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Effect of stand establishment methods and hydrogel application on soil enzyme activity under rice-greengram cropping system

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Abstract
An experiment was conducted to study the effects of methods of stand establishment of *kharif* rice and *rabi* greengram along with and without hydrogel application in greengram on soil enzyme activities i.e Flourescein diacetate (FDA), phosphatase and dehydrogenase at ICAR-NRRI, Cuttack, Odisha in 2017-18. The experiment was laid in split plot design with three replication. Rice variety shahbhagi was taken in kharif under two methods of establishment i.e. direct seeded and transplanted rice whereas greengram variety IPM 2-3 was taken under conventional tillage, conservation agriculture (zero tillage + residue retention) and paira along with and without hydrogel application and an absolute rice fallow. Results revealed that dehydrogenase and acid phosphatase activity was significantly higher under DSR compared to TPR, whereas no significant difference was noticed for FDA and alkaline phosphatase activity. In greengram, the enzymatic activities varied significantly with different stand establishment methods. Highest enzymatic activity (FDA, dehydrogenase, acid and alkaline phosphatase) was reported in greengram under conventional tillage with hydrogel application. Soil enzymatic activity in rice fallow was recorded the lowest followed by paira greengram. However, on system basis, no significant difference in enzyme activity was recorded.

Keywords: Stand establishment, hydrogel, Flourescein Diacetate, dehydrogenase, phosphatase

Introduction

Productivity and Sustainability of agricultural systems are two important parameters for a long term profitable cropping system. Major issue of sustainability is related to soil quality which changes with time (Karlen *et al*., 1997) [7] and choice of cropping system. Many parts of eastern India is characterised by growing rice in kharif and leaving the land fallow in *rabi* season. Despite of the immense scope, extensive use of rice– fallow for cultivation of pulses/ oilseed crops is mostly restricted because of the several biotic, abiotic and socio– economic constraints (Panda *et al*. 2000) [11]. Inclusion of legumes in rice fallow system not only increased the overall productivity of the system but also improves physico-chemical and biological properties of the soil. Rice-green gram is a predominant cropping system in rainfed areas of eastern India. Greengram is best suited to the low moisture condition due to its short duration and hardy nature.

Soil enzymes have their catalytic role in decomposition of soil organic matter and nutrient cycling and strongly influence agronomic productivity. However, tillage, moisture and residues application impact enzymatic activity and availability of plant nutrients (Celika, 2011) [3]. No tillage with residue retention is known to increase the soil microbial activity (Govaerts *et al*., 2007) [6]. The activities of different enzymes is typically thought to be regulating nutrient availability, resistance and resilience capacity of soil (Demoling *et al*., 2007; Kumar *et al*., 2014) [4, 9]. Therefore, Soil enzymes have been suggested as potential indicators of soil quality, owing to it's biological nature, simple measurement and rapid response to changes in soil management (Ling *et al*., 2010) [10]. However, it is necessary to understand the relationship between different cultural practices and enzyme pools activity to predict the potential impact of soil and crop management.

Material and Method

An experiment was laid out to study the soil enzyme activity under rainfed rice greengram cropping system during both kharif and *rabi* seasons in 2017-18 at ICAR - National Rice Research Institute, Cuttack, Odisha.

The soil texture of experimental site was clay loam (vertisol) with pH 6.5, EC 0.065ds/m, BD 1.24 and organic carbon 0.56.The test crops taken were rice (var- Shahabhagi) and greengram (var- IPM 2-3). For all treatments, recommended dose of 80:40:40 and 20: 40: 20 of N: P2O5:K2O kg ha-1 was applied to rice and greengram respectively. Hydrogel was applied to greengram (dry season) at a dose of 2.5kg ha^{-1}. The experiment was laid out in split plot design. The details of treatment is presented in table.1.

Table 1: Treatments details of experiment

Main plots	Establishment methods in rice
TPR	Transplanted rice
DSR	Direct seeded rice
Sub plots	**Management practices in greengram**
C	Conventional tillage
C+H	Conventional tillage + Hydrogel application
CA	Zero tillage + Residue retention
CA+H	Zero tillage + Residue retention + Hydrogel
P	Paira cropping
P+H	Paira cropping + Hydrogel application
F	Rice fallow

Soil moisture was measured by gravitational method and expressed in percentage of oven dry soil and calculated by following formula

$$\text{Soil moisture content (\%)} = \frac{W_1 - W_2}{W_2} \times 100$$

where, W_1 = weight of moist soil and W_2 = weight of oven dried soil

The dehydrogenase activity in soil was determined by Casida *et al.*, (1964) [2] method. Flourescein diacetate (FDA) hydrolysis in soil was measured by Adam and Duncan (2001) [1] method. The acid and alkaline phosphatise was measured by Tabatabai and Bremner (1969) [12] method.

Result Discussion

Enzymatic activity in soil after rice

The activity of dehydrogenase and acid phosphate found to differ significantly with stand establishment methods in rice. Direct seeded rice recorded significantly higher acid phosphatase (22.14µg *p*NPg^{-1}d^{-1}) and dehydrogenase (47.41µgTPFg^{-1}d^{-1}) compared to transplanted rice (21.08µg *p*NPg^{-1}d^{-1}, 42 µg TPFg^{-1}d^{-1} resp.), confirming high enzymatic activity and higher live microbial population under direct seeded rice than transplanted rice. Higher dehydrogenase and acid phosphatase activity under direct seeded rice could be attributed to better soil aeration and congenial rhizospheric moisture (Fig.1) and favourable soil temperature resulting in higher oxidation of organic compound. However, the enzymatic activity namely FDA, and alkaline phosphate didn't differ significantly with respect to stand establishment in rice.

Enzymatic activity after greengram

The enzymatic activity found to differ significantly with respect to management practices in greengram. Higher FDA activity was recorded under conventional tillage with application of hydrogel (l1.62µg fluorescein g^{-1}h^{-1}), which was significantly higher than conservation agriculture, paira, paira along with hydrogel and rice fallow while comparable with conventional and conservation agriculture along with application of hydrogel, The lowest FDA activity was recorded under rice fallow (9.77µg fluorescein g^{-1}h^{-1}) followed by paira greengram (l0.11µg fluorescein g^{-1}h^{-1}). This might be due to higher microbial activity owing to high organic matter decomposition (Jordan *et al.*, 1995) [5] and higher root activity as highest plant population was recorded under conventional tillage with hydrogel application while lowest plant population was recorded under paira cropping.
With respect to dehydrogenase activity, the highest value **(**40.89 µg TPF g^{-1}d^{-1}) was recorded under conventional tillage with hydrogel application, comparable with all others except paira greengram (36.84µg TPFg^{-1}d^{-1}). Lowest dehydrogenase activity was recorded under rice fallow (33.07µg TPFg^{-1}d^{-1}). The highest enzymatic activity might be due to soil moisture at the root zone (Fig.2) and soil aearion. The result also established the legume effect on soil microbial activity which was positively correlated with plant population which was highest under conventional tillage with hydrogel application and lowest under paira greengram. Lowest value under rice fallow was due to rapid drying of soil moisture due to lack of vegetation (Khan, 1970) [8].
The acid phosphate activity was recorded highest under conventional tillage along with application of hydrogel (26.92µg *p*NP g^{-1} d^{-1}) which was comparable with conventional greengram and significantly higher than all other treatments. The lowest value was recorded in rice fallow (19.05*p*NP g^{-1} d^{-1}) followed by paira greengram with hydrogel application (21.52*p*NP g^{-1} d^{-1}). In terms of alkaline phosphate, similar pattern was recorded where greengram under conventional with application of hydrogel recorded highest (9.25µg *p*NPg^{-1}d^{-1}) which was comparable with conventional and significantly higher than all other treatments while lowest vale was recorded under rice fallow (9.25µg *p*NPg^{-1}d^{-1}). The higher value of phosphatase under conventional tillage might be due to pH suitability, owing to optimum soil moisture and plant population of greengram.
The result also established that application of hydrogel had no effect on enzymatic activities (FDA, dehydrogenase, acid and alkaline phosphatase) in soil under all methods of establishment adopted in greengram. The effect of stand establishment methods of rice had also no significant on enzyme activity under greengram, i.e. on system basis, no significant difference in enzyme activity was reported.

Table 2: Effect of stand establishment of rice on enzymatic activity of soil

Treatments	FDA activity (µg fluorescein g^{-1} h^{-1})	Dehydrogenase Activity (µg TPF g^{-1} d^{-1})	Acid phosphatase activity (µg *p*NP g^{-1} d^{-1})	Alkaline phosphatase Activity (µg *p*NP g^{-1} d^{-1})
Establishment methods in rice				
TPR	10.77	42.00	21.08	7.23
DSR	11.12	47.41	22.14	7.41
SEm±	0.34	0.82	0.19	0.14
CD (p=0.05)	NS	4.98	1.14	NS
Management practices in greengram				

C	10.72	46.49	22.63	7.54
C+H	11.37	45.69	21.21	7.58
CA	11.19	43.62	22.46	7.15
CA+H	11.38	44.55	20.91	7.23
P	10.98	42.35	21.13	7.12
P+H	10.76	45.50	22.37	7.42
F	10.22	44.74	20.55	7.20
SEm±	0.53	2.41	1.09	0.33
CD (p=0.05)	NS	NS	NS	NS
MxS (p=0.05)	NS	NS	NS	NS

Table 3: Effect of stand establishment of rice and greengram on enzymatic activity of soil

Treatments	FDA Activity (µg fluorescein g^{-1} h^{-1})	Dehydrogenase Activity (µg TPF g^{-1} d^{-1})	Acid phosphatase activity (µg *p*NP g^{-1} d^{-1})	Alkaline phosphatase (µg *p*NP g^{-1} d^{-1})
Establishment methods in rice				
TPR	10.52	36.66	22.14	7.63
DSR	10.83	38.72	23.43	8.21
SEm±	0.24	0.66	0.42	0.11
CD (p=0.05)	NS	NS	NS	NS
Management practices in greengram				
C	11.16	39.36	23.91	8.76
C+H	11.62	40.89	26.92	9.25
CA	10.62	37.63	22.15	7.54
CA+H	10.84	38.50	22.72	7.42
P	10.11	36.84	23.24	7.75
P+H	10.62	37.54	21.52	7.79
F	9.77	33.07	19.05	6.92
SEm±	0.34	1.39	1.31	0.44
CD (p=0.05)	0.99	4.06	3.83	1.29
MxS (p=0.05)	NS	NS	NS	NS

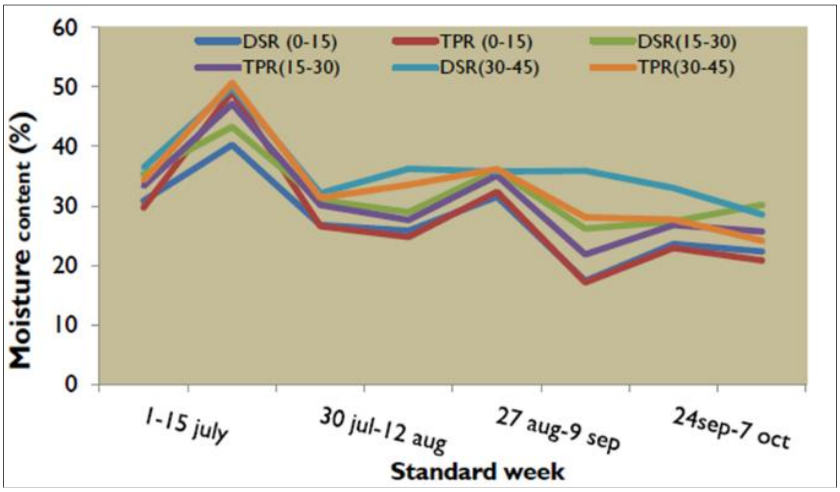

Fig 1: Soil moisture content (%) during rice

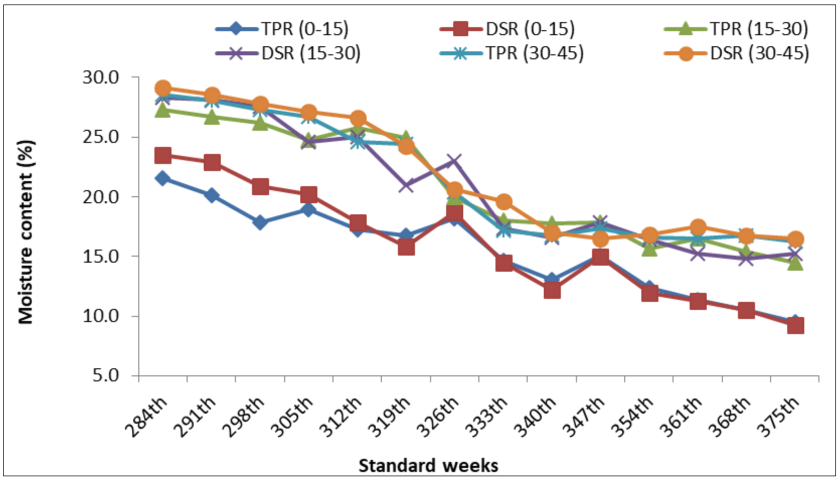

Fig 2: Soil moisture content (%) during greengram

Conclusion
Direct seeded rice followed by greengram grown under conventional tillage with hydrogel application was emerged as the best treatment as it encouraged more enzyme activity whereas rice fallow recorded the lowest enzyme activity. Therefore, inclusion of greengram in rice fallows under conventional tillage with hydrogel application after direct seeded rice is recommended for better soil health and sustainability.

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