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Effect of Different Kharif Paddy Straw Management Options and Different Levels of Nitrogen on Soil Dehydrogenase and Urease Activity

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during *rabi* 2020-21**,** at Regional Agricultural Research Station, Polasa, Jagtial, PJTSAU to study soil dehydrogenase and urease activity as influenced by different *kharif* paddy straw management options and nitrogen levels. The results reveal that dehydrogenase and urease activity of soil was significantly influenced by paddy straw management options and activity was increased with crop duration up to 60 DAT and decreased after harvest. Dehydrogenase activity was reduced after burning (1.93 mg TPF produced g^{-1} soil d^{-1}) as compared to the initial values (2.34 mg TPF produced g^{-1} soil d^{-1}). The highest dehydrogenase activity of 3.74 and 3.54 mg TPF produced g^{-1} soil d^{-1} was recorded at 60 DAT in paddy straw incorporation with

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phosphorus and incorporation without phosphorus and decreased to 3.36 and 3.03 mg TPF produced g^{-1} soil d^{-1} after harvest respectively. Soil urease activity was showed an increasing trend with crop duration up to 60 DAT and then declined. Maximum activity of 3.05, 4.84, 5.17 mg NH_4^+ released g^{-1} soil h^{-1} was observed at 60 DAT under paddy straw burning, paddy straw incorporation with phosphorus incorporation without phosphorus respectively. Paddy straw incorporation with phosphorus recorded higher urease activity and paddy straw burning recorded lower urease activity at all the intervals of crop growth. The effect of nitrogen levels on soil urease activity was found to be significant. Soil urease was highest with 120% RDN followed by 115% RDN, followed by 110% RDN, followed by 100% RDN and the similar trend was observed at all the intervals of crop growth.

Keywords: Paddy straw; burning; incorporation; nitrogen.

1. INTRODUCTION

Rice is the most residue producing crop. In future with increase in grain production will led to enormous generation of straw. In India, straw is produced in about 168.50 million tonnes [1]. The intensification of the cropping system resulting in production of paddy straw in large volumes which need to be managed over shorter turnaround period between the crops. Globally, roughly 800 to 1000 Mt per annum of rice straw is produced, with about 600 to 800 Mt per annum produced in Asia (Bhuvaneshwari et al., 2019). And due to scarcity of labour and high labour cost involved in its removal from the field and also with little management options burning of paddy straw is adapted and it has been increased dramatically over the last decade.

One of the advantages of burning is that it is cost effective and the land will be cleared quickly from residues before the next crop is taken up, thus facilitating establishment of next succeeding crop. Though it has some positive effects in managing pests, it also leads to loss of essential soil nutrients – upto 80 % N, 25% P, 21% K and 4-60% S and 13 tonnes per ha of carbondioxide causing loss of soil organic matter [2], reduces microbial diversity [3].

Several researchers advocated paddy straw incorporation in surface soil as an alternative to rice straw burning, saying that it improves soil quality and increases SOC by giving energy and substrates to microbes through soil enzyme activities [4-6].

The purpose of this research was to see how N application and paddy straw integration affected soil dehydrogenase and urease activities.

2. MATERIALS AND METHODS

The experiment was conducted at Regional agricultural research station, Polasa, Jagtial district. It is situated in the Northern Telangana Zone. The experimental site is located between 18º 51' 53'' N latitude and 78º 56'21'' E longitude at an altitude of 243.4 m above mean sea level (MSL). The soil of the experimental site was sandy clay loam, which is medium in organic carbon (0.54%), low in soil available nitrogen 157.6 kg ha^{-1}, high in soil available phosphorus (31.05kg ha^{-1}) and potassium (309.5kg ha^{-1}). The experiment was laid out in Factorial RBD, with 2 factors, factor 1 comprised of 3 levels and factor 2 comprised of 4 levels with a total of 12 treatments and replicated thrice. Paddy straw mulcher was run to chop it and is incorporated 10 days before transplanting. Paddy (variety- JGL-24423) was transplanted with a spacing of 15x15cm. The recommended dose of fertilizer was 150:60:40 kg N, P_2O_5, K_2O ha^{-1}. The entire recommended dose of phosphorus and potassium was applied as basal dose in the form of SSP and MOP respectively. Nitrogen was applied in 3 splits and the excess of RDN was applied at basal in the form of urea.

2.1 Dehydrogenase Activity

A 1 g of soil sample taken in an air tight screw capped test tubes and it was saturated with 0.2 ml of 3% triphenyl tetrazolium chloride solution. 0.5 ml of 1% glucose solution was added to the tubes and the bottom of the tubes are tapped to remove the entrapped air and a water seal was formed above the soil. The tubes were incubated for 24 h at 28±0.5°C. 10 ml of methanol was added to the incubated samples and shaken vigorously and were allowed to stand for 6 h. Clear pink coloured supernatant liquid was withdrawn and readings were taken with spectrophotometer at a wavelength of 485 nm. The results were expressed as mg of triphenyl formazan (TPF) g^{-1} d^{-1} [7].

List 1. Treatment details

T_1	100% RDN + Residue burning
T_2	10% excess N over RDN + Residue burning
T_3	15% excess N over RDN + Residue burning
T_4	20% excess N over RDN + Residue burning
T_5	100% RDN + Residue incorporation without phosphorus
T_6	10% excess N over RDN + Residue incorporation without phosphorus
T_7	15% excess N over RDN + Residue incorporation without phosphorus
T_8	20% excess N over RDN + Residue incorporation without phosphorus
T_9	100% RDN + Residue incorporation with P application through SSP
T_{10}	10% excess N over RDN + Residue incorporation with P application through SSP
T_{11}	15% excess N over RDN + Residue incorporation with P application through SSP
T_{12}	20% excess N over RDN + Residue incorporation with P application through SSP

2.2 Urease Activity

This method is based on determination of NH_3 released other incubation of soil with urea solution for 2 hours at 300℃ [8]. To a 5 g of soil was taken in duplicate in 50 ml volumetric flask. 0.2 ml toluene and 9 ml of THAM buffer (pH- 9; 0.05M) were added to it. The flasks were swirled for few second to mix the content. Then 1 ml of 0.2 M urea solution was added and swirled again for a few second. The flasks were then stoppered and placed in an incubator at 300℃ for 2 h. After 2 h the stoppers were removed and approximately 35 ml of KCl – Ag_2SO_4 solution was added and the flasks were swirled for few seconds and allowed to stand until the contents have cooled to room temperature. The volume of the flasks was made upto mark (50 ml) by addition of KCl – Ag_2SO_4 solution. The flasks were stoppered and inverted several times to mix the contents. To perform control, the above procedure was followed, but 1 ml of 0.2M urea solution was added after the addition of 35 ml KCl- Ag_2SO_4 solution.

A 40 ml aliquot of the suspension was pipetted out into 100 ml distillation flask and 0.2 g MgO was added to it for determination of NH_4^+-N in the resulting soil suspension. The content of the flask was then distilled for 15 minutes and the distillate was collected in a 50 ml conical flask containing 5 ml of 2 % boric acid indicator. The distillate was then titrated with 0.005 *N*sulphuric acid. The urease activity is expressed as mg NH_4^+-N g^{-1} $soil^{-1}$ h^{-1} at 300℃.

3. RESULTS AND DISCUSSION

3.1 Dehydrogenase Activity (mg TPF Produced g^{-1} Soil d^{-1})

Activity of dehydrogenase reflects oxidative activity of soil microflora and is a good indicator of microbial activity and the greater amount of soil organic carbon stimulates dehydrogenase activity [9]. The changes in soil dehydrogenase activity (mg TPF produced g^{-1} soil d^{-1}) at different crop growth intervals are furnished in Table 1.

The results revealed that dehydrogenase activity of soil was significantly influenced by paddy straw management and activity was increased with crop duration up to 60 DAT and decreased after harvest. Dehydrogenase activity was reduced after burning (1.93 mg TPF produced g^{-1} soil d^{-1}) as compared to the initial values (2.34 mg TPF produced g^{-1} soil d^{-1}). The results were in same line with Kumar et al. [10]. Decrease in soil dehydrogenase activity in burnt treatments indicates lower microbial activity. Burning of crop residue increases soil temperature [11]. which kills bacterial and fungal population. About 50% of bacterial population was killed by burning paddy straw [12] and loss of soil carbon from the soil [13]. However, its activity was regained at later stages [14]. Dehydrogenase showed an increasing trend with time. The Dehydrogenase activity was higher in the treatment with paddy straw incorporation with phosphorus followed by paddy straw incorporation without phosphorus and lower in paddy straw burning treatment. The highest dehydrogenase activity of 3.74 mg TPF produced g^{-1} soil d^{-1} was recorded at 60 DAT in paddy straw incorporation with phosphorus and decreased to 3.36 mg TPF produced g^{-1} soil d^{-1} after harvest. While in case of paddy straw incorporation without phosphorus the highest dehydrogenase activity of 3.54 mg TPF produced g^{-1} soil d^{-1} was recorded at 60 DAT in paddy straw incorporation with phosphorus and decreased to 3.03 mg TPF produced g^{-1} soil d^{-1} after harvest. Higher dehydrogenase activity in paddy straw incorporated treatments might be due to higher microbial activities during active decomposition of paddy straw [10] and increased

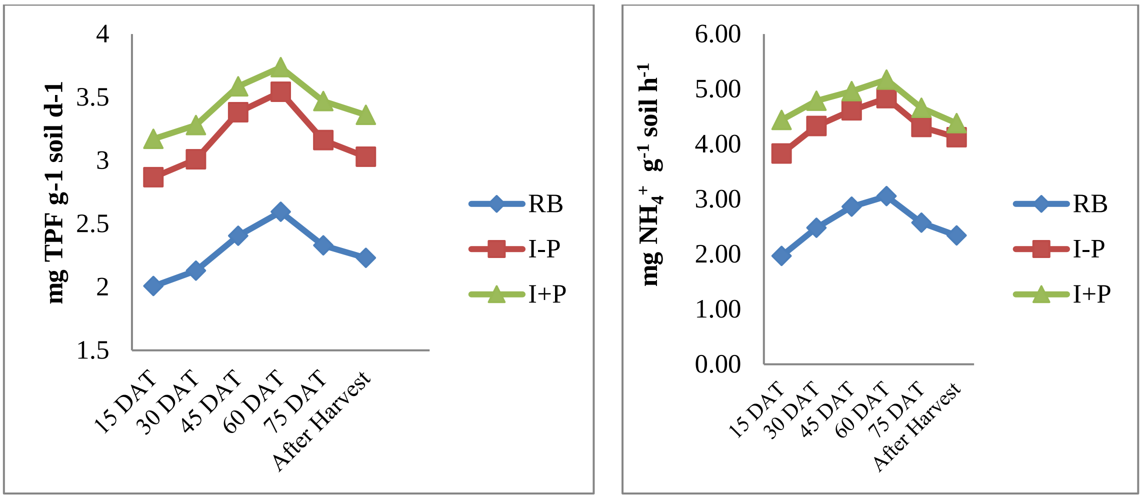

Fig. 1. Soil dehydrogenase(mg TPF produced g^{-1} soil d^{-1}) (left), and urease activity (mg NH_4^+ released g^{-1} soil h^{-1})as influenced by paddy straw managementoptions

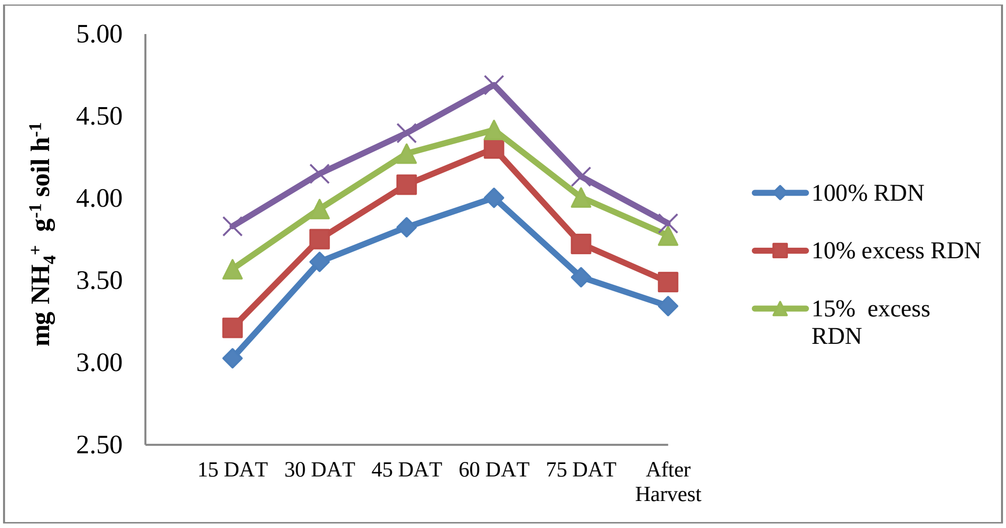

Fig. 2. Soil urease activity as influenced by different levels of nitrogen (mg NH_4^+ released g^{-1} soil h^{-1})

root activity. Crop residue incorporation to the soil adds large amount of labile organic carbon to the soil which then enhances soil dehydrogenase activity [15]. Soil becomes dry as the crop reaches maturity affecting microbial activity and thus the enzymatic activity [16].

The interaction between paddy straw management and nitrogen levels was found to be non-significant for dehydrogenase activity.

3.2 Urease Activity (mg NH_4^+ Released g^{-1} Soil h^{-1})

The data on soil urease activity (mg NH_4^+ released g^{-1} soil h^{-1})at different intervals is furnished in Table 2. Urease enzyme catalyzes the hydrolysis of urea hydroxycarbamide and semi-carbazide to carbon dioxide and ammonia and plays an important role in nitrogen cycling [17]. Paddy straw management and nitrogen levels were found to influence the soil available nitrogen.

Soil urease activity has shown an increasing trend with crop duration up to 60 DAT and then declined. At 15 DAT, minimum activity of 1.97, 3.83, 4.44 mg NH_4^+ released g^{-1} soil h^{-1} was observed in paddy straw burning, paddy straw incorporation with phosphorus and paddy straw incorporation with phosphorus respectively. Maximum activity of 3.05, 4.84, 5.17 mg NH_4^+

Table 1. Effect of different *kharif* paddy straw management options and fertilizer N levels on soil dehydrogenase activity (mg TPF produced g^{-1} soil d^{-1}) at different intervals of *rabi* rice

Treatments	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	After Harvest
Paddy straw management						
RB	2.01	2.13	2.40	2.59	2.33	2.23
I-P	2.87	3.01	3.38	3.54	3.16	3.03
I+P	3.17	3.28	3.59	3.74	3.47	3.36
SEm±	0.07	0.08	0.08	0.10	0.12	0.09
CD@ 5%	0.20	0.24	0.23	0.28	0.35	0.27
Nitrogen levels						
100% RDN	2.51	2.64	2.97	3.12	2.84	2.70
10% excess RDN	2.63	2.73	3.10	3.27	2.91	2.78
15% excess RDN	2.71	2.83	3.15	3.32	3.03	2.94
20% excess RDN	2.88	2.92	3.27	3.46	3.17	3.06
SEm±	0.08	0.09	0.09	0.11	0.14	0.11
CD@ 5%	NS	NS	NS	NS	NS	NS
Interactions						
SEm±	0.14	0.16	0.16	0.19	0.24	0.19
CD @ 5%	NS	NS	NS	NS	NS	NS
CV	8.88	10.29	8.87	10.14	13.71	11.25

Table 2. Effect of different *kharif* paddy straw management options and fertilizer N levels on soil urease activity (mg NH_4^+ released g^{-1} soil h^{-1}) at different intervals of *rabi* rice

Treatments	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	After Harvest
Paddy straw management						
RB	1.97	2.48	2.86	3.05	2.57	2.34
I-P	3.83	4.33	4.61	4.84	4.31	4.12
I+P	4.44	4.79	4.96	5.17	4.66	4.38
SEm±	0.08	0.10	0.10	0.11	0.10	0.09
CD@ 5%	0.24	0.28	0.29	0.33	0.28	0.26
Nitrogen levels						
100% RDN	3.03	3.61	3.83	4.00	3.52	3.35
110% RDN	3.21	3.75	4.08	4.30	3.72	3.49
115% RDN	3.57	3.94	4.27	4.42	4.01	3.77
120% RDN	3.83	4.15	4.40	4.69	4.13	3.85
SEm±	0.09	0.11	0.11	0.13	0.11	0.10
CD@ 5%	0.28	0.32	0.33	0.38	0.33	0.29
Interactions						
SEm±	0.16	0.19	0.20	0.23	0.19	0.17
CD @ 5%	NS	NS	NS	NS	NS	NS
CV	8.30	8.57	8.18	9.03	8.73	8.33

RB-Residue Burning, I-P-Incorporation with Phosphorus, I+P-Incorporation with Phosphorus, RDN-Recommended Dose of Nitrogen, AH-At Harvest The interaction between paddy straw management and nitrogen levels was found to be non significant.

released g^{-1} soil h^{-1} was observed at 60 DAT under paddy straw burning, paddy straw incorporation with phosphorus and paddy straw incorporation with phosphorus respectively. Paddy straw incorporation with phosphorus recorded higher urease activity and paddy straw burning recorded lower urease activity at all the intervals of crop growth. When paddy straw added to soil, microbes immobilizes the mineral nitrogen which was later mineralized [18] indicating that during decomposition a portion of straw N could be transformed into mineral in soil nitrogen cycling (Bradford and Peterson, 2000). In addition urease transforms the soil mineral N into source of N available for crop use at its later stages, which improves efficiency [19].

The effect of nitrogen levels on soil urease activity was found to be significant. Soil urease was the highest with 120% RDN followed by 115% RDN >110% RDN >100% RDN and the similar trend was observed at all the intervals of crop growth. The increase in soil urease activity with paddy straw management and nitrogen levels is in conformity with Sharma et al. [20], Singh and Sharma [21-23]. The increases might be due to straw addition enhances metabolic activity of microorganisms, microbial population thereby improving soil enzymatic activity [24-26] and Sharma et al., 2020a).

4. CONCLUSION

Soil dehydrogenase and urease activity was significantly influenced by paddy straw management. Dehydrogenase activity was reduced after burning. The highest dehydrogenase and urease was recorded at 60 DAT in paddy straw incorporation with phosphorus and without phosphorus and decreased after harvest. Paddy straw incorporation with phosphorus recorded higher dehydrogenase and urease activity and paddy straw burning recorded lower activity at all the intervals of crop growth. The effect of nitrogen levels on soil urease activity was found to be significant. Soil urease was highest with 120% RDN followed by 115% RDN, followed by 110% RDN, followed by 100% RDN and the similar trend was observed at all the intervals of crop growth.

DISCLAIMER (ARTIFICIAL INTELLIGENCE

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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