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Effect of different rice-based cropping systems on Physio-chemical properties of soil

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Abstract
A field experiments with ten cropping systems were evaluated at Pt. SKS College of Agriculture and Research Station, IGKV, Surgi Rajnandgaon during the *kharif*, *rabi* and *zaid* seasons of 2018-2019 and 2019-2020. The cropping systems were evaluated for their productivity and assess their effect of different rice based cropping systems on the Physio-chemical properties of soil in *inceptisols* (*Matasi*) under irrigated conditions. The cropping systems rice - wheat - greengram, rice - sweet corn + cowpea (1:1) - clusterbean, rice - onion+ Coriander (leaf) (3:1) - greengram and rice - potato – blackgram improve the Physio-chemical properties of soil but systems did not differ markedly during two years of span.

Keywords: Rice-based, *kharif*, Physio-chemical, soil

Introduction
Rice-rice-fallow system is the most dominant crop sequence in irrigated ecology of the Chhattisgarh. Continuous cultivation of rice for longer period with low system productivity and often with poor crop management practices, consequently loss in soil fertility due to emergence of multiple nutrient deficiency. This system deteriorates of soil Physio-chemical properties and decline crop yield as well as average productivity in high productivity areas. During rice cultivation, soil undergoes drastic changes, *i.e.* aerobic to anaerobic environment, leading to several physical and electro-chemical transformations. Puddling breaks capillary pores, reduces void ratio, destroys soil aggregates, disperses fine clay particles and lowers soil strength in the puddle layer. In rice- rice systems soil frequently goes to wet and dry conditions encourages loss of N by leaching and denitrification. Further, since nitrite is an intermediate in both the reduction of nitrate may be more substantial and widespread than previously realized especially on soils those is alternately wet and dry. Moreover, rice-rice cropping system also required huge amount of irrigation which is an alarming situation in the region. However, crop diversification with economically viable crops appears to be suitable option in the region.
It has been established that cereal-cereal crop sequences are more exhaustive and put heavy demand on soil resources as compared to cereal-legume and cereal-oilseed sequences along with adverse effect on soil condition (Kumar and Yadav, 2012) [6]. Legume crops are observed to have favourable impact on the soil fertility and help in increasing the yield of succeeding rice crop. Use of organic source not only acts as supplement for fertilizer but also improve the physico-chemical properties of soils. Production and use of nitrogen rich organic biomass offer better prospect for supplementing chemical fertilizers on regular basis. Such biological diversity brings yield and economic stability because of its potential for compensation among components of the system. This phenomenon is called as biological or economical buffering in the system (Singh *et al*., 1999). Inclusion of pulses, oilseeds and vegetables in the system has been found more beneficial than cereal after cereal. Inclusions of crops in sequential and intercropping systems reduces obnoxious weeds through formation of canopies due to competitive planting pattern and thus provide an opportunity to utilize cropping systems as a tool of weed management with non-chemical means.

Material and Methods
A field experiment on diversification of rice based cropping system for enhancing productivity, resource use efficiency and economics under irrigated condition was conducted at Research cum Instructional Farm, Pt. Shiv Kumar Shastri College of Agriculture and Research Station, Rajnandgaon for the consecutive two years during all the three seasons of 2018-19 and 2019-20.

The experimental plot was typical medium and which some time get submerged in *rainy* season and is suitable for rice in *kharif* and also to the *rabi* and *zaid* crops. The experimental plots had fairly uniform topography with homogenous fertility and soil characteristic typical to suit medium land crop cultivation.

The experiment was laid out in randomized complete block design with three replication in the same location through the study period. Treatment comprised of the rice based cropping system, namely T_1- rice - rice - fallow, T_2 - rice - chickpea - fallow, T_3 - rice - wheat - greengram, T_4 - rice - sweet corn + cowpea (1:1) - clusterbean, T_5 - rice - chickpea (veg.) - sesamum, T_6 - rice - garlic - cowpea, T_7 - rice - coriander (leaf) - sweet potato, T_8 - rice -pea - okra, T_9 - rice - onion+ Coriander (leaf) (3:1) - greengram and T_{10} - rice - potato - blackgram. All the crops were grown with the recommended package of practices the under irrigated conditions of Chhattisgarh.

Results and Discussion

Bulk density (Mgm^{-3})

Scrutiny of the data presented in Table 1 clearly showed that the variation in bulk density due to diversification of rice-wheat system in two years period was not noticeable. As compared to rice - rice (T_1) all the cropping sequences involving legume component resulted in slight reduction in bulk density recorded lowest in rice - sweetcorn + cowpea (1:1) - clusterbean (T_4), rice - coriander (leaf) - sweet potato (T_7) and rice - potato - blackgram (T_{10}). Nevertheless, the differences failed to touch the level of significance. This might be due to addition of organic matter through roots, dry leaves and stover of legume crops that resulted in reducing the bulk density of soil. Similar results also reported by Thakur *et al*. (2009) [16].

Soil pH (gI^{-1} ions): Data on pH of soil as influenced by different cropping system and data are depicted in Table 1. A critical analysis of the data showed that diversification of rice based cropping system failed to significant influence the soil pH in two years of span. Though slight decline was noticed in all the system than initial value (6.58), recording maximum value of soil pH in rice - rice (T_1) system and the lowest in rice - sweetcorn + cowpea (1:1) - clusterbean (T_4) during both the years and on mean basis of experiment but the differences failed to touch the level of significance. Similar results also reported Dhiman *et al.* (2000) [2].

EC ($dS\ m^{-1}$)

Data related to EC of soil presented in Table 1. clearly showed that the variation under different rice based cropping sequence did not differ markedly. The higher value of EC was recorded in rice - rice (T_1) and lowest value was noted in rice - sweetcorn + cowpea (1:1) - clusterbean (T_4) system during both the years and on mean basis of study.

Organic carbon (%): Data on organic carbon (%) of soil after 2 years experimentation are presented in Table 1. All the cropping sequences involving legume component resulted in slight improvement in organic carban status of soil. However, the variation among different cropping system failed to touch the level of significance during both the years and on mean basis data investigation. This might be due to addition of organic matter through roots, dry leaves and stovers of legume crops which help to improve the organic carbon percentage in soil. Similar result was observed by Thakur *et al.* (2009) [16], Baishya *et al.* (2016) [1] and Kachroo *et al.* (2014) [4]. Porpavai *et al.* (2011) [9] reported that the inclusion of legumes in the cropping system improved the organic carbon status of the soil.

Table 1: Effect of different rice based cropping systems on bulk density, soil pH, EC and organic carbon and after completion of rotation

Treatment	Bulk density (Mgm^{-3})			pH ($g\ I^{-1}$ ions)			EC (dsm^{-1})			Organic carbon (%)		
	2018-19	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2019-20	Mean
T_1: Rice - Rice - Fallow	1.46	6.53	6.56	6.53	6.56	6.55	0.26	0.32	0.29	0.61	0.61	0.61
T_2: Rice - Chickpea - Fallow	1.45	6.34	6.36	6.34	6.36	6.35	0.27	0.33	0.30	0.62	0.63	0.63
T_3: Rice - Wheat - Greengram	1.42	6.45	6.47	6.45	6.47	6.46	0.28	0.35	0.32	0.63	0.64	0.63
T_4: Rice - Sweet corn+ Cow pea (1:1) - Clusterbean	1.41	6.32	6.33	6.32	6.33	6.33	0.29	0.36	0.32	0.64	0.64	0.64
T_5: Rice - Chickpea (veg.) - Sesamum	1.43	6.39	6.41	6.39	6.41	6.40	0.28	0.35	0.32	0.61	0.62	0.61
T_6: Rice - Garlic - Cowpea	1.43	6.35	6.39	6.35	6.39	6.37	0.29	0.35	0.32	0.63	0.64	0.63
T_7: Rice - Coriander (leaf) - Sweet potato	1.42	6.51	6.53	6.51	6.53	6.52	0.28	0.34	0.31	0.62	0.63	0.62
T_8: Rice - Pea - Okra	1.44	6.42	6.46	6.42	6.46	6.44	0.29	0.35	0.32	0.62	0.63	0.62
T_9: Rice - Onion+ Coriander (leaf) (3:1)- Green gram	1.42	6.35	6.38	6.35	6.38	6.37	0.28	0.36	0.32	0.64	0.64	0.64
T_{10}: Rice - Potato - Blackgram	1.41	6.39	6.41	6.39	6.41	6.40	0.29	0.36	0.33	0.63	0.64	0.64
S.Em±	0.023	0.10	0.10	0.10	0.10	0.03	0.01	0.010	0.003	0.013	0.010	0.004
CD=0.5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Initial value	1.48	6.58		6.58			0.38			0.59		

Table 2: Effect of different rice based cropping systems on available soil nitrogen, phosphorus and potassium after completion of rotation

Treatment	N ($kg\ ha^{-1}$)			P_2O_5 ($kg\ ha^{-1}$)			K_2O ($kg\ ha^{-1}$)		
	2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean
T_1: Rice - Rice - Fallow	225.61	237.16	231.38	13.03	13.39	13.21	280.87	308.59	294.73
T_2: Rice - Chickpea - Fallow	227.42	245.62	236.52	12.82	13.12	12.97	281.57	315.77	298.67
T_3: Rice - Wheat - Greengram	227.03	246.03	236.53	12.72	13.00	12.86	282.76	318.36	300.56
T_4: Rice - Sweet corn+ Cow pea (1:1) - Clusterbean	228.12	247.72	237.92	12.69	12.91	12.80	283.48	319.88	301.68
T_5: Rice - Chickpea (veg.) - Sesamum	225.83	238.83	232.33	12.90	13.26	13.08	275.91	312.40	294.16
T_6: Rice - Garlic - Cowpea	226.83	246.83	236.83	12.72	13.04	12.88	285.46	324.06	304.76
T_7: Rice - Coriander (leaf) - Sweet potato	222.17	238.24	230.20	13.15	13.55	13.35	283.50	316.50	300.00
T_8: Rice - Pea - Okra	223.76	239.61	231.68	12.99	13.35	13.17	276.48	313.00	294.74

$T_{9:}$ Rice - Onion+ Coriander (leaf) (3:1)- Greengram	230.43	250.21	240.32	12.69	12.95	12.82	285.02	325.01	305.00
$T_{10:}$ Rice - Potato - Blackgram	233.16	253.76	243.46	12.71	12.95	12.83	286.61	327.22	306.91
S.Em±	3.52	3.67	1.14	0.20	0.21	0.06	4.38	4.44	1.39
CD=0.5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Initial value	212			10.22			242		

Available soil nitrogen (kg ha^{-1})

The soil available nitrogen presented in Table 2. showed that the variation under different rice based cropping sequence did not differ markedly during both the year and on mean basis. The soil available nitrogen improved markedly with inclusion of legume crops during *rabi* and *zaid* season particularly during second year. Rice - potato - blackgram (T_{10}) system recorded maximum available soil nitrogen in both the year and mean basis. However, lowest available nitrogen was noted under rice - coriander (leaf) - sweet potato (T_7) during the first year and on mean basis, but in second year rice - rice (T_1) system was found lower available nitrogen content in soil.

The better performance of Rice - potato - blackgram (T_{10}) system with respect to soil available N may be due to inclusion of two legume crops in the cropping system contributing to nitrogen build up of soil besides meeting the crop requirement. However, the lowest soil available N after completion of each year sequence was observed in rice - rice (T_1) system. The lowest value was observed in rice-rice system might be due to both the crop are cereals and its nitrogen exhaustive nature. Thus the results of present experiment are suggestive of the fact that maintenance and build up of organic carbon and available nitrogen in soil can be affected by inclusion of legumes in cropping system. Similarly, Saha and Moharana (2007) [12] emphasized that rice-pulse system was effective in enhancing available nitrogen, phosphorus and potassium. Pulses crops with their characteristics promotion of free living microorganism, release N in soil helps narrowing down on C:N ratio and thus, increased mineralization resulting in rapid conversion of organically bound nitrogen to inorganic form. Similar, findings also observed by Ram *et al.* (2013) [11] and Prasad (2016) [10].

Available soil phosphorus (kg ha^{-1})

The available phosphorus (kg ha^{-1}) in soil after two years of experimentation are presented in Table 2. A perusal of data on available phosphorus in soil indicated that the higher available phosphorus was recorded in rice - coriander (leaf) - sweet potato (T_7) and lowest value was noted in rice - sweetcorn + cowpea (1:1) - clusterbean (T_4) system during both the years and on mean basis of study but the difference were not significant

As compared to rice - rice system the crop system involving legume crop as *zaid* crop had slightly lower available soil phosphorus after completion of the experiment. This might be due to leguminous crop required high dose of phosphorus for better nodulation and caused for lowering down of the available phosphorus in the soil. However, intensification of cropping improved soil P as compared to initial value. This might be due to comparatively lower uptake of P by crops and also the considerable amount of applied 'P' gets fixed in the soil, mineralization of fixed 'P' at slower rate cannot be ruled out. Inclusion of potato (sole or intercrop with wheat) caused comparatively lower available P status due to heavy mining and utilization of P. These results are close conformity with the findings of Kachroo *et al.* (2014) [4], Prasad (2016) [10] and Naresh *et al.* (2017) [8]. Saha *et al.* (2012) [12] reported that with addition/inclusion of legumes either as green manure crop or grain/fodder legume proved vital improvement in availabile soil nitrogen.

Available soil potassium (kg ha^{-1})

The soil available potassium has been summarized in Table 2. It is evident from the data, the maximum soil available potassium recorded in rice - potato - blackgram (T_{10}) system during both the years and on mean basis. The lowest potassium content was observed in rice - chickpea (veg.) - sesamum (T_5) during 2018-19 and on mean basis but, in year 2019-20 the system with rice - rice (T_1) was found lowest available potassium in soil. However, the variation among different cropping system failed to touch the level of significance during both the years of investigation.

The maximum soil available K was observed in rice - potato - blackgram (T_{10}) closely related to system having at least one legume component. Hence, these sequences recorded higher available K in soil than rice-wheat sequence. However, the differences did not significant. Baishya *et al.* (2016) [1] were also of the view that inclusion of legumes in different rice-based cropping sequences indicated an improvement in available K than continuous cereal-cereal cropping. Singh *et al.* (2002) reported positive balance for phosphorus in the sequences involving leguminous green manure.This result is also in agreement with the findings of earlier workers Gangwar and Ram (2005) [5] Sharma and Sharma, 2004 [13] and Kumar *et al.* 2008 [7].

Conclusion

The diversification of rice based cropping system failed to significant influence the bulk density, soil pH and EC in two years of span. All the cropping sequences involving legume component resulted in slight improvement in organic Carban status of soil. However, the variation among different cropping system failed to touch the level of significance during both the years and on mean basis. The soil available nitrogen, phosphorus and potash under different rice based cropping system did not differ markedly during both the year and on mean basis.

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