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Research Article

Effect of Different Cropping Sequences on Soil Health under Irrigated Condition in Madhya Pradesh

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ABSTRACT

The present investigation was conducted during two consecutive years of 2018-19 and 2019-20 entitled effect of different cropping sequences on soil health under irrigated condition in Madhya Pradesh. Higher soil organic carbon noted that green gram – chickpea – green gram (7.03 -7.06 and 7.02 to 7.04 g kg^{-1}) during 2018–19 and 2019–20, respectively. With respect to soil pH it was changes in soil pH (7.53 to 7.56), highest available NPK, highest number of total bacterial counts (45.57 and 46.49 10^{5} x cfu g^{-1} soil), fungi (31.00 and 31.42 10^{-3} x cfu g^{-1} soil) and actinomycetes (7.63 and 7.72 10^{-3} x cfu g^{-1} soil) under green gram – chickpea – green gram cropping sequence as compared to rest of the cropping sequence.

Keywords: *Soil properties, Available NPK, Total bacteria, Fungi and Actinomycetes.*

INTRODUCTION

The rice –wheat system is dominant cropping system of irrigated areas of Kymore Plateau and Satpura Hill Zone. This system requires high input resources for higher productivity resulted higher cost per unit area and time. Continues cultivation of rice – wheat crops in this region cerate the more problems showed low in the system productivity with poor crop management practices consequently loss in soil fertility due to emergence of multiple nutrient deficiency (Fujisaka et al., 1994; Dwivedi et al., 2001; & Kumar et al., 2019), because of Incidence and expansion of multi-nutrient deficiencies in the soils under intensive cropping and in rice-based mono cropping systems, can be linked to inadequate and unbalanced nutrient input and considered as major reasons observed for declines in productivity associated with fertilizer use (Singh et al., 2009), unattended intervening periods (Bhatt & Kukal 2014a,b; & Bhatt & Kukal 2015a,b,c), soil degradation (Bhandari et al., 2002) and atmospheric pollution, deterioration in soil physical properties (Tripathi, 1992), decline productivity, crop yield (Yadav, 1998),

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resurgences of weed, insect, pest and disease, over mining of nutrients, reduction in organic carbon, reduction in water table (Humphreys et al., 2010; & Hira et al., 2001), imbalance use of fertilizer and water logging (Naresh et al., 2017).

Crop diversification shows lot of promises in alleviating these problems besides, fulfilling basic needs for cereals, pulses, oilseeds and vegetables as well as regulating farm income besides withstanding weather aberrations, controlling price fluctuation, ensuring balanced food supply, conserving natural resources, reducing the chemical fertilizer and pesticide loads, ensuring environmental safety and creating employment opportunity (Gill & Ahlawat, 2006). Inrecent years double and triple cropping are more focusing points for increasingfarmers income, so diversification and intensification of cropping systems withremunerative and efficient crops like pulses, oilseeds and vegetables has greatscope to generate maximum net profit per unit investment per unit time to farmers. (Kalita et al., 2019). Realizing this, significant thrust has been made on the inclusion of high value and high volume vegetable crops in rice–fallow systems to improve the economic condition of marginal and small farmers (Pooniya, 2015). Intensification of rice–fallow system is an effectual approach for achieving food and nutrition security, poverty alleviation, employment generation, prudent use of land and water resources, sustainable agricultural development and overall environmental quality improvement (Hegde, 2003). In the era of resource attenuation, resource useefficiency is an important aspect for considering the suitability ofa cropping system (Babu, 2014). Comprehensive information on effect of different cropping sequences on soil health under irrigated condition in Madhya Pradesh is meager and compilation of scientific information on this burning issue is a great challenge. Hence, with the above information the present study has been undertaken.

MATERIALS AND METHODS

A field experiment was conducted during 2018 - 19 to 2019 – 20 at the Instructional Research Farm, Department of Agronomy, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India. The soil of experimental field was sandy loam in texture with pH 7.57, electrical conductivity 0.50 dSm^{-1} and organic carbon (6.9 g kg^{-1}), available nitrogen (227 kg ha^{-1}), available phosphorus (9.4 kg ha^{-1}) and available potassium (302 kg ha^{-1}) content. The varieties and hybrids which were popularamong local farmers with respect to their yield potentialand insect-pest resistance were used. The varieties ofdifferent crops and their duration in the field, recommendedfertilizer dose applied and planting spacing. The experiment was laid out in a randomized block design with 10 treatments of rice based cropping systems and replicatedthrice. (T_1) rice – wheat, (T_2) rice – chickpea, (T_3) greengram – chickpea – greengram, (T_4) greengram – lentil – blackgram, (T_5) rice – potato – (cob) maize, (T_6) rice – *toria* (early *rabi*) wheat (late *rabi*), (T_7) sorghum (f) – egyptian clover (fodder + seed), (T_8) ricebean (f) – egyptian clover (f) – sorghum (f), (T_9) maize (cob) – vegetable pea – okra, (T_{10}) soybean – marigold – vegetable cowpea. The row to row spacingwas 20 cm for rice, wheat, 30 cm for gram, pea cowpea, lentil, greengram, blackgram, sorghum, soybean, ricebean and *Toria*, 60 cm for okra, marigold, maize (cob) and potato, while Egyptian clover crop was broadcasted. All the recommended package of practices was adopted forthe irrigated condition in all the *Kharif*, *Rabi* and *Zaid* crops. In soil samples, soil organic carbon, Electrical conductivity meter, glass electrode pH meter, N, P and K were estimated by the following methods; Walkley and Black (Jackson, 1973), Alkaline permanganate (Subbiah & Asija, 1956), modified kejldahl (Subbish & Asija, 1956), Olsen et al. (1954), and Flame Photometer (Jackson, 1954), respectively.

RESULTS AND DISCUSSION

Soil organic carbon, pH and electrical conductivity

Results of study reveal that the organic carbon significantly changed due to different cropping sequences during both the years as well as mean data. There it was interested to noted that green gram – chickpea – green gram (7.03 -7.06 and 7.02 to 7.04 g kg^{-1}) followed by green gram – lentil – black gram recorded significantly higher content of organic carbon during 2018–19 and 2019–20, respectively. These treatments were proved at par to T_7 and T_8 where egyptian clover was included in cropping sequence. The increase of OC in legume component sequence over other sequences and initial values. Due to inclusion of legume crops having relatively higher above ground leaf biomass and below ground root biomass additions. Thus, higher root and shoot biomass additions might also be possible reasons for higher OC in green gram – chickpea – green gram cropping sequence (Dwivedi et al., 2003; & Sharma & Sharma, 2004). Further greater rhizo-deposition and shedding of leaves by the leguminouscrops, both contributing to an increase in organic carbon (Thakur & Sharma, 1988). Incorporation of green gram, black gram, egyptian clover stover and roots as well as roots and stubbles of cowpea and winter pulses (Yadav, 1988). Besides this, the cropping sequences having summer green gram, back gram, egyptian clover and veg. cowpea improved the plant growth and ultimatelythe yield of component crops in the respective sequences. It is quite obvioustthat this might have added greater biomass and stubble to the soil ultimately improving the soil organic carbon. Study of soil properties with respect to soil pH it was found that green gram – chickpea – green gram cropping sequence bring out the changes in soil pH (7.53 to 7.56) followed by followed bygreen gram – lentil – black gram (7.54 to 7.52) as compared to other cropping sequence. Green gram – chickpea – green gramcropping soil pH. This decline in soil reaction might be due to organic compounds added to the soil in the form of green as well as dry biomass, which produced more humus and organic acid after decomposition. Similar results also reported by Pattanayak et al. (2001), Yaduvanshi et al. (2001), Smiciklas et al. (2002), Venkatesh (2009) and Upadhyay et al. (2011) who observed the decrease in soil pH after the use of organic materials. Due to inclusion of pulses as compared to cereal. Over initial value however the difference among the cropping sequences were found non-significant during both the years. The legume cropping sequence and legume as a component cropping system retain the pH to be neutral side. Under different cropping sequencesoil electrical conductivity and pH was non-significant.

Available Nitrogen

Data presented in Table 2 with respect to available N in soil analyzed after harvest of crop during both the years of study showed significant variation due to different cropping sequence. It was noted that the nitrogen content in soil decreased over initial value and subsequent year under cereal – cereal cropping sequence. Further it was also noted that legume – legume cropping sequence serially increased the available nitrogen over initial value and preceding year. The inclusion of legume crop in all the yearly sequence viz. green gram – chickpea – green gram, green gram – lentil – black gram, sorghum – egyptian clover for fodder & seed as well as rice bean – Egyptian clover for fodder – sorghum for fodder only recorded marketable enhancement in available nitrogen over the year. The inclusion of legume crops in a yearly sequence has been reported to increase available soil nitrogen because of beneficial effect of legume crops residues to better nutrient reserves and buffering capacity besides enhancing bio-availability of nitrogen. (Devi & Thakur, 1994, Kumar et al. 2001, Gangwar & Ram 2005 & Porpavai et al., 2011) because of their nitrogen fixation ability. Furthermore,it was also pointed out that the biomass added by legume crops such as green gram, black gram, lentil, egyptian clover, chickpea, pea and cowpea, was rich in nitrogen, as they accumulate more nitrogen fixed by rhizobia. These observations are in agreement with those of Singh et al. (1996) and Chauhan et al. (2001).

Available Phosphorus

In general it was observed that all the cropping sequences increased the available phosphorus in soil over initial values except rice – wheat and rice – chickpea cropping sequence. Further it was noted that higher value of P in soil (10.12 kg P ha^{-1}) closely followed by (10.10, 10.06, 10.04 and 9.98 kg P ha^{-1}) was recorded under green gram – chickpea – green gram, green gram – lentil – black gram, rice bean for fodder – egyptian clover for fodder – sorghum for fodder, sorghum for fodder – egyptian clover for fodder + seed and soybean – marigold – vegetable cowpea, respectively. Including of legume crops in a cropping systems not only economizes nitrogen requirement of cropping systems but also support in efficient utilization of native phosphorus due to secretion of certain acids that help in solubilization of various forms of phosphorus. This ability of legumes utilized the native phosphorus existe in different forms in soil. Increased available P is a result of P acquisition from insoluble phosphates by the action of root exudates. Chickpea crop has an ability to access P, normally not available to other crops, by mobilizing sparingly soluble Ca-P by acidification of rhizosphere through its citric acid root exudates. Ae et al. (1991), Saxena (1995), Kumar et al. (2001), Singh et al. (2004) and Gangwar and Ram (2005). Similar results were also reported by Upadhyay et al. (2007) and Kumar et al. (2008) who stated that P status marginally improved over initial value in all the legume based sequences.

Available potassium

Results of study (Table 2) reveal that the post-harvest soil of cropping sequence green gram – chickpea – green gram, green gram – lentil – black gram possessed the higher available K(303.33 kg ha^{-1}) closely followed by sorghum (F) – egyptian clover for fodder & seed (304 kg ha^{-1}) during first year and (305.67, 305.33 and 305.33 kg ha^{-1}) under same treatment during subsequent year. The highercontent of available K in green gram – chickpea – green gram cropping sequence over the initial values K. Might be due to legumes crops releases organic colloids having higher cation exchange capacity to attract K from applied K and changed non-labile pool into exchangeable pool which favours available K status in soil. (Lund & Doss, 1980). The findings are in accordance with the findings of Singh et al. (1995), Kumar et al. (2001), Gangwar and Ram (2005) and Upadhyay et al. (2011).

Soil Biological Properties

Study of soil biological properties with respect to total bacterial count, fungi and actinomycetes are presented in Table 3. It was found that thegreen gram – chickpea – green gram cropping sequence possessed higher number of total bacterial counts (45.57 and 46.49 10^5 x cfu g^{-1} soil), fungi (31.00 and 31.42 10^{-3} x cfu g^{-1} soil) and actinomycetes (7.63 and 7.72 10^{-3} x cfu g^{-1} soil) followed by green gram – lentil – black gram (45.47 to 46.46 10^5 x cfu g^{-1} soil), (30.51 and 30.63 10^{-3} x cfu g^{-1} soil) and (7.45 and 7.53 10^{-3} x cfu g^{-1} soil). The total bacterial population was increased in different legume cropping sequences and highest proliferation was observed under green gram – chickpea – green gram cropping sequence. Improvement in microbial counts of soil under legume based cropping sequence has been reported by Singh et al. (2001), Nath et al. (2011) and Davari et al. (2011). They reported indicate that inclusion of pulses in cropping sequences hence the soil microbial biomass and their activities that could be vital for long-term soil health and productivity. Tilak, (2004) also reported that higher counts of bacteria due to growing of green gram after rice.

Table 1: Soil pH, EC (dSm^{-1}) and organic carbon (g kg^{-1}) as influenced by different cropping sequences

Cropping sequences		pH			EC (dSm^{-1})			OC (g kg^{-1})		
		2018- 19	2019- 20	Mean	2018 - 19	2019 - 20	Mean	2018 -19	2019 -20	Mean
Initial		7.57			0.50			6.9		
T_1	Rice – Wheat	7.58	7.59	7.59	0.49	0.48	0.49	6.85	6.79	6.82
T_2	Rice – Chickpea	7.57	7.57	7.57	0.49	0.48	0.49	6.88	6.85	6.87
T_3	Greengram – Chickpea – Greengram	7.53	7.5	7.52	0.5	0.45	0.48	6.96	7.01	6.99
T_4	Greengram – Lentil – Blackgram	7.54	7.52	7.53	0.5	0.47	0.49	6.95	6.99	6.97
T_5	Rice – Potato – Maize (cob)	7.57	7.58	7.58	0.48	0.46	0.47	6.87	6.83	6.85

T_6	Rice – *Toria* (early *rabi*) Wheat (late *rabi*)	7.57	7.58	7.58	0.48	0.47	0.48	6.86	6.81	6.84
T_7	Sorghum (F) – Egyptian clover(F+S)	7.54	7.51	7.53	0.49	0.46	0.48	6.94	6.98	6.96
T_8	Rice bean (F) – Egyptian clover (F) - Sorghum (F)	7.55	7.54	7.55	0.49	0.47	0.48	6.93	6.98	6.96
T_9	Maize (cob) – Pea (V) - Okra	7.56	7.55	7.56	0.48	0.47	0.48	6.89	6.88	6.89
T_{10}	Soybean – Marigold – Cowpea (V)	7.56	7.53	7.55	0.48	0.46	0.47	6.92	6.95	6.94
SEM±		**0.01**	**0.15**	**0.08**	**0.024**	**0.025**	**0.02**	**0.03**	**0.03**	**0.03**
CD (p =0.05)		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.09**	**0.08**	**0.09**

Table 2: Available soil nitrogen, phosphorus and potassium as influenced by different cropping sequences

Cropping sequences		**Available Nitrogen (kg ha^{-1})**			**Available Phosphorus (kg ha^{-1})**			**Available Potassium (kg ha^{-1})**		
		2018- 19	**2019- 20**	**Mean**	**2018 - 19**	**2018 - 19**	**Mean**	**2018 -19**	**2019 -20**	**Mean**
Initial		**227.00**			**9.4**			**302.00**		
T_1	Rice – Wheat	225.33	224.33	224.83	9.35	9.29	9.32	302.67	303.00	302.84
T_2	Rice – Chickpea	226.00	226.00	226.00	9.83	9.90	9.87	303.00	303.67	303.34
T_3	Greengram – Chickpea – Greengram	230.33	233.00	231.67	10.05	10.12	10.09	304.33	304.67	304.50
T_4	Greengram – Lentil – Blackgram	229.67	232.33	231.00	10.05	10.11	10.08	304.33	304.33	304.33
T_5	Rice – Potato – Maize (cob)	226.00	225.00	225.50	9.36	9.30	9.33	302.00	302.67	302.34
T_6	Rice – *Toria* (early *rabi*) Wheat (late *rabi*)	227.00	224.00	225.50	9.38	9.32	9.35	302.33	303.00	302.67
T_7	Sorghum (F) – Egyptian clover(F+S)	229.00	229.67	229.34	10.00	10.05	10.03	303.67	304.33	304.00
T_8	Rice bean (F) – Egyptian clover (F) - Sorghum (F)	229.00	230.67	229.84	10.00	10.06	10.03	304.00	304.33	304.17
T_9	Maize (cob) – Pea (V) - Okra	227.33	227.67	227.50	9.33	9.43	9.38	303.00	303.67	303.34
T_{10}	Soybean – Marigold – Cowpea (V)	228.00	229.00	228.50	9.93	9.98	9.96	303.00	304.33	303.67
SEM±		**2.40**	**1.54**	**1.97**	**0.12**	**0.09**	**0.11**	**1.36**	**1.44**	**1.40**
CD (p =0.05)		**7.13**	**4.56**	**5.85**	**0.37**	**0.27**	**0.32**	**4.04**	**4.26**	**4.15**

Table 3: Soil biological properties as influenced by different cropping sequences

Cropping sequences		**Total bacterial count (10^5 x cfu g^{-1} soil)**			**Fungi (10^3 x cfu g^{-1} soil)**			**Actinomycetes (10^3 x cfu g^{-1} soil)**		
		2018- 19	**2019- 20**	**Mean**	**2018 - 19**	**2018 - 19**	**Mean**	**2018 -19**	**2019 -20**	**Mean**
Initial		**39.36**			**27.67**			**6.37**		
T_1	Rice – Wheat	41.51	41.74	41.63	26.2	25.95	26.08	6.53	6.27	6.40
T_2	Rice – Chickpea	41.67	42.17	41.92	27.3	27.38	27.34	6.77	6.44	6.61
T_3	Greengram – Chickpea – Greengram	45.57	46.49	46.03	31	31.42	31.21	7.63	7.72	7.68
T_4	Greengram – Lentil – Blackgram	45.47	46.46	45.97	30.51	30.63	30.57	7.45	7.53	7.49
T_5	Rice – Potato – Maize (cob)	42.26	42.52	42.39	26.48	26.28	26.38	6.62	6.02	6.32
T_6	Rice – *Toria* (early *rabi*) Wheat (late *rabi*)	41.66	41.92	41.79	26.67	26.5	26.59	6.91	6.38	6.65
T_7	Sorghum (F) – Egyptian clover(F+S)	45.58	46.2	45.89	30.74	30.82	30.78	7.10	7.24	7.17
T_8	Rice bean (F) – Egyptian clover (F) - Sorghum (F)	43.49	43.75	43.62	29.92	30.03	29.98	7.32	7.43	7.38
T_9	Maize (cob) – Pea (V) - Okra	43.43	43.68	43.56	29.13	29.19	29.16	7.17	7.09	7.13
T_{10}	Soybean – Marigold – Cowpea (V)	44.64	45.06	44.85	29.73	29.9	29.82	6.69	6.9	6.80
SEM±		**0.14**	**0.2**	**0.17**	**2.43**	**2.55**	**2.49**	**1.72**	**1.89**	**1.81**
CD (p =0.05)		**0.4**	**0.61**	**0.51**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

CONCLUSION

On the basis of present study it can be concluded that amongs different cropping sequence maximum total carbon stock soil organic carbon, available NPK, total bacteria, fungi and actinomycetes under green gram – chickpea – green gram. This cropping sequence soil health improvement under present scenario of existing cropping sequence.

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