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Conservation tillage and weed management effect on soil microflora of soybean–wheat cropping system

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ABSTRACT

A field experiment was conducted during 2013-14 and 2014-15 at Jabalpur to assess the effect of conservation tillage and weed management practices on the total bacteria, fungi, actinomycetes and dehydrogenase activity under soybean - wheat cropping system in vertisols. The results of the investigation revealed that tillage systems to influence significantly the microbial population. Among the tillage treatments, zero tillage + crop residue (soybean) *fb* zero tillage + crop residue (wheat) had higher bacterial, fungal population and dehydrogenase activity during both the seasons. But actinomycetes population was higher in zero tillage + crop residue (soybean) *fb* zero tillage (wheat) during both seasons. However, there was no adverse effects of herbicides use in soybean-wheat cropping system on microbial population during both crop seasons except *Rabi* season 2014 -15 in which bacterial population was reduced by 27.3% when mesosulfuron (12 g/ha) + iodosulfuron (2.4 g/ha) mixture was applied in wheat following application of pendimethalin (750 g/ha) *fb* imazethapyr (100 g/ha) in preceding soybean crop.

Key words: Actinomycetes, Bacteria, Conservation tillage, Dehydrogenase activity, Fungi, Herbicide

Tillage systems influence physical, chemical and biological properties of soil and have a major impact on soil productivity and sustainability. It alter the organic matter content in soil, which ultimately affects the microbial population and their activity. Conventional tillage practices may adversely affect long–term soil productivity due to erosion and loss of organic matter in soil. Suitable soil management can be practiced through conservation tillage (including zero tillage), high crop residue return and crop rotation. In conservational - tilled farming, microbial biomass and diversity are usually greater under zero tillage or reduced tillage than under conventional tillage (Carpenter-Boggs et al. 2003). Weeds are one of the major biological constraints in conservation agriculture system. Weeds can be effectively controlled by tillage operations, which uproot and bury deep into the soil. Due to lack of tillage, weeds grow and flourish in CA. Weed control technology integrates preventive, cultural, mechanical, chemical and biological means, in which the use of herbicides is most important for weed management. The ultimate destination of herbicidal chemicals is the soil system where they come in contact with different micro flora which are responsible for different biochemical transformations related to mineral nutrition of plants. Generally, herbicides are not harmful when applied at recommended rates (Selvamani and Sankaran 1993) but some reports showed that herbicidal application may have adverse effect on bacterial population (Rajendran and Lourduraj 1999). The ill effects of herbicide on non-target organisms may reduce the performance of important and critical soil functions such as organic matter decomposition, nitrogen fixation and phosphate solubilization which support the soil health, plant growth and in turn crop productivity. Some herbicides may even stimulate the growth and activities of the soil microflora. Most of the studies which were focused on effects of single application of herbicides on soil microorganisms for a short period, may not provide a realistic evaluation of such effects in cyclic application of herbicides in different cropping systems. Therefore, knowledge of long term application of herbicides on soil microbes is highly essential. Hence, present investigation entitled influence of tillage and weed management practices on micro flora of soybean- wheat cropping system under conservation agriculture system was carried out.

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MATERIALS AND METHODS

A field experiment was conducted during 2013-14 and 2014-15 at DWR, Jabalpur (M.P.) to study the influence of tillage and weed management practices on soil microflora of soybean- wheat under conservation agriculture system. Five tillage as main plot treatments, consisting of conventional tillage in soybean - conventional tillage in wheat, conventional tillage in soybean - zero tillage in wheat, zero tillage + residue in soybean - zero tillage in wheat, zero tillage in soybean - zero tillage + residue in wheat, zero tillage + residue in soybean - zero tillage + residue in wheat and these were imposed with three sub plot treatments namely weedy check, pendimethalin 750g/ ha *fb* imazethapyr 100g/ha in soybean during *Kharif* and mesosulfuron 12 g/ha +iodosulfuron 2.4 g/ha in wheat during *Rabi*, metribuzin 0.5 kg/ha+1HW at 45DAS in soybean during *Kharif* and Clodinofop 60 g/ha + metsulfuron 4 g/ha in wheat during *Rabi* season.

Enumeration of microorganisms

The soil samples were collected from 0-15cm surface soil in all the plots at the time of harvest of soybean and wheat during *Kharif* and *Rabi* season respectively. The soil samples were soaked into 90 ml deionized water at the rate of 10 g, later this mixture was shaken for 10 minute and kept for 5 minute. Thereafter, 1ml of the supernatant was diluted twice and inoculated in the diluted water at the constant temperature of 30ºC. All samples were performed in triplicate, and were used for enumeration of microorganisms. The viable microbial counts were analyzed by the standard technique of serial dilution and dour plating. Enumeration of bacteria and fungi was carried out in soil extract agar medium (James 1958) and Rose Bengal Agar medium (Parkinson *et al.* 1971). The Kenknight's Agar medium (Wellingtonn and Toth 1963) was used for enumeration of actinomycetes. After allowing for development of discrete microbial colonies during incubations under suitable conditions, the colonies were counted and the number of viable bacteria, fungi and actinomycetes [expressed as colony forming units (cfu)] per gram dry weight of soil was estimated by taking into account the soil dilutions.

Estimation of dehydrogenase activity

The method for the assay of dehydrogenase as developed by Casida *et al.* (1964) was used. This method is based on the reduction of 2,3,5-triphnyltetrazolium chloride (TTC) to triphenyl formazan (TPF). Each soil sample was treated with 0.1 g of CaCO3 and 1 ml of 0.18 mm aqueous solutions of TTC and incubated for 24 hours at 30oC. The TPF formed was extracted with methanol from the reaction mixture and assayed at 485 nm in spectrophotometer (UV- Thermoscientific).

RESULTS AND DISCUSSION

Effect of tillage

Different tillage systems appreciable influenced the soil microorganism (Table 1). The bacterial population was significantly higher in soybean and wheat rhizosphere (6.3 x 10^6 and 7.5 x 10^6 cfu/g), when zero tillage was done in both crop components in presence of residues of preceding crop during *Kharif* as well as *Rabi* season, followed by zero tillage in soybean–zero tillage in wheat in presence of residues of preceding crop, zero tillage in soybean in presence of residues of preceding crop – zero tillage in wheat and conventional tillage in soybean–zero tillage in wheat being the minimum under conventional tillage to both the crop components during first year. However, the bacterial population was increased significantly under former treatment during second year of experimentation in *Rabi* season 2014-15 and proved significantly superior over

Table 1. Effect of conservation tillage and weed management practices on bacterial population

Treatment		Bacteria (10^6 cfu/g dry weight of soil)			
		Kharif 2013	*Rabi* 2013-14	*Kharif* 2014	*Rabi* 2014-15
Tillage practices					
Kharif	*Rabi*				
CT	CT	4.4	6.7	15.2	14.6
CT	ZT	4.9	6.9	15.8	33.6
ZT + R	ZT	5.2	7.4	18.3	35.8
ZT	ZT + R	5.3	6.9	19.8	41.6
ZT + R	ZT + R	6.3	7.5	23.3	50.0
LSD(P=0.05)		1.3	NS	6.5	13.3
Weed management					
Weedy check	Weedy check	5.5	7.2	20.1	40.6
Pendimethalin 750g/ha *fb* imazethapyr 100g/ha	Mesosulfuron 12 g/ha + iodosulfuron 2.4 g/ha	5.1	6.9	17.5	29.5
Metribuzin 0.5kg/ha+1HW at 25DAS	Clodinofop 60 g/ha + metsulfuron 4 g/ha	5.2	7.2	17.8	35.2
LSD(P=0.05)		NS	NS	NS	8.8

conventional tillage to both soybean and wheat, conventional tillage in soybean – zero tillage in wheat and zero tillage in soybean in presence of residues of preceding crop – zero tillage in wheat but at par to zero tillage in soybean – zero tillage in wheat in presence of residues of preceding crop. Higher bacterial population under zero tillage in both the crop components in presence of residues of preceding crop during *Kharif* (soybean) and *Rabi* (wheat) crops, caused more accumulation of organic matter on the soil surface and as a consequence increased the abundance of microbial population particularly bacteria (Mathew 2012). On the contrary, reverse was true in case of conventional tillage to both crop components (soybean – wheat) during both the years because conventional tillage was done in both the crops without any crop residues of previous crops and whatever the quantity of crop residues left over after harvesting of the preceding crop, was incorporated in the soil during tillage and later decomposed by the organism. There after, the bacterial population was less under conventional tillage to both the crop components (Younesabadi *et al.* 2014).

Similar trend was observed in case of fungal population during both the years (Table 2). The actinomycetes population was significantly higher in soybean and wheat rhizosphere when zero tillage was done in both the crop components in presence of residues of preceding crop during *Kharif* season only followed by zero tillage in soybean in presence of residue of preceding – zero tillage in wheat in presence of residue of preceding crop , zero tillage in soybean–zero tillage in wheat in presence of residues preceding crop being the minimum under conventional tillage to both the crop components during first year of field experimentation closely followed by conventional tillage in soybean-zero tillage in wheat (Table 3). However, actinomycetes population was increased significantly under former treatment during second year of experimentation in *Rabi* season 2014-15 and proved significantly superior over conventional tillage to both soybean and wheat and conventional tillage in soybean – zero tillage in wheat but at par to zero tillage in soybean in presence of residues of preceding crop – zero tillage in soybean in presence of residues of preceding crop in wheat and zero tillage – zero tillage in wheat in presence of residues of preceding crop. Higher actinomycetes population under zero tillage in both crop component in presence of residues of preceding crop in soybean or wheat and in both crops caused accumulation of organic matter, which increased soil aeration, cooler and wetter condition and higher carbon content in soil surface. Thus, inch up the population of actinomycetes. Minimum actinomycetes population was recorded in case of conventional tillage to both crop components (Soybean – wheat) during both the years. Similar observations were also made by Younesabadi *et al.* (2014) and Govindan and Chinnusamy (2014).

Higher dehydrogenase activity was observed when zero tillage was done in both crop components in presence of residues of preceding crop during *Kharif* as well as *Rabi* season, followed by zero tillage in soybean in presence of residues preceding crop – zero tillage in wheat , zero tillage in soybean – zero tillage in wheat in presence of residue of preceding crop, and conventional tillage in soybean – zero tillage in wheat being the minimum under conventional tillage to both the crop components during first year of field experimentation (Table 4).

Table 2. Effect of connservation tillage and weed management practices on fungal population

Treatment		Fungi (10^4 cfu /g dry weight of soil)			
		Kharif 2013	*Rabi* 2013-14	*Kharif* 2014	*Rabi* 2014-15
Tillage practices					
Kharif	*Rabi*				
CT	CT	3.1	4.0	4.8	8.9
CT	ZT	4.0	4.3	6.8	9.1
ZT + R	ZT	4.2	4.3	9.3	11.0
ZT	ZT + R	4.3	4.4	12.3	15.1
ZT + R	ZT + R	4.4	4.7	18.3	15.9
LSD(P=0.05)		NS	0.2	0.6	1.7
Weed management					
Weedy check		4.2	4.4	11.1	13.3
Pendimethalin 750g/ha *fb* imazethapyr 100g/ha	Mesosulfuron 12 g/ha +iodosulfuron 2.4 g/ha	3.8	4.3	9.5	12.7
Metribuzin 0.5 kg/ha+1 HW at 25DAS	Clodinofop 60 g/ha + metsulfuron 4 g/ha	4.1	4.3	10.3	9.9
LSD(P=0.05)		NS	NS	NS	NS

Table 3. Effect of conservation tillage and weed management practices on actinomycetes population

Treatment		Actinomycetes (10^3 cfu /g dry weight of soil)			
		Kharif 2013	*Rabi* 2013-14	*Kharif* 2014	*Rabi* 2014-15
Tillage practices					
Kharif	*Rabi*				
CT	CT	3.4	4.5	7.2	14.1
CT	ZT	3.7	5.5	9.9	17.0
ZT + R	ZT	4.0	5.7	13.6	39.4
ZT	ZT + R	3.7	5.5	10.8	32.7
ZT + R	ZT + R	3.7	5.5	11.9	33.2
LSD(P=0.05)		NS	0.8	4.3	8.5
Weed management					
Weedy check	Weedy check	3.8	5.3	11.1	28.7
Pendimethalin 750 g/ha *fb* imazethapyr 100 g/ha	Mesosulfuron 12 g/ha +iodosulfuron 2.4 g/ha	3.5	5.4	10.2	25.4
Metribuzin 0.5 kg/ha+1HW at 25DAS	Clodinofop 60 g/ha + metsulfuron 4 g/ha	3.7	5.4	10.7	27.7
LSD(P=0.05)		NS	NS	NS	NS

Table 4. Effect of conservation tillage and weed management practices on dehydrogenase activity

Treatment		Dehydrogenase activity (µg TPF/g soil/24 hr)			
		Kharif 2013	*Rabi* 2013-14	*Kharif* 2014	*Rabi* 2014-15
Tillage practices					
Kharif	*Rabi*				
CT	CT	22.5	22.5	26.8	31.1
CT	ZT	24.3	26.6	29.7	31.4
ZT + R	ZT	24.3	31.2	31.3	35.5
ZT	ZT + R	25.9	34.5	29.8	34.2
ZT + R	ZT + R	26.1	35.3	32.3	36.7
LSD(P=0.05)		1.8	4.04	2.5	5.2
Weed management					
Weedy check	Weedy check	24.8	29.1	30.7	34.7
Pendimethalin 750 g/ha *fb* imazethapyr 100 g/ha	Mesosulfuron 12 g/ha + iodosulfuron 2.4 g/ha	24.8	29.7	28.9	32.5
Metribuzin 0.5 kg/ha+1HW at 25DAS	Clodinofop 60 g/ha + metsulfuron 4 g/ha	24.2	31.4	30.3	34.1
LSD(P=0.05)		NS	NS	NS	NS

But dehydrogenase activity was increased identically, during second year of experimentation during *Rabi* season 2014-15 being the maximum under the former treatment and proved significantly superior over conventional tillage to both soybean and wheat and conventional tillage in soybean–zero tillage in wheat but at par to zero tillage in soybean in presence of residues of preceding crop–zero tillage in wheat and zero tillage in soybean–zero tillage in wheat in presence of residues of preceding crop. Kladivko (2001) stated that most of the classes of organisms showed higher presence of their biomass in non-treated soil (conservation tillage) than treated (conventional tillage).

Weed management practices

Weed management practices did not affect the soil microbial population (bacteria, fungi and actenomycetes) and dehydrogenase activity significantly during the both years except *Rabi* 2014-15 in which bacterial population was reduced by 27.3% when mesosulfuron (12 g/ha) + iodosulfuron (2.4 g/ha) mixture was applied in wheat following application of pendimethalin (750g/ha) *fb* imazethapyr (100g/ha) in preceding soybean crop. This is because of abundance of herbicides (mixture of mesosulfuron and iodosulfuron) on the soil surface due to slow rate of degradation on account of lower values of maximum and minimum temperature during *Rabi* 2014-15 over mean maximum and minimum

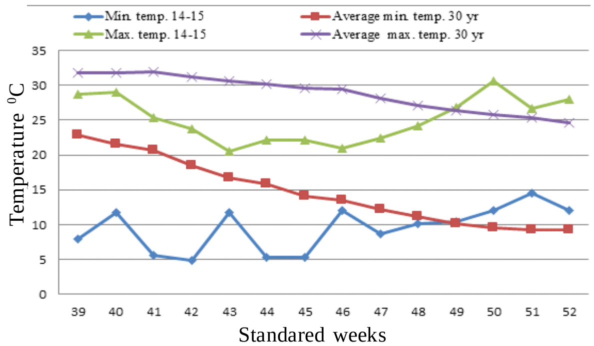

Fig. 1. Relative minimum and maximum temperature during *Rabi* 2014-15

temperature of 30 years. As a consequence the bacterial population was less during Rabi season 2014-15 (Fig. 1). Rajendran and Lourduraj (1999) also made similar observation. Numerically higher soil microbial population and dehydrogenase activity under weedy check plot was attributed to large increase in microbial biomass, as it is positive by correlated with weed biomass because of high decomposability (Wardle *et al.* 1999).

It was concluded that soil microbial population and dehydrogenase activity were significantly higher when zero tillage was done in both soybean and wheat in presence of residues of preceding crop. Weed management practices involving herbicide in soybean – wheat cropping did not reduce the population of soil microorganism and dehydrogenase activity except bacteria, which population was reduced during *Rabi* 2014-15 due to lower values of temperature (maximum and minimum) over temperature of 30 years. Similarly weed management practice involving pre-emergence application of metribuzin (0.5 kg/ha) + 1 HW in soybean and post-emergence application of clodinofop (60 g/ha) + metsulfuron (4 g/ha) mixture to wheat was found safe for soil microorganism and dehydrogenase activity.

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