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Studies on Effect Of Incorporation of Korra Crop Residue on C And N Dynamics in Soil

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ABSTRACT

An incubation experiment was conducted to study the influence of Korra crop residue along with microbial consortium and nitrogen and phosphorus fertilizers on the decomposition dynamics and nutrient release pattern under greenhouse condition at Agricultural Research Station, Amaravati for 90 days in a completely randomized design. The soil total carbon, total nitrogen, C:N ratio and mineral nitrogen were estimated at 15 days interval and observed that total soil carbon content decreased and content of total soil nitrogen increased with incubation. The total soil carbon content decreased with incubation in all treatments. The decrease was more pronounced in the earlier stages of incubation than at later stages and the decrease in carbon content was more pronounced at all intervals of incubation (15 to 90 DAI) in treatment T_7 which received crop residue @1.5 t ha^{-1} + 3.0 kg MC + 3.0 kg urea +15 kg SSP. The total nitrogen content in the entire residue applied treatments increased progressively with days of incubation whereas decreased N content was observed in case of T_8 (RDF) and T_1 (absolute control). The soil C:N ratio was steadily maintained in absolute control throughout the incubation period where as in treatments which received crop residue from T_2 to T_7 had wider C:N ratio in soil up to 45 days of incubation and at later stages of decomposition the C:N ratio was narrowed with days of incubation. Mineral nitrogen content increased linearly with days of incubation from 15 to 60 days after incubation and then decreased in treatments which received crop residue along with microbial consortium and inorganic fertilizers.

Key words: *Crop residue, microbial consortium, total carbon, total nitrogen, mineral nitrogen, Days after incorporation and C:N ratio*

Crop residues are the main input in maintaining soil organic carbon and nutrients in cultivated soils. The nutrient cycling is a complex process that takes differing amounts of time based on the type of residue. Addition of crop residues into soils leads to rapid decrease in soil nitrate content and increase in soil carbon and nitrogen. Nitrogen mineralization and immobilization are the two important processes that governs the bioavailability of nitrogen from fertilizers and crop residues applied to the soil. Degradation of organic matter in soil is mainly biochemical in nature involving hydrolysis and oxidation brought about by various hydrolytic enzymes liberated by microorganisms. Knowledge about the dynamics of crop residue decomposition becomes essential for sustaining soil health. To recycle crop residues into useful product for meeting the nutrient requirement for soil microorganism as well as succeeding crops in a cropping system the C:N ratio and biochemical composition are useful quality indicators. The information on decomposition of Korra crop residue and its contribution to soil fertility is very scarce as it is one of the millet crops popular in rainfed ecosystem of Andhra Pradesh. Keeping this in view, the present study was conducted to study changes in soil carbon and nitrogen dynamics during the decomposition process.

MATERIALS AND METHODS

An incubation study was conducted at green house of Agricultural Research Station, Amaravati, AcharyaN. G. Ranga Agricultural University of Andhra Pradesh during 2017-18. The bulk surface soil collected from field was clayey in texture used for incubation experiment. The soil was processed and filled in 20 kg capacity cement pots. The experiment was conducted with eight treatments maintaining absolute control without incorporation of crop residue in T_1(only soil) and T_8(Soil +RDF) . The treatments from T_2 to T_7 crop residue was incorporated in soil @1.5 t ha^{-1} after chopping in to 3-4 cm size either alone or in combination with microbial consortia and nitrogen and phosphorus fertilizers at two levels. The microbial consortium used in the present study consists of decompo.A (fungal consortium of Pleurotousostreatous, *Phanerochaetechrysosporium*, yeast and *Trichoderma*), decompo.B (bacterial consortium of *Bacillus sp*, *Lactobacillus* sp and *Pseudomonas sp*) developed at Agricultural Research Station, Amaravathi. Each treatment was replicated thrice by following completely randomized block design. Turnings were given at weekly intervals and the residue was allowed for aerobic decomposition for 90 days and maintained at 60 per cent water filled pore space throughout incubation. The biochemical composition and soil samples were collected at 15 days interval after incubation were analysed for assessing the impact applied korra crop residue on soil ammonical and nitrate content and C: N ratio. The total carbon and nitrogen in soil were determined by CN analyser. To determine ammonical nitrogen in soil, ten grams of soil taken in a polyethylene bottle was shaken for one hour with 100 mL of 2M KCl solution and filtered through Whattman No. 1 filter paper. An aliquot of 20 mL of the above filtrate was steam distilled with freshly ignited MgO in Bremner's(1955) distillation apparatus and the distillate collected in 4 per cent boric acid containing mixed indicator and was titrated with standard H_2SO_4. Nitrate nitrogen was determined by Kjeldhal method. The sample in the distillation flask was treated with 1 ml of sulfamic acid solution and the flask was swirled for a few seconds to destroy NO_2^-. A pinch of Devardas alloy was added to the distillation flask and the distillation was continued. The amount of NO_3^--N was determined as described for exchangeable NH_4^+-N and the initial activities are presented in Table 1 and Table 2.

Table.1 Initial soil properties

Soil property	value
pH	8.1
Electrical conductivity(dSm^{-1})	0.23
Organic carbon (%)	0.21
Total carbon	0.59
Total nitrogen	0.053
C:N ratio	11.13
Nitrate N (mg kg^{-1})	41
Ammonical N(mg kg^{-1})	21.45
Microbial biomass carbon(µg/g)	149
Bacteria (CFU g^{-1} soil)	10×10^6
Fungi(CFU g^{-1} soil)	8×10^4
Actinobacteria(CFU g^{-1} soil)	19×10^5

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	

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.

1. Total carbon content

The data pertaining to total carbon content in soil at 15 days interval with incorporation of korra crop residue under various treatments are presented in Table 3. The results revealed that the total carbon content in soil was significantly influenced by the treatments. The crop residue applied treatments from T_2 to T_7 are at par with each other with respect to total carbon content from 15 DAI up to the end of incubation. It was observed that the total carbon content decreased in all residue applied treatments with advancement of incubation. This might be due to faster decomposition of Korra residue at initial phase due to its good biochemical quality and slowed down with time due to accumulation of recalcitrant compounds. The results are in agreement with the findings of Xu *et al.* (2019). Among the treatments, the treatment T_7, which received crop residue @ 1.5 t ha^{-1} along with 3.0 kg microbial consortia, 3.0 kg of urea and 15 kg of SSP recorded the highest decrease in carbon content from 15 to 90DAI and it was followed by T_6 , which crop residue @ 1.5 t ha^{-1} along with 3.0 kg microbial consortia and 1.5 kg urea + 7.5 kg SSP. The decrease in carbon content was in the order of T_7>T_6 >T_3 treatments, which might be due to the application of microbial consortium when compared to other treatments. It was observed that where microbial activity was optimum, the decomposition of crop residue was so rapid and the accumulation of carbon content does not occur. The total carbon content was not much influenced by days of incubation in absolute control (T_1) and in T_8 which received RDF. The decrease in total carbon content with the days of incorporation might be due to loss of carbon as CO_2 through microbial respiration and part of it may be assimilated by microorganisms. Similarly, the decrease in carbon content with decomposition period was earlier reported by Bharne *et al.* (2003) with incubation of wheat straw. The results were also in agreement with Kochsiek *et al*. (2013), Carreiro *et al.* (2000) and also Henriksen and Breland (1999). Similar decrease in C content by straw incorporation was observed by Fontaine *et al* (2004) and Xu *et al.* (2019).

2. Total N

The data pertaining to total nitrogen content in soil at 15 days interval with incorporation of korra crop residue under various treatments are presented in Table 4. The results revealed that there was a non significant influence of treatments on total nitrogen content up to 45 days of incubation and later it was significant .The treatments which received crop residue (T_2 to T_7) recorded lower content of nitrogen at 15 DAI when compared to the treatments which received RDF and absolute control. The non significant influence of treatments in the initial stages of decomposition (from 15 to 45 DAI) and lower content of nitrogen in residue applied treatments might be due to immobilization of native nitrogen. At later stages of incubation (60 to 90 DAI) the treatment T_7, which received crop residue @ 1.5 t ha^{-1} along with 3.0 kg microbial consortia and 3.0 kg urea + 15 kg SSP, recorded the highest nitrogen content and it was followed by T6, which received crop residue @ 1.5 t ha^{-1} along with 3.0 kg microbial consortia and 1.5 kg urea + 7.5 kg SSP, respectively. However, at 90 DAI the treatment T_7, was at par with all the treatments except T1. The increase in nitrogen content at different intervals among the treatments which received crop residue was in the order of T_7>T_6>T_3>T_5>T_4 treatments. The application of microbial consortium and starter dose of urea, SSP might have enhanced process of decomposition of crop residue leading to accumulation of nitrogen. The total nitrogen content in all the treatments which received crop residue increased progressively with days of incubation whereas decreased in case of T_8 (RDF) and T_1 (absolute control). Further, it was observed that significant difference was observed in total N content in soil at later stages of decomposition between treatments, which received only crop residue, recommended dose of fertilization and absolute control. Addition of nitrogen to decomposing crop residue had positive effect on decomposition in short term as added N balanced immobilization that had happened due to proliferation of microorganisms. If N is not added externally the native N is immobilized and crop suffer ill effects of immobilization. The results are in agreement with Rezig *et al*. (2013). Thomsen and Christensen (2004) reported similar linear increase of nitrogen contents with straw rate.

Table3. Effect of incorporation of korra crop residue on total carbon content of soil during incubation

Treatment details	Total carbon (%)					
	15 DAI	30 DAI	45 DAI	60 DAI	75 DAI	90 DAI
T_1: Absolute control	0.59b	0.59 b	0.60b	0.60 b	0.59 b	0.58 b
T_2:Crop residue@1.5 t ha^{-1}	0.72a	0.71a	0.71 a	0.70 a	0.69 a	0.69 a
T_3:T_2+MC@2 kg t^{-1} of residue	0.69a	0.68 a	0.68 a	0.67 a	0.66 a	0.65 a
T_4:T_2+Urea 1.5kg+SSP 7.5 kg t^{-1} of residue	0.71a	0.70 a	0.70 a	0.69 a	0.69 a	0.68 a
T_5:T_2+ Urea 3.0 kg+SSP 15 kg t^{-1} of residue	0.70a	0.69 a	0.69 a	0.68 a	0.68 a	0.67 a
T_6:T_3+ Urea 1.5 kg+SSP 7.5 kg t^{-1} of residue	0.68a	0.67 a	0.67 ab	0.66 ab	0.65 ab	0.64 ab
T_7: T_3+ Urea 3 kg+SSP 15 kg t^{-1} of residue	0.67a	0.66 a	0.65 ab	0.65 ab	0.64 ab	0.63 ab
T_8:RDF(20:50:0:40)	0.60 b	0.61 b	0.62b	0.61 b	0.60 b	0.60 b
SE(m)±	0.02	0.02	0.02	0.02	0.02	0.02
CD(0.05)	0.06	0.06	0.07	0.06	0.06	0.06
CV(%)	5.34	5.36	5.87	5.7	5.14	5.07

DAI-Days after incubation

Note: Any two treatment means which having common alphabet indicates non significance otherwise significant

Table 4. Effect of incorporation of korra crop residue on soil total N content during incubation

Treatment details	Total Nitrogen (%)					
	15 DAI	30 DAI	45 DAI	60 DAI	75 DAI	90 DAI
T_1: Absolute control	0.053	0.053	0.054	0.053 d	0.053c	0.052 d
T_2:Crop residue@1.5 t ha^{-1}	0.049	0.049	0.051	0.054 cd	0.056 bc	0.054 cd
T_3:T_2+MC@2 kg t^{-1} of residue	0.05	0.053	0.056	0.061 abc	0.058 abc	0.062 abc
T_4:T_2+Urea 1.5kg+SSP 7.5 kg t^{-1} of residue	0.051	0.052	0.054	0.055bcd	0.056 bc	0.056 bcd
T_5:T_2+ Urea 3.0 kg+SSP 15 kg t^{-1} of residue	0.051	0.052	0.054	0.056bcd	0.056 bc	0.057abcd
T_6:T_3+ Urea 1.5 kg+SSP 7.5 kg t^{-1} of residue	0.052	0.054	0.055	0.062 ab	0.063 ab	0.064 ab
T_7: T_3+ Urea 3 kg+SSP 15 kg t^{-1} of residue	0.053	0.056	0.056	0.064 a	0.064 a	0.065 a
T_8:RDF(20:50:0:40)	0.059	0.058	0.058	0.057bcd	0.056 bc	0.054 cd
S.Em±	0.002	0.002	0.002	0.002	0.002	0.002
CD(0.05)	NS	NS	NS	0.01	0.01	0.01
CV(%)	9.51	11.49	8.78	7.25	4.42	5.64

3.C: N ratio

The total carbon and nitrogen content at different intervals of incubation were computed as C:N ratio and presented in Table 5. The C:N ratios of Korra residue and soil at the beginning of incubation were 65:1 and 11:1, respectively. The C:N ratio of soils during the incubation period was varied from 9.69 to 14.69. The data indicated that the soil C:N ratio was steadily maintained in absolute control throughout the incubation period whereas in treatments which received crop residue from (T_2 to T_7) recorded wider C:N ratio in soil up to 45 days of incubation and at later stages of decomposition the C:N ratio was narrowed. The treatment T_8 recorded increased C:N ratio with days of incubation. A gradual decrease in C: N ratio was recorded in all treatments except control and RDF treatments during incubation. In treatment T_8 (RDF) the application of nitrogen might have led to a decrease in soil C:N ratio with a subsequent SOC decomposition due to growth of microbial population. The reason for narrowing down of C:N ratio in treatments from T_2 to T_7 might be due to increased mineralization which resulted in rapid conversion of organically bound N to inorganic forms. When a residue of high C:N ratio is added to the soil, the microbes become active due to substrate availability and multiply rapidly to decompose the material. As a result, their demand for nitrogen increases with decreases in soil available nitrogen. As the decomposition proceeds and the level of substrate decreases, the demand for nitrogen by microbes also decreases and the mineralized nitrogen becomes more available in soil. Masunga *et al*. (2016) reported a C:N ratio ranging from 9.1 to 11.4 with white clover residue incorporation. The results are in agreement with Bilenky (2021).

Table 5. Effect of incorporation of korra crop residue on C: N ratio of soil during incubation

Treatment details	C: N ratio					
	15 DAI	30 DAI	45 DAI	60 DAI	75 DAI	90 DAI
T_1: Absolute control	11.13	11.13	11.11	11.11	11.13	11.15
T_2:Crop residue@1.5 t ha^{-1}	14.69	14.49	13.92	13.21	13.02	12.78
T_3:T_2+MC@2 kg t^{-1} of residue	13.8	12.83	12.14	10.98	10.65	10.32
T_4:T_2+Urea 1.5kg+SSP 7.5 kg t^{-1} of residue	13.92	13.46	12.96	12.55	12.32	12.14
T_5:T_2+ Urea 3.0 kg+SSP 15 kg t^{-1} of residue	13.73	13.27	12.78	12.14	12.14	11.75
T_6:T_3+ Urea 1.5 kg+SSP 7.5 kg t^{-1} of residue	13.08	12.41	12.18	10.65	10.32	10
T_7: T_3+ Urea 3 kg+SSP 15 kg t^{-1} of residue	12.88	11.79	11.61	10.16	10	9.69
T_8:RDF(20:50:0:40)	10.17	10.52	10.69	10.7	10.71	11.11

4. Mineral nitrogen (ammonical and nitrate- N)

Ammonical nitrogen content (NH_4^+ - N): Data presented in Table 6 indicated that the ammonical nitrogen was increased in all the treatments up to 90 DAI except T_1 and T_8. The treatment T_2 which received only crop residue recorded lower ammonical nitrogen content than the initial content and significantly the lowest ammonical nitrogen among the treatments at 15 DAI. This clearly indicates that there is immobilization immediately due to the application of only crop residue. The treatment T8 which received only inorganic fertilizer recorded significantly highest ammonical nitrogen content up to 45 DAI and later decreased with incubation. The low nitrogen content in residue applied treatments in the first 15 days of incubation was due to immobilization of nitrogen released from residue. Ghoneim *et al.* (2008) also reported low nitrogen availability from rice residues which were largely due to the rapid immobilization of nitrogen by microbial activity.

Among the treatments maximum ammonical N content at 90 days after incubation was recorded by T_7 which received crop residue @ 1.5 t ha-1 along with 3.0 kg microbial consortia and 3.0 kg urea + 15 kg SSP and it was at par with T_6 and T_3 treatments and lowest was in absolute control (T_1). The increase in ammonical nitrogen content with days of incubation up to 90 days after incubation in crop residue treatments might be attributed to the continuous release of nitrogen from organic forms which coincide with peak growth period of microbes. Yadav and Singh (1991) also reported the favourable influence of applied manures on ammonical nitrogen. The treatment, where nitrogen was applied only through inorganic fertilizers (T_8), the nitrogen might have lost by leaching or denitrification (Duraisami *et al.*, 2001).

Nitrate nitrogen content (NO_3^- - N): The addition of crop residues resulted in a significant influence on nitrate nitrogen content in soil. The nitrate nitrogen content was first decreased at 15 DAI and found to increase up to 60 DAI later it followed a decreasing trend in all the crop residue applied treatments. Further it was observed that higher nitrate values were recorded in treatments supplied with crop residues at later stages of incubation. The lowest nitrate nitrogen content was recorded in T_2 (crop residue @ 1.5 t ha^{-1}) at 15 DAI. The data indicated that treatments, which received microbial consortia recorded superiority over the other residue applied treatment up to the end of incubation emphasizing the role of microbes in sustaining the nitrogen supply. The high amounts of NO_3^- - N at 60 DAI could be due to high rate of mineralization encouraged by enhanced microbial activity. The per cent increase in nitrate nitrogen content at 60 DAI when compared to absolute control was 18.61. The treatment T_7 was significantly superior to all treatments but was on par with T_6 and T_3 treatments. Increase in soil nitrogen improved the activities of microorganisms, which enhanced the decomposition of crop residues and release of nitrate nitrogen in to the soil (Bhattacharyya *et al*., 2008; Anwar *et al*., 2005). At 75 and 90 DAI the nitrate nitrogen content in soil has decreased when compared to 60 DAI. The reason for decrease in nitrate nitrogen might be due to lack of root activity as this was an incubation study and also some of the nitrate nitrogen might have lost through leaching. In treatments T_1 and T_8, the nitrate nitrogen has decreased progressively up to 90 DAI.

Table 6. Effect of incorporation of korra crop residue on mineral nitrogen (ammonical and nitrate-N) content of soil during incubation

Treatment details	Mineral Nitrogen (mg kg^{-1})											
	15 DAI		30 DAI		45 DAI		60 DAI		75 DAI		90 DAI	
	NH_4^+-N	NO_3^- N	NH_4^+-N	NO_3^- N	NH_4^+-N	NO_3^- N	NH_4^+-N	NO_3^- N	NH_4^+-N	NO_3^- N	NH_4^+-N	NO_3^- N
T_1: Absolute control	19.10 c	40.18b	19.00c	39.63bc	18.90bc	39.67b	18.70d	38.67c	18.60cd	37.67c	18.33d	37.00e
T_2:Crop residue@1.5 t ha^{-1}	15.63 d	34.71c	18.75c	38.52c	19.30c	40.67b	20.10d	41.33c	21.35d	41.00bc	21.40bcd	40.63cde
T_3:T_2+MC@2 kg t^{-1} of residue	17.96 d	36.61bc	20.86c	40.32bc	21.00bc	42.33ab	22.32abc	43.00bc	23.47bc	42.50ab	24.00abc	41.67abc
T_4:T_2+Urea 1.5kg+SSP 7.5 kg t^{-1} of residue	19.04 c	35.71c	19.30c	39.96bc	19.77bc	41.00b	21.33cd	41.50c	21.86d	41.20bc	22.33bcd	41.00bcd
T_5:T_2+ Urea 3.0 kg+SSP 15 kg t^{-1} of residue	19.10 c	35.91c	20.21b	40.75bc	20.32bc	41.67b	21.80bcd	41.83bc	22.60bcd	41.40bc	23.00bcd	41.50abcd
T_6:T_3+ Urea 1.5 kg+SSP 7.5 kg t^{-1} of residue	19.23 c	37.50bc	20.91b	41.09bc	22.91bc	42.67a	23.00a	44.33bc	23.70ab	44.00ab	24.67ab	42.00ab
T_7: T_3+ Urea 3 kg+SSP 15 kg t^{-1} of residue	20.00 bc	39.39bc	21.00b	42.43ab	23.00b	43.53ab	22.67a	45.87a	24.19a	45.33a	25.33a	43.33a
T_8:RDF(20:50:0:40)	26.34 a	48.21a	25.79a	46.30a	24.32a	45.67a	21.33ab	45.00a	20.43bc	41.00c	20.33cd	40.67de
S.Em$\pm$	0.61	1.32	0.59	1.22	0.64	1.22	0.57	1.29	0.58	1.24	0.6	1.32
CD(0.05)	1.83	3.95	1.77	3.67	1.92	3.45	1.71	3.86	1.75	3.72	1.8	3.97
CV(%)	5.34	5.95	5.04	5.17	5.36	4.73	5.05	5.03	5.32	5.2	5.7	5.78

The total carbon content in soil was significantly influenced by the treatments from 15 DAI up to the end of incubation. The lower content of total soil nitrogen in initial stages of decomposition in treatments which received crop residue might be due to immobilization of native nitrogen. Decomposition and nutrient release pattern are determined by relative ease of mineralization by decomposer organisms and in this context C:N ratio has been accepted as a general index of quality of crop residue. 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 accelerated the process of decomposition of residue and mineralization of nitrogen It was concluded that incorporation of korra crop residue having wider C:N ratio along with microbial consortia consisting fungi and bacteria accelerated the process of mineralization of nitrogen and stabilized the C:N ratio of soil.

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