International Journal of Agriculture Sciences
ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 8, Issue 53, 2016, pp.-2691-2695.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

IMPACT OF CONSERVATION AGRICULTURE AND WEED CONTROL MEASURES ON SOIL PHYSICAL AND BIOLOGICAL PROPERTIES UNDER RICE – WHEAT-MUNGBEAN CROPPING SYSTEM IN VERTISOLS

SAPRE NISHA[1]*, KEWAT M.L.[1] AND SHARMA A.R.[2]

[1]Department Agronomy, College of Agriculture, Jawaharlal Nehru Agricultural University, Krishinagar, Adhartal, Jabalpur, 482004, Madhya Pradesh, India
[2]Directorate Weed Research, Jawaharlal Nehru Agricultural University, Krishinagar, Adhartal, Jabalpur, 482004, Madhya Pradesh
*Corresponding Author: Email-toughysingh@gmail.com

Received: September 20, 2016; Revised: September 23, 2016; Accepted: September 24, 2016; Published: November 01, 2016

Abstract- A field experiment was conducted during 2014-15 and 2015-16 at DWR, Jabalpur (M.P.) to assess the impacts of conservation agriculture and weed control measures on soil physical and biological properties under rice-wheat-mungbean cropping system in vertisols. The experiment consisted of fifteen treatments comprising of, five tillage as main-plot treatments and three weed control measures as sub plot treatments were, laid out in split plot design with three replications. Among the tillage treatments, maximum bulk density was found in transplanted rice-conventional tilled wheat (1.41 g/cc) followed by zero tillage in rice -wheat -mungbean without presence of previous crop residues (1.40 g/cc) after the second year of experiment. Maximum porosity (47.81 %) was observed in conventional tillage in both rice and wheat with zero tillage in mungbean with presence of previous crop residues. However, weed control measures did not affect the bulk density and porosity of soil. Zero tillage in rice-wheat-mungbean with previous crop residues had higher population of total bacterial (14.43 and 29.12 x 10^6 cfu/g first and second year respectively), and, fungal, (10.20 and 18.89 x 10^4 cfu/g, first and second year respectively) actinomycetes (9.23 and 14.08 x10^3 cfu/g first and second year respectively) and dehydrogenase (20.74 and 26.03 µg TPF/ soil/2hr, first and second year respectively) activity during both years. Whereas, maximum population of bacteria, fungus, actinomycetes and dehydrogenase activity (15.90 and 28.63 x 10^6 cfu/g, 9.46 and 21.55 x 104 cfu/g, 11.10 and 14.48 x10^3 cfu/g and 25.05 and 35.99 µg TPF/ soil/2hr, first and second year respectively) was found in weedy plots.

Keywords- Conservation tillage, Weed control, Rice-wheat-mungbean, Biological properties

Citation: Sapre Nisha., et al., (2016) Impact of Conservation Agriculture and Weed Control Measures on Soil Physical and Biological Properties Under Rice– Wheat-Mungbean Cropping System in Vertisols. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 8, Issue 53, pp.-2691-2695.

Academic Editor / Reviewer: Ajay Chourasiya

Introduction

Rice–wheat cropping system is one of the important and most prevalent agricultural practices in India as well as regions of the world. Rice-wheat cropping system occupies about 11 M ha area in India. [1]. Generally is rice grown under wetland condition which destroys the soil structure and creates poor physical condition for the following wheat crop and as a consequence there is decline in wheat yield presumably by limiting root growth and their distribution [2,3]. Intensive tillage also causes excessive breakdown of aggregates and leading to soil erosion. Besides this, carbon loss occurs from soil to atmosphere as CO_2 due to faster decomposition of crop residues on account of build up of congenial conditions and ultimately helping in global warming. Suitable soil management through conservation tillage, high crop residue return and inclusion of legume crop in summer increase soil organic carbon, decrease soil bulk density and increase soil porosity or if used as mulch, the residue can modify soil temperature, which enhance soil microbial population [4,5]. Increased organic matter improves soil aggregation, moisture conservation, porosity, pore size and bulk density [6]. Bulk density varies with management as well as with inherent soil qualities. Zero tillage significantly increases bulk density of soil as compare to conventional tillage. Soil aeration is important for both agricultural and environmental functions of soil. Plant roots and soil fauna require oxygen and aerobic microbs are important decomposers. In conservation tillage system (zero or reduced tillage) microbial biomass and its diversity are usually greater than conventional tillage [7]. On adoption of conservation tillage, application of herbicides has become unavoidable. Herbicides also effect the soil microbial population and enzymes, which are essential part of the soil system. Microbes perform essential role in soil and act as marker of soil health and quality. Many other workers also reported adverse effects of herbicides on soil micro organisms [8,9]. Dehydrogenase enzyme is associated with oxidation-reduction processes occurring in soil. The effect of herbicides on soil enzymatic activity is a key feather, which describes the potential toxicity of herbicide in soil [10]. Generally, herbicides are not harmful when applied at recommended rates, but some reports showed that herbicidal application may have adverse effect on bacterial population [11,12].

The ill effects of herbicide on non target organisms may reduce some important functions in the soil such as decomposition of organic matter, nitrogen fixation and solubilization of phosphate which improve 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 only on effects of application of herbicides on soil microbial population and their activity for a short period, may not provide a realistic evaluation of such effects in cyclic application of herbicides in different cropping systems.

Since, the information on impact of tillage and weed management practices on soil properties in rice-wheat-mung bean cropping system is very meagre for this region. Hence, forth, the present investigation entitled on impact of conservation tillage and weed management practices on soil properties in rice-wheat- mung bean cropping system was proposed.

MaterialsandMethods

The field experiment was conducted during 2014-15 and 2015-16 at Directorate of Weed Research, Jabalpur (M.P.). The experiment was consisted of Fifteen treatments comprising of five tillage as main-plot treatments (T_1- conventional tillage in rice + susbania - conventional tillage in wheat - zero tillage in mungbean, T_2- conventional tillage in rice +susbania + previous crop residues – conventional tillage- + rice residues in wheat-zero tillage in mungbean, T_3- zero tillage in rice + susbania - zero tillage in wheat - zero tillage in mungbean, T_4- zero tillage in rice + susbania + previous crop residues - zero tillage + rice residue in wheat - zero tillage in mungbean, T_5- transplanted rice - conventional tillage in wheat) and three weed control as sub plot treatments (W_1- weedy check, W_2- application of bispyribac 25g/ha in rice and application of tank mix solution of clodinafop 60 g/ha and sulfosulfuron 25g/ha in wheat as post emergence (in both the years) and W_3- application of chlorimuron + metsulfuron-methyl 4.0g ready mix /ha (post emergence) during 2014 and bispyribac 25g/ha (post emergence) in 2015 in rice and application of clodinafop 60 g/ha+2, 4-D 0.5kg/ha (post emergence) during 2014-15 and mesosulfuron 3% + iodosulfuron methyl 0.6%@12+2.4g/ha (post emergence) during 2015-16 in wheat, were laid out in split plot design with three replications. The soil of site had a clay loam texture in the 0–15 cm surface layer and a clay texture in the 15–75 cm depth with 7.3 pH, EC 0.22 dSm^{-1}, 0.54% organic carbon, available nitrogen (238 kg/ha), phosphorus (16.5 kg/ha) and potassium (342kg/ha).

Estimation of soil bulk density

Soil bulk density was measured by using a core sampler, before start of experiment and after the completion of each crop cycle during both the years of the experiment. Three cores were collected from each plot, and bulk density was determined using slandered method. [13].

$$\text{Bulk density (g/cc)} = \text{Oven dry weight of soil} \div \text{Volume of core}$$

Estimation of soil porosity

Soil porosity was measured by using the value of specific gravity of the soil and it is obtained by using slandered method of pycnometric determination [13].

$$\text{Soil porosity \%} = \left(\frac{\text{p.d.} - \text{b.d.}}{\text{p.d.}}\right) \times 100$$

Enumeration of microorganisms

The soil samples were collected from 0-15cm surface soil in all the plots before the start of experiment and at the end of the each crop cycle. The soil samples were soaked into 90 ml de-ionized 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 microbial counts were analyzed with the standard technique of Serial dilution and dour plating. Enumeration of total soil bacteria and fungi was carried out in soil extract agar medium (14) and Rose Bengal Agar medium [15] respectively. The Kenknight's Agar medium [16] was used for enumeration of actinomycetes. After allowing for development of discrete bacterial and fungal colonies in incubator under suitable conditions, the colonies were counted and the number of total bacteria, fungi and actinomycetes were expressed as colony forming units (cfu)] per gram dry weight of soil.

Estimation of dehydrogenase activity

The method is based on the reduction of 2,3,5- triphenyltetrazolium chloride (TTC) to triphenyl formazon (TPF). Each soil sample was treated with 0.1 g of $CaCO_3$ and 1 ml of 0.18 mm aqueous solutions of TTC and incubated for 24 hours at 30 ^oC. The TPF formed was extracted with methanol from the reaction mixture and assayed at 485 nm in spectrophotometer [17].

Results

Effect of tillage

Changes in soil physical property

The changes in physical soil properties like bulk density and porosity as affected by different tillage and weed control measures over initial status during 2014-15 and 2015-16 are given in [Table-1]. It is obvious from the data that bulk density of soil was almost unchanged under different tillage treatments after first year of the field experiment. Further, maximum bulk density (1.41 g/cc) was found in transplanted rice-conventional tilled wheat followed by zero tillage in both rice, wheat and mungbean without presence of previous crop residues (1.40 g/cc) after second year of field experiment. However, the lowest bulk density (1.34 g/cc) was found in conventional tillage in both rice, wheat and zero tillage in mungbean with presence of previous crop residues. The porosity of the soil was almost unchanged from the initial status under different treatments after first year of field experiment. But after the end of second year of crop cycle notable change was observed. Maximum porosity (48.81 %) was observed in conventional tillage in both rice and wheat and zero tillage in mungbean with presence of previous crop residues followed by conventional tillage in both rice and wheat and zero tillage in mungbean without presence of previous crop residues (48.78 %). Minimum soil porosity (46.62 %) was observed in transplanted rice with conventional tilled wheat.

Table-1 *Impact of different tillage and weed management practices on bulk density and porosity of the soil*

Tillage treatment	Bulk density (g/cc)			Porosity %		
	Initial (2014)	Ist year (2015)	IInd year (2016)	Initial (2014)	Ist year (2015)	IInd year (2016)
CT (DSR)+S-CT(Wheat)-ZT (Mungbean)	1.37	1.38	1.36	47.48	47.78	47.57
CT (DSR) +R+S-CT+R(Wheat)-ZT (Mungbean)	1.36	1.35	1.34	47.59	47.81	48.78
ZT (DSR)+S-ZT(Wheat)-ZT (Mungbean)	1.37	1.37	1.40	47.49	47.38	47.18
ZT (DSR) +R+S-ZT+R(Wheat)-ZT (Mungbean)+R	1.365	1.36	1.38	47.48	47.57	47.81
CT(TPR)-CT(Wheat)	1.37	1.39	1.41	47.46	47.48	46.62
SEm±	0.02	0.02	0.006	0.04	0.17	0.02
LSD (P= 0.05)	NS	NS	0.020	NS	NS	0.09
Weed control measures						
Weedy check	1.37	1.37	1.38	47.44	47.45	47.53
Continuous use of same herbicides	1.36	1.37	1.37	47.47	47.58	47.51
Herbicides rotation	1.36	1.37	1.38	47.71	47.50	47.34
SEm±	0.01	0.01	0.005	0.03	0.09	0.02
CD	NS	NS	NS	NS	NS	NS

Changes in Soil biological properties

Data pertaining to initial status of different biological properties of soil *viz*., total bacterial, fungal, actinomycetes population and dehydrogenase activity were recorded at the time of start of the present investigation during *Kharif* 2014-15. Thus, initial data on these parameters were recorded first time during the start of *Kharif* season 2014-15. Data on these parameters as affected by varying treatments are given in [Table-2]. It is evident from the said data that different biological properties deviate much over their initial status due to different tillage and weed control measures in rice-wheat-mungbean cropping system. The bacterial population was non-significant at the start of the experiment. Whereas, significantly higher bacterial population (14.43 and 29.12 x 10^6 cfu/g in first and second year, respectively) was found when zero tillage was done in rice, wheat and mungbean in presence of residues of preceding crop followed by zero tillage in rice, wheat and mungbean without presence of residues of preceding crop (13.91 and 27.13 x 10^6 cfu/g in first and second year, respectively). However, minimum total bacterial population (11.20 and 23.35 x 10^6 cfu/g in first and second year, respectively) was observed in transplanted rice with zero tilled wheat. Similarly, maximum population of fungi (10.20 and 18.89x 10^4 cfu/g in first and second year, respectively) was observed in plots receiving zero tillage in both crop components in presence of residues of preceding crop , followed by zero tillage in rice, wheat and mungbean without presence of residues of preceding crop, (9.89 and 17.24 x 104 cfu/g first and second year, respectively). Whereas, minimum population of bacteria (6.84 and 12.06 x 104 cfu/g in first and second year, respectively) was observed in transplanted rice with conventional tilled wheat.

Table-2 *Impact of different tillage and weed management practices on total bactirial and fungal population of the soil*

Tillage treatment	Total Bacteria (106 cfu/g dry weight of soil)			Total Fungi (104 cfu/g dry weight of soil)		
	Initial (2014)	Ist year (2015)	IInd year (2016)	Initial (2014)	Ist year (2015)	IInd year (2016)
CT (DSR)+S-CT(Wheat)-ZT (Mungbean)	11.50	11.20	24.36	7.39	7.87	12.76
CT (DSR) +R+S-CT+R(Wheat)-ZT (Mungbean)	11.53	12.53	26.00	7.41	8.47	17.02
ZT (DSR)+S-ZT(Wheat)-ZT (Mungbean)	11.62	13.91	27.13	7.47	9.89	17.24
ZT (DSR) +R+S-ZT+R(Wheat)-ZT (Mungbean)+R	11.67	14.43	29.12	7.51	10.20	18.89
CT(TPR)-CT(Wheat)	11.29	11.36	23.35	7.16	6.84	12.06
SEm±	0.26	0.41	0.41	0.29	0.38	0.40
LSD (P= 0.05)	NS	1.34	1.34	NS	1.09	1.41
Weed control measures						
weedy check	11.73	15.90	28.63	7.66	9.46	15.50
Continuous use of same herbicides	11.43	13.01	25.07	7.36	8.66	13.18
Herbicides rotation	11.40	9.07	20.40	7.14	7.24	7.21
SEm±	0.15	0.35	0.63	0.29	0.20	0.21
LSD (P=0.05)	NS	1.04	1.87	NS	0.63	0.67

The actinomycetes population was non-significant at the start of the experiment. However, significantly higher population (9.23 and 14.08x 10^3 cfu/g in first and second year, respectively) was found in plots receiving zero tillage in both crop components in presence of residues of preceding crop during both the years, followed by zero tillage in rice, wheat and mungbean without presence of residues of preceding crop, (9.04 and 13.52 x 10^3 cfu/g in first and second year, respectively). Whereas, minimum population of actinomycetes (6.73 and 9.11 x 10^3 cfu/g in first and second year, respectively) was observe in transplanted rice with conventional tilled wheat. Dehydrogenase activity (26.03 and 39.76 µg TPF/ soil/2hr in first and second year, respectively) was more when zero tillage was done in both crop components in presence of residues of preceding crop followed by zero tillage in rice , wheat and mungbean without presence of residues of preceding crop (25.59 and 35.76 µg TPF/ soil/2hr in first and second year, respectively). However, the minimum dehydrogenase activity was observed under transplanted rice- conventional tillage in wheat during end of the experiment (22.57 and 31.30 µg TPF/ soil/2hr in first and second year, respectively) [Table-3; and Plate-3].

Table-3 *Impact of conservation tillage on actinomycetes population and dehydrogenase activity*

Tillage treatment	Actinomycetes (10^3 cfu/g dry weight of soil)			Dehydrogenase activity (µg TPF/ soil/2hr)		
	Initial (2014)	Ist year (2015)	IInd year (2016)	Initial (2014)	Ist year (2015)	IInd year (2016)
CT (DSR)+S-CT(Wheat)-ZT (Mungbean)	3.43	7.22	11.00	20.73	23.47	32.05
CT (DSR) +R+S-CT+R(Wheat)-ZT (Mungbean)	3.51	8.35	11.38	20.55	24.66	34.63
ZT (DSR)+S-ZT(Wheat)-ZT (Mungbean)	3.59	9.04	13.52	20.48	25.59	35.76
ZT (DSR) +R+S-ZT+R(Wheat)-ZT (Mungbean)+R	3.65	9.23	14.08	20.74	26.03	39.76
CT(TPR)-CT(Wheat)	3.21	6.73	9.11	20.72	22.57	31.30
SEm±	0.22	0.28	0.37	0.77	0.55	0.27
LSD (P= 0.05)	NS	0.82	1.19	NS	1.79	0.87
Weed control measure						
Weedy check	3.39	11.10	14.48	21.17	25.05	35.99
Continuous use of same herbicides	3.49	7.83	11.88	20.55	24.28	34.71
Herbicides rotation	3.55	5.42	9.10	20.22	24.06	33.39
SEm±	0.26	0.24	0.36	0.39	0.37	0.33
LSD (P=0.05)	NS	0.79	1.06	NS	1.09	0.97

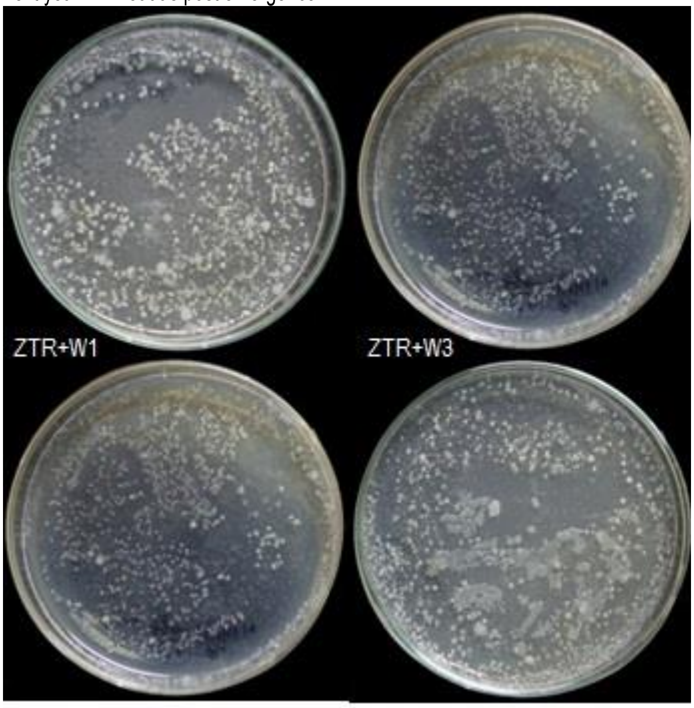
Weed management practices

Changes in soil physical property

It is obvious from the data presented in [Table-1] that bulk density and soil porosity were remain unchanged due to the different weed control measures in both the crop cycle over the initial status.

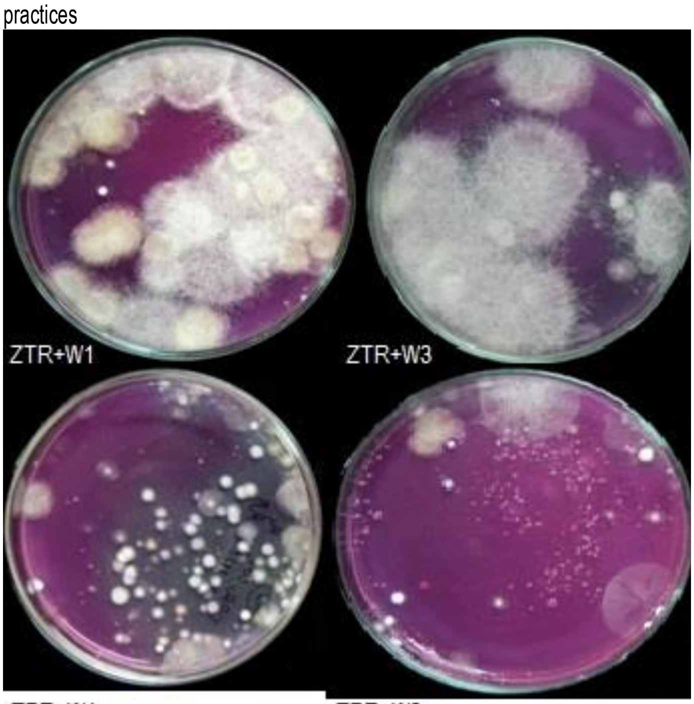
Changes in Soil biological properties

Weed management practices significantly affect the soil microbial population and dehydrogenase activity during end of the field experimentation. Maximum population of bacteria, fungus, actinomycetes and dehydrogenase activity (15.90 and 28.63 x 10^6 cfu/g, 9.46 and 21.55 x 10^4 cfu/g, 11.10 and 14.48 x10^3 cfu/g and 25.05 and 35.99 µg TPF/ soil/2hr, first and second year respectively) was found in weedy plots. Minimum population of bacteria, fungus, actinomycetes and dehydrogenase activity (9.07 and 20.40 x 106 cfu/g, 7.24 and 7.57 x 104 cfu/g, 5.42 and 9.10x103 cfu/g and 24.06 and 33.39µg TPF/ soil/2hr, first and second year respectively) was found with application chlorimuron +metsulfuron-methyl 4 g/ha (post emergence) in first year and bispyribac 25g/ha next year in rice and clodinafop 60 g/ha+2,4-D 0.5kg/ha (post emergence)in first year and mesosulfuron 3%+ iodosulfuron methyl 0.6% @ 12+2.4g/ha (Atlantis 400g/ha) in next year in wheat as post emergence.



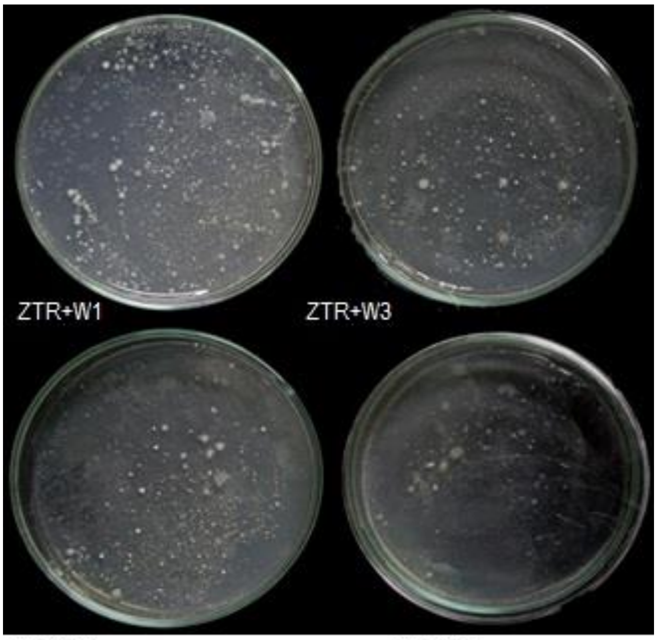
TPR+W1 TPR+W3

Plate-1 Total bacterial population as affected by different tillage and weed control practices



TPR+W1 TPR+W3

Plate-2 Total Fungal population as affected by different tillage and weed control practices



ZTR+W1 ZTR+W

Plate -3 Actenomycetes population as affected by different tillage and weed control practices

Discussion

Tillage had greater impacts on soil bulk density than residue retention and all plots that received residues had lower bulk density. The reason for lower bulk density under conventional tillage in the surface soil layer due to loosening of soil by tillage and the incorporation of crop residues into the plough layer of soil [18]. In the succeeding year, porosity was increased in all the tillage treatments specially plots those receiving privies crop residues either in zero tillage as well as in conventional tillage. This might be due to porosity of soil inversely related to the bulk density and found strong negative correlation between porosity and bulk density [19]. Maximum bacterial population under zero tillage in both the crop components in presence of residues of preceding crop also caused by more accumulation of organic matter on the soil surface and as a consequence increased the abundance of microbial population particularly bacteria [20]. On the contrary, reverse was true in case of transplanted rice-conventional tilled wheat because conventional tillage was done in both the crops without previous crops residues 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. Henceforth, the bacterial population was less under conventional tillage to both the crop components [21]. Higher population of total fungus in zero tillage might be due minimum disturbance of soil in zero tillage provides a steady source of organic carbon to support the microbial population specially growth of fungal community compared to conventional tillage and less disturbance of soil favours formation and stabilization of macro aggregates to improve and protect habitat for microbial population [22]. Presence of residues of preceding crop caused accumulation of organic matter, which increased soil aeration, cooler and wetter condition and higher carbon content in soil surface which facilities higher actinomycetes population. Similar, findings were also made by some workers [21, 23]. Decline in microbial population ultimately led to decrease dehydrogenase activity because dehydrogenase activity reflects the total range of oxidative activity of soil microflora. [24]. Higher population of bacteria, fungus, actinomycetes and dehydrogenes activities was observed when zero tillage was done in soybean and wheat in the presence of preceding crop [25].

Rotational use of herbicides or higher dose of herbicides reduces bacterial population because these herbicides disrupt amino acid assimilation ability of nitrifiers number [26]. Bacterial population was reduced by 27.3% when mesosulfuron and iodosulfuron applied in mixture in wheat followed by application of pendimethalin or imazethapyr in preceding soybean crop. This is because of abundance of herbicides (mixture of mesosulfuron and idosulfurron) on the soil surface due to slow rate of degradation on account of lower value of maximum and minimum temperature during *rabi* in last 30 years [25]. High dose of herbicides also leads to the death of fungi and as a result, their population decreased [9]. Higher soil microbial population and dehydrogenase activity under weedy check plot was attributed to large increase in microbial biomass, as it is positively correlated with weed biomass because of high decomposability [27].

Conclusion

It could be concluded that addition of crop residues of previous crop reduces the bulk density and increase soil porosity in conventional as well as in zero tillage, and enhanced the soil microbial as well as dehydrogenize activities and use of same herbicides in the rice-wheat-mungbean cropping system was found better than the rotational use of herbicides for higher microbial population and dehydrogenase activity in soil.

Conflict of Interest: None declared

References

[1] Anonymous (2016) www.gktoday.in
[2] Boparai B.S., Singh Y. and Sharma B.D. (1992) *Arid Soil Research Rehabilitation,* 6, 135–143.
[3] Oussible M., Crookstan R.K. and Larson W.E. (1992) *Agronomy Journal,* 84, 34–38.
[4] Bhagat R.M. and Acharya C.L. (1988) *Journal of Indian Society of Soil Science,* 36, 389–396.
[5] Bhattacharyya R., Pandey S.C., Bisht J.K., Bhatt J.C., Gupta H.S., Tuti M.D., Mahanta D., Mina B.L., Singh R.D., Chandra S., Srivastva A.K. and Kundu S. (2013) *Agronomy Journal,* 105,101–112.
[6] Jalota S.K., Buttar G.S., Sood A., Chahal G.B.S., Ray S.S. and Panigrahy S. (2008) *Soil and Tillage Research,* 99, 77–83.
[7] Carpenter-Boggs L., Stahl P.D., Lindstrom M. J. and Schumacher T.E. (2003) *Soil and tillage research,* 71, 15-23.
[8] El-Ghamry A.M., Chang-yong H. and X. Jian-ming (2000) *Journal of Environmental Science,* 12, 138-143.
[9] Pampulha, M.E. and Oliveira A. (2006) *Current Microbiology,* 53, 238-243.
[10] Quilchano, C. and Maranon T. (2002). Springer-Verlag, 103.
[11] Selvamani S. and Sankaran S. (1993) *Madras Agriculture Journal,* 80, 397-399.
[12] Rajendran K. and Lourduraj A.C. (1999) *Agriculture Review,* 20, 48-52.
[13] Mishra R.D. and Ahmad M. (1987) Manual on irrigation agronomy. New Delhi, India: Oxford and IBH Publishing Co. Pvt. Ltd.
[14] James N. (1958) *Canadian Journal of Microbiology,* 4, 363-370.
[15] Parkinson D., Gray T.R.G. and Williams S.T. (1971) IBP Hand Book 19, Blackwells Science Pubication Limited, Oxford.
[16] Wellington E.M.H. and Toth I.K. (1963) University of warwick.
[17] Casida L.E., Klein D.H. and Santoro T. (1964) *Soil Science,* 98, 371-376.
[18] Hussain I., Olsen K.R. and Siemens J.C. (1998) *Soil Science,* 163,970–981.
[19] Chaudhari Pravin R., Ahire Dodha V., Vidya Ahire D., Chkravarty Manab and Maity Saroj. (2013) *International Journal of Scientific and Research Publications,* 3, 1-8.
[20] Mathew R.P., Feng Y., Githinji L., Ankumah R. and Balkcom K.S., (2012) Hindawi Publishing Corporation, Applied Environment Soil Science.
[21] Younesabadi M., Das T.K. and Paul S. (2014) *International Journal of Farming and allied sciences,* 3(9), 962-969.
[22] Balota E.L., Colozzi-Fitho A., Andrade D.S. and Hungric M. (1998) *Rev Bras cienc Salo.*, 22, 641-649.
[23] Govindan R. and Chinnusamy C. (2014) *Trends in Biosciences,* 7(15), 1932-1936.
[24] Abbas Zafar, Akmal Muhammad, Khan Saifullah Khalid and Hussan Fayaz-Ul. (2015) *International Journal of agriculture and Bioscience,* 17, 305-312.
[25] Singh Priya, Sarathambal C., Kewat M.L. and Singh V.P. (2015) *Indian Journal of weed science,* 47(4),1-5.
[26] Allievi L. and Gigliotti C. (2001) *Journal of Environmental Science and Health, Part B,* 36, 161-175.
[27] Wardle D.A., Yeates G.W., Nicholson K.S., Bonner K.I. and Watson R.N. (1999) *Soil Biology Biochemistry,* 31(12), 1707-1720.