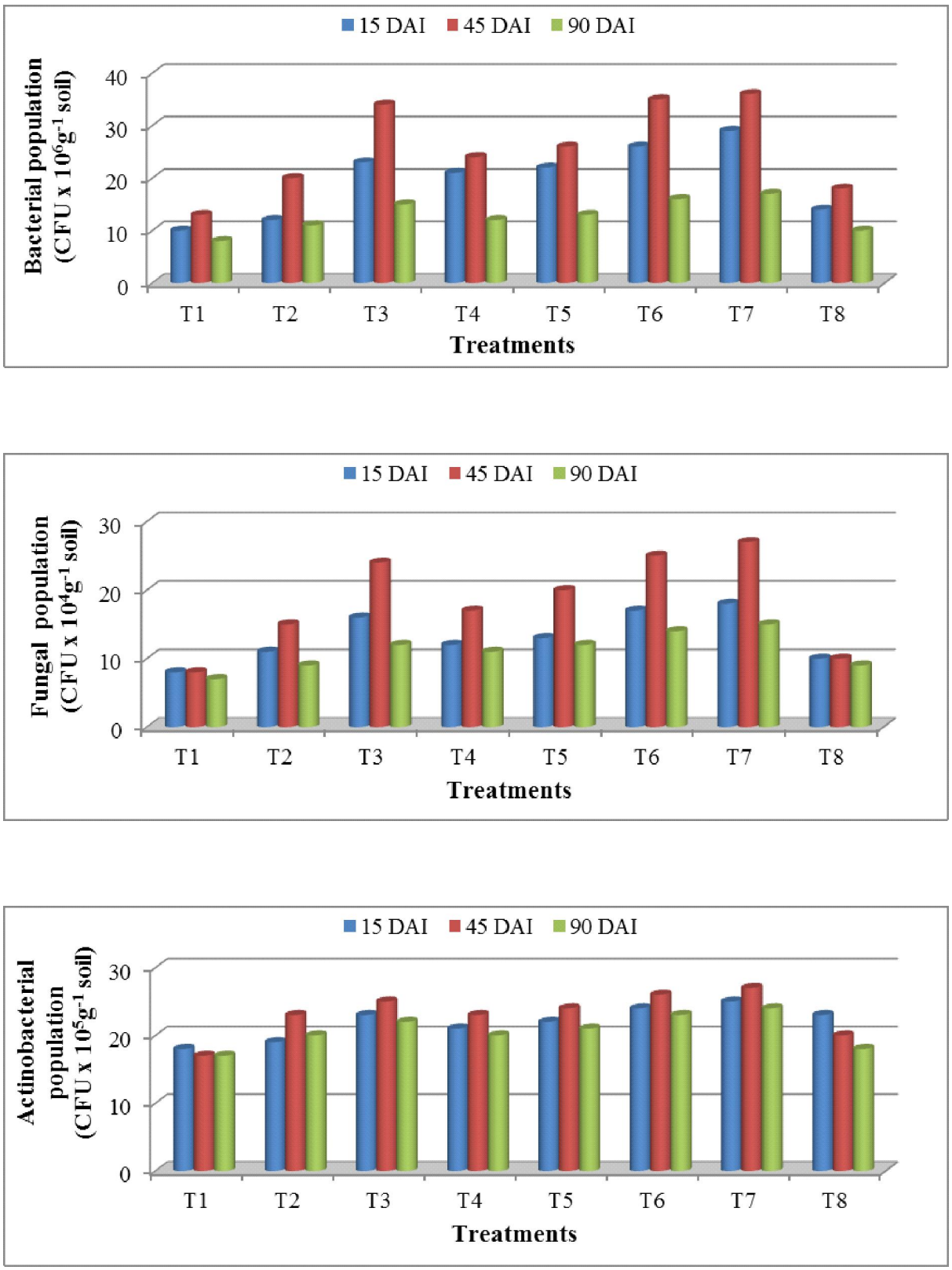

Fig. 1. Effect of incorporation of korra crop residue on microbial population (bacterial (a), fungal (b) and actinobacterial (C) during incubation

The results of the present study indicated that incorporation of korra crop residue having wider C:N ratio along with microbial consortia and N and P fertilizers in soil recorded significantly higher microbial biomass carbon and the population of bacteria, fungi and actinobacteria rather than incorporation of crop residue or inorganic fertilizer alone.

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