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# Interaction of different conservational practices and weed management on soil biological properties in rice-wheat system

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## ABSTRACT

Intensive tillage in the rice-wheat system affects soil microbial health by use of agrochemicals, particularly herbicides for control of weeds. Tillage and crop rotation also affects microbial immobilization of soil nutrients. Tillage and agrochemical load directly or indirectly affect the performance of different soil microbial health and its functions which supports the soil health, plant growth and ultimately crop performance. Thus, learning about the interaction of different conservational practices and weed management in terms of soil biological properties is extremely necessary. Hence, the present study was conducted at N.E. Borlaug Crop Research Centre of Govind Ballabh Pant University of Agriculture & Technology, Pantnagar (Uttarakhand) during 2015-16 to 2016-17 with 5 establishments methods of rice and 3 weed management practices under strip plot design with three replications. Conventional Agricultural practices with weed management practices had a significant impact on soil biological properties *i.e.* dehydrogenase activity, acid, and alkaline phosphatase activity, during both the years. The value of dehydrogenase, acid, and alkaline phosphatase activity was higher in zero till rice and wheat with retention of residues followed by *Sesbania* brown manuring in summers (ZTR+R-ZTW+R-ZTS) with a weedy check, during both the years of study.

## INTRODUCTION

Soil biological properties involve soil micro-organisms and soil enzymes that play a major role in soil health in particular immobilization of soil nutrients required for the plant growth and development. They reflect the minute change in the soil environment and thus, considered as sensitive biological indicators of soil quality evaluation. Soil enzymes catalyze various reactions for biological assessment of soil processes like dehydrogenase, phosphatase, and urease. The dehydrogenase activity is an indicator of biological activity in soils (Burns 1978). Phosphatase catalyzes hydrolytic break down of phosphomonoesters, which is correlated between the amount of soil phosphorus and fertility. Urease enzyme catalyzes the hydrolysis of urea to $CO_2$ and $NH_4^+$ ions. It is important as it mediates the conversion of organic nitrogen to inorganic nitrogen and has been widely used to evaluate the changes in soil fertility (Nazreen *et al.* 2012). However, adoption of continuous intensive tillage in the rice-wheat system has affected the soil microbial health by use of agrochemicals, particularly herbicides for control of weeds. Conventional tillage leads to the impairment of soil microbiological activity and enzyme activities (Acosta-Martinez *et al.* 2003). Herbicide usage has increased by the time of green revolution which also resulted in leaching of herbicides and accumulating in the top 0 to 15 cm soil depth causing huge damage to the life processes of the micro-organism, which ultimately affects the soil health (Latha and Gopal 2010). Thus, a study was conducted with an objective to find out the interaction effect of different conservational practices and weed management on soil biological properties, *viz.* dehydrogenase, phosphatase and urease activity in the soil.

## MATERIALS AND METHODS

A field experiment was conducted in 2015-16 to 2016-17 at N.E. Borlaug Crop Research Centre of Govind Ballabh Pant University of Agriculture & Technology, Pantnagar (Uttarakhand). The site is situated at 29°N latitude and 79.32°E longitude having an altitude of 243.8 m above the mean sea level. The experiment, comprising 5 establishment methods of rice in vertical strip, *viz.* conventional transplanted rice (TPR-CT), TPR-CT followed by *Sesbania* as green manure, direct seeded rice (DSR) fb *Sesbania* incorporation, zero-till direct seeded rice (ZT-DSR) fb *Sesbania* as brown manure and ZT-DSR with retention of residues of previous wheat crop along with *Sesbania* as brown manure and 3 weed control measures in horizontal strip, *viz.* unweeded control, recommended herbicide *i.e.* bispyribac-sodium 20 g/ha as post-emergence and integrated weed management *i.e.* herbicide application *fb* 1 hand weeding at 45 DAS/DAT, was laid out in strip plot design with a total of 15 treatments replicated thrice in clay loam soil. Under ZT condition, the *Sesbania* was knocked down by 2,4-D application at 30 days after sowing and used as brown manure. After sowing of the crop, residue of the previous crop (wheat residue in rice and vice versa) was applied manually in the plots according to the treatments. Bispyribac-sodium 20 g/ha was applied after 25 days of sowing by using 500 litre volume of water/ha with knap sack sprayer fitted with flat fan boom nozzle Paliwal *et al.* (2017).

The soil sample collected was divided into 2 parts. One partwas stored at 4°C for enzymatic studies while the other part was shade dried, processed and analyzed to determine the fertility status of the soil. Soil dehydrogenase, phosphatase and urease activity was determined by Casida *et al.* (1964), Tabatabai and Bremner (1969) and Bremmer and Douglas (1971), respectively. The data was statistically analyzed adopting statistical package CPCS-1, designed and developed by Punjab Agricultural University, Ludhiana (Cheema and Singh 1991).

## RESULTS AND DISCUSSION

### Soil dehydrogenase activity (µg TPF/hr/g soil)

A significant interaction of establishment methods of rice and weed management practices on dehydrogenase activity was obtained during 2015 after the harvest of rice, while it was non-significant during 2016. However, after both the years of wheat harvest (2015-16 and 2016-17), a significant interaction was recorded.

Zero-till rice and wheat with retention of residues followed by *Sesbania* brown manuring (ZTR+R-ZTW+R-ZTS) under weedy check recorded highest soil dehydrogenase activity, after harvest of the crop, which was at par with application of bispyribac-Na 20 g/ha post-emergence (PoE) after harvest of rice during 2015, while was significantly superior over ready mix application of clodinafop + Metsulfuron-methyl (MSM) 64 g/ha and integrated approaches of weed management (IWM) practice after harvest of wheat, during both the years (**Table 1 and 2**). Zero till under weedy situation reported 61 and 65.2% higher activity of dehydrogenase after harvest of rice and wheat, respectively.

### Soil acid phosphatase activity (µg p-nitrophenol released/hr/g soil)

Establishment methods of rice and wheat with weed management practices showed significant interaction on soil acid phosphatase activity during both the years, after the crop harvest.

**Table 1. Interaction of establishment methods and weed management on soil dehydrogenase activity after rice harvest (*Kharif* 2015)**

| Treatment | TPR-CTW | TPR-ZTW-ZTS | DSR- CTW-ZTS | ZTR-ZTW-ZTS | ZTR+R-ZTW+R-ZTS |
|---|---|---|---|---|---|
| Bispyribac-Na 20 g/ha PoE | 15.8 | 18.8 | 19.3 | 29.2 | 37.0 |
| IWM (bispyribac-Na 20 g/ha PoE *fb* 1 HW at 45 DAS/DAT) | 14.8 | 16.7 | 18.1 | 27.9 | 33.7 |
| Weedy check | 16.9 | 29.2 | 24.8 | 34.5 | 38.0 |
| LSD (p=0.05) | | | 1.3 | | |

**Table 2. Interaction effect of establishment methods and weed management on soil dehydrogenase activity after wheat harvest (*Rabi* 2015-16 and 2016-17)**

| Treatment | 2015-16 | | | | | 2016-17 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | TPR-CTW | TPR-ZTW-ZTS | DSR-CTW-ZTS | ZTR-ZTW-ZTS | ZTR+R-ZTW+R-ZTS | TPR-CTW | TPR-ZTW-ZTS | DSR-CTW-ZTS | ZTR-ZTW-ZTS | ZTR+R-ZTW+R-ZTS |
| Ready mix clodinafop + MSM 64 g/ha PoE | 14.3 | 18.1 | 17.5 | 25.7 | 34.4 | 14.1 | 16.7 | 18.0 | 25.5 | 34.4 |
| IWM (clodinafop + MSM 64 g/ha PoE *fb*1 HW at 45 DAS) | 12.6 | 16.8 | 16.4 | 24.6 | 31.2 | 12.6 | 16.4 | 16.4 | 24.6 | 31.2 |
| Weedy check | 16.5 | 21.3 | 26.5 | 33.6 | 36.2 | 16.4 | 26.5 | 21.3 | 33.2 | 36.2 |
| LSD (p=0.05) | | | 1.3 | | | | | 1.2 | | |

TPR= Transplanted rice, DSR=Direct seeded Rice, ZTR=Zero tillage rice, CTW=conventionally tilled wheat, ZTW=Zero tilled wheat, ZTS=Zero tilled *Sesbania*, R=Residue retention

Integration of zero till rice and wheat with retention of residues and *Sesbania* brown manuring under weedy check recorded significantly highest acid phosphatase activity of the soil which was significantly superior to the sole herbicidal application and IWM practice, during both the years of study (**Table 3 and 4**). However, after harvest of rice, similar results were observed during 2016, which was found at par with of zero till rice and wheat with *Sesbania* brown manure (ZTR-ZTW-ZTS) **(Table 3)**. Zero till under weedy situation reported 62.2 and 56.4% higher activity of acid phosphatase after harvest of rice, during 2015 and 2016, respectively. However, there was increment of 62.9 and 62.6% after wheat harvest, during respective years of 2015-16 and 2016-17.

### Soil alkaline phosphatase activity (µg p-nitrophenol released/hr/g soil)

Establishment methods of rice and wheat with weed management practices showed significant interaction on soil acid phosphatase activity during both the years, after the crop harvest.

Integration of zero till rice and wheat with as well as without residue retention followed by *Sesbania* brown manure (ZTR-ZTW-ZTS and ZTR+R-ZTW+R-ZTS) under weedy check recorded at par alkaline phosphatase activity of the soil, after the harvest of crops, which was significantly superior to either herbicide applied alone as PoE or herbicide integrated with manual operation post-emergence herbicidal application and IWM practices both during the years (**Table 5 and 6**).

There was 48.2 and 41.7% increase in activity of alkaline phosphatase after harvest of rice, during 2015 and 2016, respectively under zero till weedy condition. While, slight increase of 44.8 and 44.7% was observed after wheat harvest also, during respective years of 2015-16 and 2016-17.

### Soil urease activity (mg urea/hr/g soil)

No significant interaction was found with different establishment methods of rice and wheat and weed management practices on urease activity of soil after the harvest of crops, during both the years.

Tillage or crop rotation affects microbial immobilization of soil nutrients. Thus, study revealed that enzyme activity was higher in zero till rice and wheat with retention of residues followed by *Sesbania* brown manuring (ZTR+R-ZTW+R-ZTS) with a weedy check, during both the years of study. This was in close conformity with Celik *et al.* (2011). This indicates that puddling and flooding conditions had detrimental effects on soil microbes and reduce their activities (Unger *et al.* 2009). Zero tillage with 20% residue retention was found to be suitable for soil health and achieving optimum yield (Alam *et al.* 2014). Maximum soil respiration and enzyme activities (acid, alkaline phosphatase and dehydrogenase) were recorded in zero tillage due to improvement in physicochemical and biological properties of soil (Kumar *et al.* 2016). On the other hand, more weeds resulted in high under-ground biomass, which acts as a carbon source for the growth and activity of micro-organisms (Sebiomo *et al.* 2011). The results are in close agreement with the findings of Rao *et al.* (2012).

**Table 3. Interaction of establishment methods and weed management on soil acid phosphatase activity after rice harvest (*Kharif* 2015 and 2016)**

| Treatment | 2015 | | | | | 2016 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | TPR-CTW | TPR-ZTW-ZTS | DSR-CTW-ZTS | ZTR-ZTW-ZTS | ZTR+R-ZTW+R-ZTS | TPR-CTW | TPR-ZTW-ZTS | DSR-CTW-ZTS | ZTR-ZTW-ZTS | ZTR+R-ZTW+R-ZTS |
| Bispyribac-Na 20 g/ha PoE | 52.8 | 88.5 | 56.1 | 80.3 | 109.5 | 48.2 | 87.6 | 48.8 | 75.3 | 98.6 |
| IWM (bispyribac-Na 20 g/ha PoE *fb*1 HW at 45 DAS/DAT) | 48.7 | 58.5 | 47.1 | 60.4 | 94.4 | 48.3 | 51.3 | 42.2 | 56.9 | 88.5 |
| Weedy check | 61.4 | 104.4 | 110.8 | 112.0 | 128.8 | 61.3 | 99.2 | 103.6 | 106.3 | 110.6 |
| LSD (p=0.05) | 6.8 | | | | | 5.4 | | | | |

**Table 4. Interaction effect of establishment methods and weed management on soil acid phosphatase activity after wheat harvest (*Rabi* 2015-16 and 2016-17)**

| Treatment | 2015-16 | | | | | 2016-17 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | TPR-CTW | TPR-ZTW-ZTS | DSR-CTW-ZTS | ZTR-ZTW-ZTS | ZTR+R-ZTW+R-ZTS | TPR-CTW | TPR-ZTW-ZTS | DSR-CTW-ZTS | ZTR-ZTW-ZTS | ZTR+R-ZTW+R-ZTS |
| Ready mix clodinafop + MSM 64 g/ha PoE | 50.5 | 81.7 | 51.5 | 75.4 | 103.2 | 50.3 | 80.9 | 50.3 | 75.2 | 99.9 |
| IWM (clodinafop + MSM 64 g/ha PoE*fb*1 HW at 45 DAS) | 44.8 | 51.8 | 42.2 | 57.9 | 91.2 | 44.7 | 51.2 | 41.8 | 57.3 | 91.0 |
| Weedy check | 59.2 | 100.2 | 105.4 | 107.5 | 120.7 | 58.9 | 100.0 | 103.2 | 107.1 | 119.4 |
| LSD (p=0.05) | 4.0 | | | | | 4.1 | | | | |

TPR= Transplanted rice, DSR= Direct-seeded Rice, ZTR= Zero tillage rice, CTW= Conventionally tilled wheat, ZTW= Zero tilled wheat, ZTS= Zero tilled *Sesbania*, R= Residue retention

**Table 5. Interaction of establishment methods and weed management on soil alkaline phosphatase activity after rice harvest (*Kharif* 2015 and 2016)**

| Treatment | 2015 | | | | | 2016 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | TPR-CTW | TPR-ZTW-ZTS | DSR-CTW-ZTS | ZTR-ZTW-ZTS | ZTR+R-ZTW+R-ZTS | TPR-CTW | TPR-ZTW-ZTS | DSR-CTW-ZTS | ZTR-ZTW-ZTS | ZTR+R-ZTW+R-ZTS |
| Bispyribac-Na 20 g/ha PoE | 136.1 | 137.9 | 127.6 | 144.1 | 153.2 | 136.7 | 146.3 | 132.0 | 146.5 | 159.6 |
| IWM (bispyribac-Na 20 g/ha PoE *fb*1 HW at 45 DAS/DAT) | 99.2 | 133.2 | 43.0 | 140.5 | 150.5 | 112.9 | 138.3 | 89.6 | 143.3 | 153.6 |
| Weedy check | 149.5 | 179.5 | 176.6 | 186.6 | 191.5 | 153.2 | 181.1 | 176.6 | 189.3 | 193.5 |
| LSD (p=0.05) | 6.8 | | | | | 8.1 | | | | |

**Table 6. Interaction effect of establishment methods and weed management on soil alkaline phosphatase activity after wheat harvest (*Rabi* 2015-16 and 2016-17)**

| Treatment | 2015-16 | | | | | 2016-17 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | TPR-CTW | TPR-ZTW-ZTS | DSR-CTW-ZTS | ZTR-ZTW-ZTS | ZTR+R-ZTW+R-ZTS | TPR-CTW | TPR-ZTW-ZTS | DSR-CTW-ZTS | ZTR-ZTW-ZTS | ZTR+R-ZTW+R-ZTS |
| Ready mix clodinafop + MSM 64 g/ha PoE | 128.5 | 129.2 | 113.5 | 133.4 | 139.5 | 127.8 | 129.0 | 113.5 | 133.1 | 139.0 |
| IWM (clodinafop + MSM 64 g/ha PoE*fb*1 HW at 45 DAS) | 95.4 | 124.6 | 42.9 | 132.8 | 138.6 | 95.3 | 124.5 | 42.5 | 132.0 | 137.9 |
| Weedy check | 137.2 | 153.6 | 152.1 | 160.5 | 172.9 | 136.9 | 153.0 | 151.6 | 160.1 | 172.4 |
| LSD (p=0.05) | 5.1 | | | | | 5.1 | | | | |

TPR= Transplanted rice, DSR= Direct-seeded Rice, ZTR= Zero tillage rice, CTW= Conventionally tilled wheat, ZTW= Zero tilled wheat, ZTS= Zero tilled *Sesbania*, R= Residue retention

The lower dehydrogenase activity observed in bispyribac sodium applied alone due to less substrate availability (Raj *et al.* 2015).

It was concluded that conventional agriculture practices with weed management practices had a significant impact on soil biological properties *i.e.* dehydrogenase, acid and alkaline phosphatase activity, during both the years. Thus, the present investigation resulted in that zero-till practice under weedy situation considerably improved the soil health. As IWM and herbicidal application, practices have lowered substrate availability for the microbes and thus the biological activity of soil microbes got declined.

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