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Fluorescein Diacetate Activity as Affected by Residue Retention and P Fertilization in Maize under Maize-Wheat Cropping System

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A B S T R A C T

Crop residue (CR) retention is one of the viable option for improving soil properties as well as soil microbial community. Different enzymatic activity in soil is used as indicator of soil biological health. Experiment was conducted to access the crop residue retention and P fertilization on fluorescein diacetate activity (FDA) in soil which is an important indicator of microbial activity vis-a-vis biological health of soil. Maize-wheat cropping system is the third most important cropping system after rice-wheat and rice-rice cropping system in India. Crop residue retention @50% and 75% significantly enhanced fluorescein diacetate activity of soil, irrespective of soil sampling zone and depth. FDA in soil was significantly higher in rhizospheric soil than the non-rhizospheric soil. Both in rhizospheric and non rhizospheric soil (0-5 cm), FDA had significant and positive relation with P fertilization.

Introduction

Tillage and residue retention management affect soil properties and also soil microbial community. Soil microorganisms play important roles in agro ecosystem, and their changes influences soil nutrient cycling. No-tillage with residue retention is known to increase the soil microbial community (Govaerts *et al.,* 2007). Application of decomposed residues in form of farm yard manure play a vital role in exploiting high yield potential through its beneficial effect on nutrients supply and chemical and biological properties (Sharma *et al.,* 2015 and 2016).

On the other hand mulching effect of residue retention improves the physical condition and fertility of the soil. It also check runoff and soil erosion, increase infiltration, help to maiintain proper soil temperature, inhibit movement of water vapour (evaporation) from soil to air, check weed growth and thereby, cut transpiration loss of water, and reduce soil compaction and aggregate breakdown (Mbagwu, 1991, Ghosh *et al.,* 2006). Enzymes are vital soil components involved in the dynamics of soil nutrient transformations. Enzyme activity in the soil milieu is considered to be a chief contributor

of overall soil microbial activity (Frankenberger and Dick, 1983). The biomass of microbes and activities of different enzymes is typically thought to be regulating indicator of nutrient availability, resistance and resilience capacity of soil (Demoling *et al.,* 2007; Kumar *et al.,* 2014). Soil respiration and enzyme activities, particularly hydrolase activities, involved in organic matter turnover, hence in nutrient cycles and plant nutrition, have been utilized by soil scientists in order to investigate the effects of different soil management strategies and agricultural practices, including organic amendments on soil fertility and health (Dick, 1997). In this respect, soil FDA is an important indicator of soil microbial activity and biological health of soil. The aim of this research was to assess the effects of crop residue retention and P fertilization on FDA activity in soil.

Materials and Methods

General information about experimental site

An ongoing field experiment on conservation agriculture initiated during kharif 2013 at IARI Research Farm was chosen for further study. The experimental soil represents Indo-gangatic plain and Mahrauli series of order Inceptisol. Taxonomically it is classified as Typic Haplustept. The soil is alluvial, sandy loam in texture with low CEC, alkaline in reaction, free from salinity and has nearly level to gently sloping topography. The initial physico-chemical characteristics of the surface soil (0-15 cm) are given in Table 1.

Experimental details

The field experiment on maize (*Zea mays* L.) -wheat (*Triticum aestivum* L.) cropping system commenced in July 2013 at IARI Research Farm. Twenty treatments were evaluated in a split-plot design, comprising crop residue retention (four) as main plot i.e.T1: Residue removal (No-residue), T2: 25% crop residue, T3: 50% crop residue, T4: 75% crop residue and phosphorus fertilizer rate (five) in sub-plot treatments were S1: No-Phosphorus, S2: 50% Recommended dose of phosphorus (RDP), S3: 100% RDP, S4:150% RDP, S5: 50% RDP + PSB & AM with three replications.

Soil test-based recommended N-P2O5-K2O rates were 150-80-50 kg ha-1 for maize, which were applied through urea, diammonium phosphate (DAP) and muriate of potash (MOP), respectively. Fertilizer N and K were applied uniformly to all the plots, whereas P was applied as per treatments. Entire amount of P and K was applied as basal dressing at the time of sowing. On the other hand, N was applied in 3 equal splits i.e. at sowing, at four leaves vegetative stage and eight leaves vegetative stage of maize. Previous wheat crop residues were retained in plots. Maize (cv. PHM-1) was sown in first week of July and harvested during end of October. Previous wheat crop was harvested manually from ground level, and aboveground biomass/residues were retained in the plots. Maize crop was raised under assured irrigated condition, and prescribed weed and pest control measures were adopted.

Soil sampling and processing

Plot-wise soil samples were collected at tasseling stage for determination of enzymatic activities from rhizospheric and non rhizospheric soil (0-5 cm and 5-15 cm). For this, plants were uprooted with intact roots and adhering soil was removed by gently shaking the roots on a clean plastic sheet. Soil beneath the root up to a depth of 15 cm from top was also collected and mixed with the adhered soil. The samples were separated into two parts; one part was processed for chemical analysis and the other part was

preserved in refrigerator at 4oC for enzymatic analysis. The samples for chemical analysis were dried in shade, ground in wooden pestle-mortar, and sieved to pass through a 2 mm sieve. All the chemical analysis of soil samples were done according to the methods outlined by Page *et al.,* (1982). Fluorescein diacetate hydrolysis was estimated as per the method outlined by Green *et al.*, (2006). The activity was estimated through the production of fluorescein from fluorescein diacetate by the action of hydrolytic enzymes in soil. In brief, one gram of soil was taken in a screw cap vial and 5.0 mL of 60 mM sodium phosphate (pH 7.6) and 10 µl of fluorescein diacetate (0.02%) were added. The tubes were incubated at 37ºC for 3 h. The reaction was stopped by adding 0.2 mL of acetone after incubation period i.e.3 hrs. The mixture was centrifuged at 8000 rpm for 5 minute, further filtered through Whatman No. 2 filter paper and absorbance was recorded spectrophotometrically at 490 nm.

Results and Discussion

Effect of CR and P fertilization on Fluroscence Diacetate Activity (FDA)

Fluroscence diacetate activity in soil as affected by different amount of crop residue retention and doses of P fertilizer in rhizospheric soil are presented in (Table 2). Highest FDA (378.3 µg fluorescein g-1 dry soil h-1) was recorded with 75% CR, while lowest FDA (349.6 µg fluorescein g-1 dry soil h-1) in 25% CR. Significant increase in FDA was recorded at 50% CR and 75% CR over control. But these two treatments were equally effective in increasing the FDA activity in soil. In case of P fertilization, application of higher dose improved FDA activity. Highest FDA (398.4 µg fluorescein g-1 dry soil h-1) was recorded with 100% RDP, followed by P fertilization @ 50% RDP + PSB & AM (386.1 µg fluorescein g-1 dry soil h-1) and lowest (340.5 µg fluorescein g-1 dry soil h-1) in 50% RDP. Treatments 100% RDP and 50% RDP + PSB & AM were statistically at par with each other and significantly higher than rest of the treatments with respect to FDA of rhizospheric. Interactive effect of CR and P fertilization was no significant on FDA activity.

Fluroscence diacetate activity in non rhizospheric soil as evident in (0-5 cm) Table 3, are maximum FDA (298 fluorescein g-1 dry soil h-1) in 75% CR followed by 50% CR (294 fluorescein g-1 dry soil h-1) and minimum (260 fluorescein g-1 dry soil h-1) in No CR. Significant increase in FDA was observed with 75% CR over the control. Treatments 50% CR and 75% CR were statistically at par and significantly higher over 25% CR treatment. Application of 100% RDP recorded significantly higher FDA (302 µg fluorescein gm-1 dry soil h-1) over other treatments. Both the treatments 50% RDP and150% RDP were statistically at par with each other.

Crop residue retentions had no significant effect on FDA Fluroscence diacetate activity (FDA) in 5-15 cm soil depth (Table 4). FDA activity increases with increasing rate of P fertilizer up to 100 % RDP over control. Maximum FDA (197 fluorescein g-1 dry soil h-1) was observed with 100% RDP treatment, followed by 150% RDP (184 fluorescein g-1 dry soil h-1) and minimum (172 fluorescein g-1 dry soil h-1) in No P (control). Exceptionally, 100% RDP treatment recorded very high FDA activity than rest of the treatments. Thus both in rhizospheric and non rhizospheric soil (0-5cm), FDA had significant and positive relation with CR and P fertilization. But this activity was higher in rhizospheric soil than non rhizospheric soil. This may be attributed to the fact that, the oxidative functional activity of microbial communities in the rhizosphere is higher than

that of bulk soil. Yang et al (2013). This higher oxidative functional activity may be due to the higher carbon resources in the rhizosphere soil, which is considered as the driving force for microbial activity and density as reported by several workers (Bowen and Rovira, 1999; Yang *et al.,* 2013).

Table.1 Initial soil characteristics of the field experiment

Parameter	Value
pH	8.53
EC	0.45
Mechanical Composition	Sandy loam
Clay (%)	18
Silt (%)	23.8
Sand (%)	58.2
Texture	Sandy loam
Organic Carbon (%)	0.32
Available N (kg ha^{-1})	189
Available P (kg ha^{-1})	26.1
Available K (kg ha^{-1})	227
DTPA-Zn (mg kg^{-1})	3.2
DTPA-Fe (mg kg^{-1})	5.6
DTPA-Cu (mg kg^{-1})	2.8
DTPA-Mn (mg kg^{-1})	7.1

**USDA-United States Department of Agriculture*

Table.2 Fluorescence diacetate activity (µg fluorescein g^{-1} soil h^{-1}) in rhizospheric soil as affected by crop residues and phosphorus fertilization

Crop residue (CR)	**Phosphorus rates (P)**					
	No-P	**50% RDP**	**100% RDP**	**150% RDP**	**50% RDP + PSB & AM**	**Mean**
No-CR	325	326	392	338	368	**350^{B}**
25% CR	331	343	382	327	363	**349^{B}**
50% CR	356	344	405	359	403	**373^{A}**
75% CR	356	348	413	363	409	**378^{A}**
Mean	**342^{B}**	**340^{B}**	**398^{A}**	**347^{B}**	**386^{A}**	
	CR	P	P at same CR		CR at same P	
SEm (±)	8.42	8.25	16.50		17.00	
LSD ($p \leq 0.05$)	20.61	16.81	NS		NS	

Table.3 Fluorescence diacetate activity (µg fluorescein g^{-1} soil h^{-1}) in 0-5 cm soil as affected by crop residues and phosphorus fertilization

Crop residue (CR)	Phosphorus rates (P)					
	No-P	**50% RDP**	**100% RDP**	**150% RDP**	**50% RDP + PSB & AM**	**Mean**
No-CR	251	257	270	262	261	**260^{B}**
25% CR	255	255	306	266	254	**267^{B}**
50% CR	269	322	314	258	306	**294^{A}**
75% CR	322	259	317	277	315	**298^{A}**
Mean	**274^{C}**	**273^{CD}**	**302^{A}**	**266^{D}**	**284^{B}**	
	CR	P	P at same CR		CR at same P	
SEm (±)	4.11	4.09	8.18		8.39	
LSD ($p \leq$ 0.05)	10.06	8.33	16.66		17.92	

Table.4 Fluorescence diacetate activity (µg fluorescein g^{-1} soil h^{-1}) in 5-15 cm soil as affected by crop residues and phosphorus fertilization

Crop residue (CR)	Phosphorus rates (P)					
	No-P	**50% RDP**	**100% RDP**	**150% RDP**	**50% RDP + PSB & AM**	**Mean**
No-CR	162	175	178	176	178	**174**
25% CR	170	170	190	182	168	**176**
50% CR	185	202	207	180	179	**191**
75% CR	171	179	211	196	202	**192**
Mean	**172^{B}**	**181^{B}**	**197^{A}**	**184^{B}**	**182^{B}**	
	CR	P	P at same CR		CR at same P	
SEm (±)	6.91	6.42	12.84		13.40	
LSD ($p \leq 0.05$)	NS	13.08	NS		NS	

Similar results were reported by Lopes *et al.*, (2010), where FDA hydrolysis activities were increased by native forest due to high deposition of residues. Other studies have also suggested that FDA activities are generally the most sensitive indicators of residue management changes on the belowground microbial community (Jordan *et al.*, 1995). Conjoint application of CR with 50% RDP+PSM and AM improved hydrolysis capacity of soil. Nath *et al.*, (2011) found significant increase in FDA hydrolysis due to the combined use of compost and biofertilizers or enriched compost with substantial reduction of inorganic fertilizer. Singh and Dhar, 2011 reported a higher FDA due to integrated use of NPK and FYM which could be attributed to increased microbial biomass resulting from organic matter enrichment and enzymatic activities in soil. Activities of FDA which represent microbial activity of soil were increased with retention of crop residues than the control plot, in this study which is similar to some other studies (Huang *et al.*, 2010). This might have been because there was more decomposable organic material in soil with the incorporated crop residues which favoured soil microbial population and activity.

In conclusion the crop residue retention @50% and 75% significantly enhanced fluorescein diacetate activity of soil, irrespective of soil sampling zone and depth. Thus both in rhizospheric and non rhizospheric soil (0-5cm), FDA had significant and positive relation with CR and P fertilization. But this activity was higher in rhizospheric soil than non rhizospheric soil.

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