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Responses of soil enzymatic activity to rice residue management technologies and fertilizer levels in the rice rhizosphere on a clay loam

G. Veena Madhuri[1]*, V. Sailaja[2] and T.V. Sridhar[3]

[1,3]Department of Soil Science and Agricultural Chemistry, Agricultural college, Acharya N.G. Ranga Agricultural University, Bapatla 522 101, Andhra Pradesh, India
[2]Regional Agricultural Research Station, ANGRAU, Lam 522034, Andhra Pradesh, India

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ABSTRACT

Crop residues returned to the soil can maintain or enhance soil quality and productivity through favourable effects on soil properties and life-support processes. The field experiment was conducted during the *kharif* season of 2021-2022 at the Agricultural College Farm, Bapatla, ANGRAU, Lam, Guntur, Andhra Pradesh to study the "Responses of soil enzymatic activity to rice residue management technologies and fertilizer levels in the rice rhizosphere on a clay loam". The experiment was laid out in split-plot design with the rice residue management practices, assigned to the main plots and fertilizer levels to sub plots. The main plot comprised four different rice residue management practices viz; Straw burning (M_1), Straw incorporation (M_2), Straw incorporation + FYM @ 5.0 t ha^{-1} (M_3) and Straw incorporation + DI (decomposing inoculum) + FYM @ 5 t ha^{-1} (M_4). Three fertilizer levels were applied to rice viz., 75% RDF (S_1), 100% RDF (S_2) and 125% RDF (S_3), as sub plot treatments. Enzyme activities *viz.*, dehydrogenase, urease, acid and alkaline phosphatase activities at panicle initiation were significantly influenced by the crop residue management practices and fertilizer levels while their interactions were not significant. Straw incorporation + DI + FYM @ 5 t ha^{-1} showed significantly higher enzymatic activities among the residue management practices and among the fertilizer levels, 125% RDF is significantly superior over 75% RDF.

***Key words**: Residue incorporation, Straw burn, Enzyme activity, Decomposing inoculum, Fertilizer levels*

Introduction

One of the most important challenges the humanity is facing today are to conserve/sustain natural resources, including soil and water, for increasing food production while protecting the environment. As the world population grows, stress on natural resources increases, making it difficult to maintain food security. A balance between increasing crop production, maintaining soil health and environmental sustainability is important. The greatest global concern on the agriculture front for last two decades has been to maintain fertility and productivity of arable lands through adoption of different strategies like sustainable agriculture, farm residue and waste management.

Rice (*Oryza sativa* L.) is one of the most predominant cereal and stable food crop for more than 40 countries in the world. A large amount of rice residue is annually produced in the rice growing countries. There is an enormous potential of recycling these easily available residues in the crop production systems. A rice crop yielding 7 t ha^{-1} grain removes more than N 300, P 30 and K 300 kg ha^{-1} from the soil. Another estimate shows that a 10t ha^{-1} crop removes 730 kg NPK from the soil that is often not returned to the soils. If this residue is not returned this may cause mining of soil for major nutrients leading to net negative balance and multi nutrient deficiencies in crops (Mandal *et al*., 2004). This is one of the reasons for declining of crop yield. Therefore, the urgent need is to manage the residues of these crops for sustainability and stabilization of various nutrient in soil.

Residue management on the soil surface is one of the important components of conservation agriculture (CA). The incorporation of rice straw conserves soil water, moderates the thermal regimes, suppresses weeds, and improves soil health, which in turn help in improving crop yield and may result in saving of irrigation water. The potential of recycling crop residues as an important source of plant nutrients for crop production and means for improving soil physical, chemical and biological properties for sustained crop production is enormous. This can only be achieved with better management of soil and crop residues, which affect the decomposition of residues and nutrient release process (Kumar and Goh, 2000).

There is not enough information on the effects of residue management and fertilizer rates onsoil health. Keeping this in view and also considering the need to sustain soil health on one side and environmental quality on the other hand with the help of residue management practices, a study was conducted to assess the responses of soil enzymatic activity to rice residue management technologies and fertilizer levels in the rice rhizosphere on a clay loam.

Materials and Methods

The field experiment was conducted during *kharif*, 2021-22 at the Agricultural College Farm, Bapatla. The soil of the experimental site was a clay loam (sand 41.45%, silt 18.75% and clay 39.80%) with a bulk density of 1.31 g cm^{-3} having pH 7.66, EC 0.55 dS m^{-1}, low in organic carbon (0.43%), low in available nitrogen (272 kg ha^{-1}), medium in available phosphorus (52.5 kg ha^{-1}) and high in available potassium content (325.2 kg ha^{-1}). Rice variety BPT-5204Samba Mahsuriwas taken as the test variety with 140-150 days growth duration. The experiment was laid out in split-plot design with the rice residue management practices, assigned to the main plots and fertilizer levels assigned to sub plots. Rice straw obtained from the previous year was chopped and incorporated into the field in calculated amounts as per the treatment with the help of rotavator one month before sowing. FYM and decomposing inoculum was applied in calculated amounts as per the treatment combination for each plot separately and thoroughly incorporated into the soil with the help of spade as per treatments.

The main plot comprised four different rice residue management practices viz; Straw burning (M_1), Straw incorporation (M_2), Straw incorporation + FYM @ 5.0 t ha^{-1} (M_3) and Straw incorporation + DI (decomposing inoculum) + FYM @ 5 t ha^{-1} (M_4). Three different fertilizer levels were applied to rice viz., 75% RDF (S_1), 100% RDF (S_2) and 125% RDF (S_3) as sub plot treatments.

Results

The soil samples at PI stage of rice were collected and assayed for enzymatic activities as per the standard procedures.

Dehydrogenase Activity

The data pertaining to dehydrogenase activity of soil at PI stage of rice as influenced by rice residue management practices and fertilizer levels is presented in the Table 1. The dehydrogenase activity

Table 1. Dehydrogenase activity in soil (μg of TPF produced g^{-1} soil d^{-1}) at PI stage of rice asinfluenced by rice residue management practices and fertilizer levels

CRM	Panicle Initiation			
	S_1	S_2	S_3	Mean
M_1	37.04	38.03	41.26	**38.66**
M_2	40.50	41.45	43.29	**41.76**
M_3	42.72	43.77	51.27	**45.92**
M_4	49.01	53.09	55.53	**52.54**
Mean	42.33	44.15	47.84	
	SEm±	CD(P=0.05)	CV%	
M	1.70	5.87	11.37	
S	1.37	4.10	10.59	
MxS	2.74	NS		
SxM	2.81	NS		
Initial value	25.2			

M_1: Straw burning S_1: 75% RDF
M_2: Straw incorporation @ 5 t ha^{-1} S_2: 100% RDF
M_3: Straw incorporation @ 5 t ha^{-1}+ FYM @ 5 t ha^{-1}
S_3: 125% RDF
M_4: Straw incorporation @ 5 t ha^{-1}+ DI + FYM @ 5 t ha^{-1}

was significantly influenced by the individual effects of rice residue management practices and fertilizer levels, but their interactions were not significant.

Straw incorporation + DI + FYM @ 5 t ha^{-1}was significantly superior over all the crop residue management practices with a mean dehydrogenase activity of 52.54 µg of TPF produced g^{-1} soil d^{-1}. Straw burning resulted in a significantly lower dehydrogenase activity of 38.66 µg of TPF produced g^{-1} soil d^{-1} which was on par with straw incorporation alone. Among the fertilizer levels, 125% RDF is significantly superior (47.84 µg of TPF produced g^{-1} soil d^{-1}) over 75% RDF and it is on par with 100% RDF. Among the fertilizer levels, 125% RDF is significantly superior over 75% RDF.

The interaction effect of crop residue and fertilizer was found non-significant in influencing the dehydrogenase activity in soil.

Urease Activity

The data pertaining to urease activity of soil at PI stage of rice as influenced by rice residue management practices and fertilizer levels is furnished in the Table 2.

Rice residue management practices and fertilizer levels were significant in influencing the urease activity in soil. Straw incorporation + DI + FYM @ 5 t ha^{-1}was significantly superior over all other crop residue management practices with a urease activity of 52.22 µg NH_4^+ - N g^{-1}soil 2h^{-1}. Straw incorporation + FYM @ 5t ha^{-1} is significantly on par with Straw incorporation with 37.67 and 42.81 µg NH_4^+ - N g^{-1} soil 2h^{-1}. Straw burning was significantly inferior on urease activity among all other residue management practices. Among fertilizer levels, 125% RDF was significantly superior over 75% RDF, however it was significantly on par with 100% RDF.

The interaction effect of crop residue and fertilizer was found non-significant in influencing the urease activity in soil.

Table 2. Urease activity in soil (µg of NH_4^+ N released g^{-1} soil 2h^{-1}) at PI stage of rice as influenced by rice residue management practices and fertilizer levels

CRM	Panicle Initiation			
	S_1	S_2	S_3	Mean
M_1	35.14	37.73	40.13	37.67
M_2	39.67	42.00	46.77	42.81
M_3	44.33	46.80	50.47	47.20
M_4	50.17	51.17	55.32	52.22
Mean	42.33	44.43	48.17	
	SEm±	CD(p=0.05)	CV%	
M	1.31	4.52	8.71	
S	1.51	4.51	11.59	
MxS	3.01	NS		
SxM	2.78	NS		
Initial value	24.5			

M_1: Straw burning S_1: 75% RDF
M_2: Straw incorporation @ 5 t ha^{-1} S_2: 100% RDF
M_3: Straw incorporation @ 5 t ha^{-1}+ FYM @ 5 t ha^{-1}
S_3: 125% RDF
M_4: Straw incorporation @ 5 t ha^{-1}+ DI + FYM @ 5 t ha^{-1}

Acid phosphatase Activity

Acid phosphatase activity of soil was assayed at PI stage of rice and the data was presented in Table 3.

Table 3. Acid phosphatase activity in soil (µg of p-nitro phenol released g^{-1} soil h^{-1}) at PI stage of rice as influenced by rice residue management practices and fertilizer levels

CRM	Panicle Initiation			
	S_1	S_2	S_3	Mean
M_1	64.66	64.99	68.73	66.12
M_2	67.49	69.96	72.50	69.99
M_3	71.95	73.05	77.30	74.10
M_4	76.83	77.65	80.12	78.20
Mean	70.23	71.41	74.66	
	SEm±	CD(p=0.05)	CV%	
M	1.91	6.62	7.95	
S	0.82	2.45	3.93	
MxS	1.63	NS		
SxM	2.33	NS		
Initial value	60.3			

M_1: Straw burning S_1: 75% RDF
M_2: Straw incorporation @ 5 t ha^{-1} S_2: 100% RDF
M_3: Straw incorporation @ 5 t ha^{-1}+ FYM @ 5 t ha^{-1} S_3: 125% RDF
M_4: Straw incorporation @ 5 t ha^{-1}+ DI + FYM @ 5 t ha^{-1}

Rice residue management practices and fertilizer levels were significant in influencing the acid phosphatase activity in soil. Straw burning was significantly inferior among all the residue management practices and was on par with straw incorporation alone with corresponding mean acid phosphatase activities of 66.12 and 69.99 µg PNP g^{-1} soil h^{-1}. Straw incorporation + DI + FYM @ 5 t ha^{-1} showed significantly higher enzyme activity of 78.20 µg PNP g^{-1} soil h^{-1}, while it was on par with straw incorporation

+ FYM @ 5 t ha^{-1} with 74.10 ìg PNP g^{-1} soil h^{-1}.

Among fertilizer levels, 125% RDF is significantly superior (74.66 µg PNP g^{-1} soil h^{-1}) over other fertilizer levels in influencing mean acid phosphatase activity. Fertilizer levels 75% and 100 % RDF were significantly on par with mean values of 70.23 and 71.41 µg PNP g^{-1} soil h^{-1} respectively.

The interaction effect of crop residue and fertilizer was found non-significant in influencing the acid phosphatase activity in soil.

Alkaline phosphatase Activity

The data pertaining to alkaline phosphatase activity of soil at PI stage of rice as influenced by rice residue management practices and fertilizer levels is depicted in the Table 4.

Table 4. Alkaline phosphatase activity in soil (µg of p-nitro phenol released g^{-1} soil h^{-1}) at PI stage of rice as influenced by rice residue management practices and fertilizer levels

CRM	Panicle Initiation			
	S_1	S_2	S_3	Mean
M_1	78.63	79.58	85.41	**81.21**
M_2	82.45	96.32	96.72	**91.83**
M_3	96.59	97.07	104.21	**99.29**
M_4	104.14	105.54	120.12	**109.94**
Mean	90.45	94.63	101.62	
	SEm±	CD(p=0.05)	CV%	
M	2.12	7.34	6.66	
S	2.93	8.79	10.63	
MxS	5.87	NS		
SxM	5.24	NS		
Initial value	70.3			

M_1: Straw burning S_1: 75% RDF
M_2: Straw incorporation @ 5 t ha^{-1} S_2: 100% RDF
M_3: Straw incorporation @ 5 t ha^{-1}+ FYM @ 5 t ha^{-1}
S_3: 125% RDF
M_4: Straw incorporation @ 5 t ha^{-1}+ DI + FYM @ 5 t ha^{-1}

At PI stage, the rice residue management practices and fertilizer levels were significant in influencing the alkaline phosphatase activity in soil. Straw incorporation + DI + FYM @ 5 t ha^{-1} was significantly superior over other residue management practices with 109.94 µg PNP released g^{-1} soil h^{-1} of alkaline phosphatase activity. Straw burning was significantly inferior (81.21 µg PNP released g^{-1} soil h^{-1}) among all the residue management practices.

Among fertilizer levels 125% RDF is significantly superior over 75% RDF, and on par with 100%RDF.

The interaction effect of crop residue and fertilizer was found non-significant in influencing the alkaline phosphatase activity in soil.

Discussion

The higher dehydrogenase activity may be associated with high microbial growth due to addition of paddy straw, which resulted in availability of substrate with the improvement in organic matter content of soil, microbial community is also known to improve since dehydrogenase is one of the most important soil biological indicators because it exists only in viable cells and plays an essential role in initial stages of oxidation of soil organic matter by transferring electrons or hydrogen from substrate to acceptors. The addition of inorganic fertilizer at a higher level significantly increased the dehydrogenase activity in soil. Rajeshwari (2005) also reported significant increase in dehydrogenase activity in soil with the application of inorganic fertilizers over absolute control in maize crop.

Urease catalyzes urea into ammonia. Higher urease activity in soil amended with inorganic and organic fertilization may be due to greater quantity of available nitrogenous compounds. In soils, it can be found as a free enzyme in solution, bound to colloidal particles (mineral or organic) and inside microbial cells (Klose and Tabatabai, 1999).

Acid and alkaline phosphatase mineralizes organic phosphate by hydrolyzing phosphoric (mono) ester bonds under acidic/alkaline conditions. Acid and alkaline phosphatases catalyze the hydrolysis of P-ester bonds binding P to C (C-O-P ester bonds) in organic matter and release inorganic P from organically bound P from rice residue. Among the two phosphatases, acid phosphatase is mainly produced by plants and soil microorganisms (Nannipieri *et al*., 2012). The addition of inorganic fertilizer at a higher level significantly increased the acid and alkaline phosphatase activity in soil. Similar results were reported by several other workers (Mandal *et al*., 2004; Garg and Bahl, 2008), who found an increase in alkaline phosphatase activity with both organic and inorganic fertilization. The increase in alkaline phosphatase activity with the application of inorganic nutrients was attributed to greater input of root biomass due to better crop productivity and with FYM may be due to enhanced microbial activity and perhaps diversity of phosphate solubilizing bacteria due to manure input (Basak *et al*., 2017).

Conclusion

- The activities of dehydrogenase, urease, acid and alkaline phosphatase enzymes were improved due to the incorporation of rice straw along with DI and FYM @ 5 t ha^{-1} and were inferior in straw burn. Among the fertilizer levels, 125% RDF proved to be superior in improving the soil parameters when compared to 75% RDF, while it was on par with 100%RDF.
- Straw incorporation + DI + FYM @ 5 t ha^{-1} was observed to be the best rice residue management technology for sustaining the soil health.

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References

Basak, N., Biswas, S., Tamang, A., Basak, P., Murmu, S., Hazra, G.C. and Mandal, B. 2017. Impact of inorganic fertilizers on soil biological health. *Fertilizers and Environment News*. 3(2): 13-16.

Garg, S. and Bahl, G.S. 2008. Phosphorus availability to maize as influenced by organic manures and fertilizer P associated phosphatase activity in soils. *Bioresource Technology*. 99: 5773-5777.

Klose, S. and Tabatabai, M.A., 1999. Urease activity of microbial biomass in soils. *Soil Biology and Biochemistry*. 31(2): 205-211.

Kumar, K. and Goh, K.M. 2000. Crop residues and management practices: Effects on soil quality, soil nitrogen dynamics, crop yield, and nitrogen recovery. *Advances in Agronomy*. 68: 197-319.

Mandal, K. G., Misra, A. K., Hati, K. M., Bandyopadhyay, K. K., Ghosh, P. K. and Mohanty, M. 2004. Rice residue-management options and effects on soil properties and crop productivity. *Food Agriculture & Environment*. 2(1): 224-231.

Nannipieri, P., Giagnoni, L., Renella, G., Puglisi, E., Ceccanti, B., Masciandaro, G., Fornasier, F.L.A.V.I.O., Moscatelli, M.C. and Marinari, S.A.R.A. 2012. Soil enzymology: classical and molecular approaches. *Biology and Fertility of Soils*. 48(7): 743-762.

Rajeshwari, R. S. 2005. *Integrated nitrogen management on growth and yield of maize* (*Zea mays* L.). MSc (Ag) thesis. University of Agricultural Sciences, Dharwad, 91.