Evaluation of Soil Biological Indicators Under Conventional and Conservation Tillage in Rice-Wheat Cropping System

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Abstract

The objective of this review paper is to provide a detailed information that how different tillage practices affect soil biological indicators under a rice-wheat cropping system. The tillage practices here we explain are conservation and conventional tillage. The important soil biological indicators that are used to assess soil quality are earthworms, particulate organic matter, potentially mineralized nitrogen, soil enzymes and soil respiration. All of these have a direct relation with soil microbial communities. For understanding the effect of tillage practices on soil biological indicators we studied the effect of tillage practices on soil microbial communities. The tillage practices affect the activity and community structure of soil microorganisms by changing the habitat characteristics for soil microorganism soil porosity, soil moisture and the substrates for soil microorganisms. The microbial communities involve soil bacterial communities, pathogenic fungal colonies, non-pathogenic fungal colonies and nematodes. Under zero tillage soil micro-arthropods and earthworms densities (number m^{-2}) were higher than conventional tillage. Soil bacterial community, fungal colonies and nematodes were higher in zero tillage. Conservation tillage improves both physicochemical and biological properties of soil. Hence conservation tillage effect biological indicators positively in a rice-wheat system.

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1-Introduction

Rice (Oryza sativa) as a muesli grain is the mainly broadly consumed primary provisions for a bulky position of the world's population, particularly in Asia and Africa. It is the agricultural commodity with the third top worldwide construction (rice, 741.5 million tonnes in 2014), after sugarcane and maize [1]. Pakistan has a foremost job as rice exporter in the humankind and annually exports about 2 million tons, which is 10 percent of the world's trade. In Basmati rice, about 25 percent exports is Pakistan's eminent fragrant. Rice export is second earning obtain of Pakistan. Rice grains accomplish about 60 percent of the populace of Pakistan chow needs, every one of through the globe period rice is a probable mine of chow for animals during frost term [2][3]. .

Rice is the mainly main grain with respect to being food and caloric intake, on condition that further than one-fifth of the calories consumed worldwide by humans [9]. Rice is the clip cooking of over partially the world's population. It is the leading nutritional energy mine for 17 countries in Asia and the Pacific, 9 countries in North and South America and 8 countries in Africa. Rice provides 20% of the world's nutritional energy supply, at the same time as wheat food 19% and maize (corn) 5% [8]. Rice, a monocot, is generally full-grown as a twelve-month plant, even though in steamy areas it container live through as a continuing and bottle produce a ratoon crop for up to 30 living [4]. Rice tin can be adult in not the same environments, depending upon stream availability [5]. Generally, rice does not flourish in a drenched area, thus far it be capable of continue to exist and nurture at this time in [6] and it be able to carry on flooding [7].

Wheat (Triticum aestivum) is a pasture generally refined for its seed, a muesli grain which is a worldwid rations [10][11][2]. The numerous species of wheat at once create up the group Triticum; the mainly far and wide full-grown is everyday wheat. Wheat is grown-up on additional nation theme than any other fodder crop (220.4 million hectares, 2014 [13] humanity trade in wheat is larger than for completely other crops pooled [14]. In 2017, planet fabrication of wheat was 772 million tonnes, with a forecast of 2019 assembly at 766 million tonnes, [15] manufacture it the second as a rule bent muesli after maize [15][16]. Since 1960, planet construction of wheat and other grain crops has tripled and is probable to become adult advance through the internal of the 21st century [17].

In wheat production, Punjab and Sindh provinces which are Pakistan's irrigated provinces declare chronological focus for grassy revolution in wheat. During the stop of 1960s, new Revolution in Pakistan plus complex broadcast investment in irrigation canals and sell development. The rural the upper classes and wheat making were transformed; the anticipation of hunger retreated [22]. Wheat is a crucial breakfast cereal crop for loads of countries everywhere it is existence consumed as a chief food. It is admitted detail that naught is supplementary critical than the human being being's needs. Sustainability and reliability in cooking fabrication is a principal for sustainable crop production. For wheat production, availability of irrigation and energy is of splendid meaning and will carry on to be an principal foundation in farming that container guarantee sustainability and reliability in cuisine making (GOP, 2008-09).

Wheat is of great magnitude find of carbohydrates [18]. Globally, it is the important track down of vegetable protein in human being food, having a protein make happy of about 13%, which is comparatively sharp compared to other chief cereals [19] but rather down in protein value for supplying important amino acids [20][21] at what time eaten as the entire grain, wheat is a font of manifold nutrients and nutritional stuff[18].

Rice and wheat crops encompass been grown-up in South Asia (India, Pakistan, Nepal, Bangladesh, and Bhutan) and China for extra than 1000 years. The rice-wheat (RW) cropping system, that is, on the rise these crops in an order in once a year rotation, has been industrial through the foreword of rice in the accepted wheat-growing areas and sub- versa [24][26]. This cropping system is one of the world's leading agricultural construction systems, layer an region of 26 million hectares (Mha) put out over the Indo-Gangetic Plains (IGP) in South Asia and China. It financial statement for about one-third of the field of mutually rice and wheat in South Asia and produces pin fare for further than 20% of the humankind population. The RW system at the present comprises about 13 Mha in section in the IGP, of which the Indian capacity of the IGP comprises about 10 Mha [25]. In Pakistan, the RW cropping system occupies about 10% of the complete refined quarter (2.1 Mha), mostly in two zones, the Punjab RW zone, comprising about 1.2 Mha, and the Sindh RW zone, occupying the left behind neighborhood [23].

Conventional tillage consisting of plowing or disking be able to induce fill up and nutrient losses, and in that case soil degradation with muted organic make a difference contented and a fragile real construct [27]. Conventional tillage refers to tillage operations measured model for an aspect position and crop and be apt to put out of sight the crop residues; by and large measured as a heart for influential the expense effectiveness of attrition manage practices.

Sustainable soil management be able to be accomplished through conservation tillage (including no-tillage), far above the ground crop remainder return, and crop rotation [34]. Studies conducted under a broad breadth of climatic conditions, soil types, and crop rotation systems showed that soils under no-tillage and concentrated tillage say notably elevated soil organic problem inside compared with conservatively tilled soils [35].

Conservation tillage is any logic of soil nurturing that foliage the before year's crop excess (such as corn stalks or wheat stubble) on fields before and after planting the after that crop to ease soil attrition and runoff, as fondly as other reimbursement such as carbon confiscation [37]. With this technique, at slightest 30% of the soil ascends is roofed with crop residue/organic excess next planting [36]. Conservation tillage methods incorporate zero-till, strip-till, ridge-till and mulch-till. Zero-tillage is the maximum system of conservation tillage consequential in smallest disturbance to the soil surface. Zero-till involves planting crops speedily into dregs that hasn't been tilled at each and every one [37]. An archetypal zero-tillage automaton is an intense applies that tin scatter seed in slits 2-3cm broad and 4-7cm immersed and besides fix to nourishment in one surgical procedure [35].

Conservation tillage, mainly no tillage, had convinced sound effects on soil properties. No tillage may possibly spread soil organic matter, domain soil moisture, condense erosion, moderate soil fever and promote cumulative stability [29][30][32]. No-tillage with deposit purpose was proved to proliferation the soil microbial unity [33]. In scores of cases, equally bacteria and fungi were extra copious under no-tillage than conventional tillage [31]. In no-tillage systems, fungi authority was often establish and the remains was primarily musty by the fungal unity [28][33].

2-Soil biological indicators

Soil biological indicators offer insight into the living piece of the soil. Alike to natural and compound indicators, biological indicators get an affiliation to soil functions and tin evaluate soil functions to assess soil quality. These indicators are dynamic soil properties that are enormously responsive to get management, unpretentious disturbances, and compound contaminants. It is reported that an indicator, anyway of its nature, ought to realize the next criteria: 1) be interpretable; 2) correlate to cut a long story short with environment processes; 3) integrate soil physical, chemical, and biological properties and processes; 4) be handy to lots of users; and 5) be easily upset to changes [40][41]. Many biological indicators in the matrix are allied to organic be important and are coupled to nutrient cycling and the biodiversity and productivity functions.

2.1 Earthworms

Eathworms are not native to Europe and Asia but are communicate in these areas. Earthworms depending on their habitation give birth to three groups. Litter-dwellers gulp down place residues, live in litter may not portray in soil free from litter. Limestone soil-dwellers expound in earth having extreme OM. They reach narrow channels and provide for soil and lodge residues mixture. Subterranean soil burrowers get to long, portly channels into arcane soil layers. For their intake they have in stock transplant residues. Cast is a background in soil excreted earlier from earthworms. Despite the fact that surface through worm's digestive system it becomes enriched with nutrients (N, P, K, and Ca). A situate of summit nutrient cycling and microbial commotion is light cast. Earthworms add nutrients to the soil and get well porosity, tilth and ransack development. Earthworms additionally perform character in building soil configuration and cumulative stabilization.

Keeping in view the functions of earthworms, it is clear that earthworms play a part a necessary function in soil. Earthworm moreover acts as an indicator to assess soil health. Disturbance in soil of course have a consequence on earthworms. In conventional tillage near will continuously downgrade records of earthworms in soil compared to conservation tillage. For the reason that in conventional tillage soil gets uneasy powerfully by discrete tillage implement. Selected gear take a breather the soil layers in this fashion they besides shatter the lengthy and narrow channels of earthworms. At what time here is no or less important figure of earthworms near will be no light cast for the microbial doings and nutrient recycling. Consequently it reduces the soil health and additionally shows that conventional tillage brings about this biological indicator in an off-putting manner.

In conservation tillage near is no or single slight disturbance of soil hence at hand will each time be top figure of earthworms in that area. From completely the dissimilar forms of conservation tillage, zilch tillage has the premier digit of earthworms and extraordinary microbial activity. Soil-arthropod and earthworm densities (number m−2) were superior ($P < 0.05$) under no-tillage than conventional tillage practices. Enchytraeid worms were superior in conventional tillage. Two predaceous groups, bring down beetles (Carabidae: Coleoptera) and spiders (Araneae), comprised extra than one-half of every soil macroarthropods collected. Altogether main microarthropod suborders (Oribatids, Prostigmatids, Mesostigmatids, and the demand Collembola) were senior ($P < 0.01$) under no-tillage than conventional tillage. Far above the ground soil-arthropod and earthworm densities under no-tillage systems call to mind a long-drawn-out and beneficial involvement for these soil fauna in crop-residue-decomposition processes [42].

2.2 Soil enzymes

Soil enzymes escalation the outcome at which workshop residues go moldy and liberate plant-available nutrients. They are catalysts—without undergoing everlasting alteration, they affect element reactions to proceed at nearer charge [39]. The substance acted upon by a soil enzyme is called the substrate. Enzymes are specialized to a substrate and contain vigorous sites that join with the substrate to procedure a provisional complex. The enzymatic feedback releases a product, which container be a nutrient controlled in the substrate. Under conservation tillage nearby will be further soil enzymes as in rice-wheat system crop residues gone in the ground and for breakdown in attendance will be high spot microbial doings which looked-for new enzymes.

2.3 Particulate organic matter

Particulate organic affair (POM) fraction, as discussed in this document, comprises completely soil organic be significant (SOM) particles a reduced amount of than 2 mm and larger than 0.053 mm in amount [38]. POM is geographically and chemically functional and is carves up of the labile (easily decomposable) fund of SOM. Studies own given away that POM records for tiny to obese amounts of soil C (20 percent or more) in round about soils of eastern Canada and the United States, depending upon agro-ecosystem and management practices. Additional POM-C was leisurely in at peace soils than in concerned soils, e.g, individuals under conventional tillage [38].

2.4 Potentially mineralizable nitrogen (PMN)

Potentially mineralizable nitrogen (PMN) tin be clear as the little bit of organic nitrogen converted to transplant untaken (or mineral) forms under known factor setting of temperature, moisture, aeration, and time influential levels of PMN be capable of present an estimation of on hand N in the soil. PMN originates essentially from microbial biomass and works and innate tissues——the core starting place of the organic nitrogen pool. It represents the little of nitrogen definitely decomposable by soil germs and is careful an indirect assess of nitrogen availability during the on the rise term (if leisurely during that period) time the possibility for anaerobic N mineralization may be a fine indicator of the makings for soil to hand over N, it does not essentially consider microbial biomass N levels. It was not compulsory that the ratio of N mineralized to overall organic nitrogen N might operate as a delicate indicator of differences in soil organic matter further PMN had slow in free from anxiety soil than in the concerned soils subsequently advanced PMN was put on in conservation tillage than conventional tillage.

2.5 Soil microbial community

Soil microbial community is also a biological indicator which gives idea about the soil health. If there are more soil microorganisms it represent good soil health by having high microbial activity and nutrient cycling. The microbial communities mainly involve non-pathogenic fungal colonies, pathogenic fungal colonies and nematode population in soil. To check the effect of different tillage practices on soil microbial community we used following five tillage practices as treatments in rice-wheat cropping system. In these treatments only one treatment was the conventional tillage while four others were the types of conservation tillage.

i. Conventional tillage: 6 disc harrow planker(CT)
ii. Conservational tillage I : 1 Mould board plough 4 disc harrow planker (CMB)
iii. Conservational tillage II : 1 Standard disc plough 4 disc harrow planker (CSD)
iv. No tillage system I : Zero-till ferti-seed drill sowing (ZT)
v. No tillage system II: Strip-till-drill sowing (ST)

2.5.1 Non- Pathogenic Fungal Colonies

The frequency of occurrence of non-pathogenic fungi *viz., Mucor species, Trichoderma species, Rhizopus species, Aspergillus flavus and Aspergillus niger* in soil was recorded. *Mucor species* was statistically similar in number under various tillage practices except under ZT, which showed significantly higher number of colonies. The lowest number of *Trichoderma species* was recorded under CT which being at par with CMB was significantly lower than other tillage practices. Significantly lower number of *Rhizopus species* was recorded in CMB and CST compared to other tillage *Aspergillus niger* were recorded to be significantly higher under ZT and ST than CMB and CSD.

2.5.2 Pathogenic Fungal Colonies

In the pathogenic fungi, *Curvularia lunata, Alternaria alternata, Fusarium oxysporum, Helminthosporium sativum* were studied. The number of *Curvularia lunata* was lowest in CMB and differed from CSD and ST significantly. Zero-till practice had the lowest number of *Alternaria alternata* which was significantly lower that practices. Anyway, the highest number of *A.alternata* was recorded in CT. *Fusarium oxisporum* was found in highest number in CSD followed by CT. ZT showed lowest number of *F.oxisporum*. *Helminthosporium sativum* was also highest in CSD followed by ST and CMB. ZT retained lowest number of *H. sativum.* In general, ZT practices retained lower number of pathogenic fungi while CT contained maximum number of pathogenic fungi (Table 1).

(Table 1) Effect of tillage practices on the average frequency of fungi

Treatments	Frequencies of fungi (number of cfu/g of soil x 10^{-2})								
	Average non-pathogenic fungal colonies					Average pathogenic fungal colonies			
	Mucor Spp.	Trichoderma Spp.	Rhizopus Spp.	Aspergillus Flavus	A.niger	Curvularia lunata	Alternaria alternata	Fusarium oxysporum	Helminthosporium sativum
CT	3.41	6.40	4.50	6.25	4.08	4.25	2.50	3.00	3.91
CMB	3.25	6.41	4.25	6.16	4.00	3.91	2.41	2.91	4.41
CSD	3.50	7.91	3.50	6.25	4.83	4.50	2.91	3.41	5.00
ZT	4.41	8.41	6.16	8.25	6.25	4.25	1.75	2.25	2.00
ST	3.25	7.33	3.75	7.25	4.50	4.41	2.41	2.50	4.50
CD	0.42	0.36	0.35	0.40	0.42	0.44	0.32	0.48	0.41

2.5.3 Nematode Population

Mononchus species and *Rhabditis spp* were counted as non phyto-pathogenic nematodes however *Dorylaimuss spp., Hoplolaimus spp., Pratylenchus spp., Tylenchorhynhusspp* was recorded as phyto-pathogenic nematodes. The maximum number of non-pathogenic nematodes was found under ZT followed by ST and CMB practices (Table 3). Dorylaimuss spp was equally found in CMB and ZT. *Hoplolaimus spp* were similar CST, CT and ST; *Helicotylenchus spp* were numerically similar in CMB and CSD. All the tillage practices showed similar numbers of *Pratylenchus species* and *Tylenchorynchus spp.* The average of nematode count revealed that ZT contained maximum number of nematodes followed by CMB and ST, the minimum being in CT and CSD.

The previously mentioned observations revealed a higher status of microflora and microfauna under ZT practice which is in accordance with the previous findings [43][44][45][46]. It is reported that the reduction of mechanical soil cultivation intensified soil microbial activities in the upper horizon and reduced soil phytotoxicity to wheat seedlings. Incorporation of residue in soil resulted in 2 to 11fold increase in the micro-flora population.

(Table 2) Nematode population under five different tillage treatments

Treatments	Nematode population (per 50 cc soil)							Mean
	Monococus spp	Rhabditis spp	Dorylaimuss spp	Hoplolaimus spp	Helicotylenchus spp	Pratylenchus spp	Tylenchorhynhus spp	

CT	400.00	400.00	250.00	350.00	450.00	450.00	500.00	399.99
CMB	400.00	450.00	300.00	300.00	600.00	450/00	550.00	435.71
CSD	400.00	400.00	200.00	350.00	600.00	450.00	500.00	414.28
ZT	450.00	500.00	300.00	400.00	700.00	500.00	550.00	485.71
ST	400.00	450.00	250.00	350.00	650.00	400.00	500.00	428.57
MEAN	392.80	435.70	250.00	335.70	607.10	435.70	507.10	

3-Conclusion

This study shows that, the soil under the long term no-till treatment had higher densities of earthworms, more soil enzymes, high particulate organic matter and potentially mineralizable nitrogen. More particulate organic matter carbon (POM-C) was measured in undisturbed soil than in disturbed soil. It means there is more carbon contents in soil under conservation tillage practices because in this practice in rice-wheat system crop residues left in the field which results in high organic matter and also in high organic carbon. High earthworm densities under zero-tillage system suggest an expanded and beneficial involvement for these soil fauna in crop residue decomposition process. In case of soil microbial communities there were higher number of pathogenic fungi, non-pathogenic fungi and nematodes under conservation tillage and especially in zero-tillage. Conservation tillage specifically zero-tillage, had positive effects on soil properties. Soil OM and aggregate stability can be increased by zero-tillage. The microbial community was proved to increase by the application of residues in zero-tillage. In many cases both fungi and bacteria were more abundant under zero-tillage. The residue was mainly decomposed by the fungal community in zero-tillage. Soil microbial shifted with tillage treatment and soil depth. Tillage practice and soil depth were two important factors affecting soil microbial communities. Studies revealed a higher status of soil microflora and microfauna under zero-tillage practice. Results suggested that tillage practices need to be considered when making soil management practices.

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