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INFLUENCE OF CROP RESIDUES UNDER RICE PLANTING AND NUTRIENT MANAGEMENT ON SOIL MICROBIAL DYNAMICS AND PRODUCTIVITY OF CHICKPEA IN VERTISOLS

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ABSTRACT

Field experiment was conducted during Rabi season 2014-2015 at Research farm of IGKV, Raipur Chhattisgarh. To study the "influence of crop residues under rice planting & nutrient management on soil microbial dynamics and productivity of chickpea in vertisols". The experimental consisted of eight treatments, each replicated three times in split plot design. The two rice establishment methods *Viz:* transplanting and direct seeded rice and four nutrient management practices *Viz.* Rainfed-Farmer practice, Rainfed -Improved practice, Farmer practice with life saving irrigation and improved practice with life saving irrigation. The residual effect of rice establishment on chickpea grain yield (1890 kg/ha) was found higher in transplanted rice under rice-chickpea. Among nutrient management practices *viz* improved practice with life saving irrigation was found significantly higher yield (1997 kg/ha).The two stages of microbial dynamics, initial and growth stage (flowering) of chickpea like *Dizotrophs, (3.39 CFU/gm of soil) Rhizobium,* (7.79 CFU/gm of soil) *Phosphorus SolublizingB* (5.23CFU/gm of soil), and *Dehydrogenage* activity (74.52 ìgTPF/soil/day) significantly increased both grain yield and soil health under transplanted rice field.

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INTRODUCTION

Crop residue are the part of plants left in the field after the crops have been harvested and thresh hold crop residue is good source of plant nutrients, are the primary source of organic materials added to the soil and are the important components for the stability of agriculture ecosystem. The crop establishment methods affect root length density and their distribution. Naklang *et al.* (1996) Soil conditions (puddled in wet seeded and transplanted rice and direct seeded rice) also affected the water release characteristics of the soil during the stress period. These in turn, may have a pronounced influence on the water extraction pattern and crop response when the plant is subjected to a water deficit. Boiling *et al.* (1998) reported that during the drought period, dry seeded rice had significantly lower soil moisture tension levels and a more uniform water tension profile with respect to soil depth than wet seeded and transplanted rice. Dry seeded rice also survived also a longer drought period than wet Seeded and transplanted rice.

Rice-chickpea is the predominant cropping system after rice-wheat. Inclusion of chickpea in rice system not only increased the overall productivity of the system but also improved physico-chemical properties of the soil. Dry DSR differs from transplanted rice in terms of crop establishment as well as subsequent crop management practices. The broadcast sowing/ drilling/ dibbling of dry seeds in soil is called direct seeded rice. However, it offers many advantages such as more efficient water use, high tolerance to water deficit, less methane gas emission, reduced cultivation cost, prevents the formation of hard pan in sub-soil and minimizes labour input. This type of rice establishment method is also called ZT rice Mohanty *et al.* (2014), Ali *et al.* (2015)

Chickpea (*Cicer arietinum L*) is an important grain legume crop in the world approximately 73% of global chickpea growing area is in south and south-east Asia. It is mainly grown as a rain fed crop during the rabi season on conserved soil moisture from the preceding monsoon. However, with the expansion of irrigation facilities, the crop can be raised successfully under limited moisture condition. The water requirement of chickpea varies from place to place due to variation of agro-climatic and soil conditions Ray *et al.* (2001) and Singh *et al.* (2015). The consumptive use of water (evapo-transpiration) depends on the soil moisture supply and yield level. Evapo-transpiration should range from 110-240 mm to get a good yield of chickpea. Chickpea is a leguminous crop, fixes atmospheric nitrogen through symbiosis, therefore improving soil fertility and productivity of subsequent cereal crop. Microbial fertilizer like *Rhizobium* and Phosphorus solubilizing bacteria (PSB) are highly beneficial in enhancing nitrogen and phosphorus content. Rhizobium inoculation helps to improve nodulation, plant growth and yield of chickpea. *Rhizobium* inoculated crop produces a 10-12% higher grain yield than a crop that has been inoculated Singh *et al.* (2004),and Singh *et al.* (2015). To study the "influence of rice establishment methods and nutrient management practice on soil microbial dynamics and productivity of chickpea under Vertisols'

MATERIALS AND METHODS

The investigation was conducted on the research farm at Indira Gandhi Krishi

Viswavidyalaya, Raipur, Chhattisgarh. To study the influence of crop residues under rice planting & nutrient management on soil microbial dynamics and productivity of chickpea in vertisols. The soil is a *Vertisols* with clay texture (43-50 % clay), bulk density of 1.36Mgm^{-3} at 48.3% available water capacity of 10.16 cm, 0.80 % organic carbon and less than 0.21 dSm-^{1} electrical conductivity. The experimental consisted of eight treatments, each replicated three times in split plot design having plot size of 5x5 m^2. The two rice establishment methods *Viz:* puddled transplanting and direct seeded rice and four nutrient management practices *Viz*. Rainfed- Farmer practice, Rainfed -Improved practice, Farmer practice with life saving irrigation and Improved practice with life saving irrigation, and 30 cm rice stubble height with chickpea variety JG-130 used as common in this experiment. The physical and biological properties i.e. bulk density measured by standard methods by core sampler, infiltration rate estimated by standard procedure double ring infiltrometer method and the microbial properties like *Dizotrophs, Rhizobium*, *Phosphorus solublizing bacteria* and *Dehydrogenage* activity were also estimated by standard methods by Vance *et al. (*1987). The root samples were collected by cores (root sampler 20 cm diameter and at 30 cm height) up to a depth of 30 cm by using standard method. The mean data of experiment were statistical analyzed by adopting appropriate statistical methods as outline by Panse and Sukhatme (1978). The critical difference was calculated at five percent level, of significant for various growth and yield parameters under this study.

RESULTS AND DISCUSSION

Physical properties

The infiltration rate is governed by the amount of pores space present in soil. The direct seeded rice condition recorded significantly higher infiltration rate 32 mm/hr,(Table 1) which may be attributed due to increased pores in the soil and better aggregation and the lowest being found under transplanted rice condition due to the compaction that led to less cumulative infiltration rate. The study states that infiltration rate was significantly higher under deep tillage than under shallow-minimum and minimum tillage system in silty loam soil of Doon valley. Further, IR values were higher in direct seeded plots than that of puddled (transplanted) plots as reported by Agrawal *et al*. (1992). Similar finding report that the higher infiltration was recorded under direct seeded rice which reveals the quality of seed bed prepared which allow greater amount of water to penetrate into the field and allowed subsequent crops to grow vigouraly. The similar finding reported by Gangwar *et al*. (2008) and Kulkarni *et al*. (2015).

The bulk density (1.34Mg/ m^3) was higher under puddled transplanted condition of rice. The lower (1.30 Mg/m^3, Table. 1) bulk density was found under direct seeded rice condition at 10 cm depth of soil. The decrease in bulk density under tilled plots may be due to increase in non-capillary porosity and low soil mass per unit volume. After sowing of chickpea, the bulk density increased with the march of crop growth period. Mielke *et al*. (1986) and Mehta *et al*. (1996) have also found a similar increase in Bulk Density. A comparison of methods of rice cultivation showed that, bulk density values remained lower in direct seeded plots as compared to puddled plots at both the depths. The tillage treatments were super imposed after harvest of paddy crop. The tillage operations created cloddy seedbed which was responsible for higher bulk density values. The higher bulk density values in puddled plots may also be due to the residual effect of puddling in these plots (lehi and transplanted), which could not be ameliorated by super imposing the tillage treatments. The higher bulk density values in puddled plots at sub surface. The residual effect of rice establishment method under drill or direct seeded rice lower bulk density as compared of transplanted rice; similar findings were reported by Gangwar *et al*. (2008) and Kulkarni *et al*. (2015). the higher value of bulk density was recorded under puddled conditions because puddling resulted in destruction of soil aggregates and dispersion of soil particles to form a compact layer with reduced porosity as reported by Mehta *et al*. (1996).

Microbial dynamics

The data presented in table 2 showed that residual effect of rice establishment methods in chickpea at both the stages (Initial and Growth stage) the highest *Dizotrophs* (2.73 x 10^5 CFU/gm and 3.38 x 10^5 CFU/gm) of soil was found under transplanted rice fallows chickpea crop. The lowest was found (2.56 x 10^5 CFU/gm of soil and 3.23 x 10^5 CFU/gm) under direct seeded rice fallows chickpea crop. Among, the nutrient management, under improved practice with life saving irrigation, in *Dizotrophs* was found 2.77 x 10^5 CFU/gm of soil the lowest was found under rainfed farmer practice 2.56 x 10^5 CFU/gm of soil. The similar finding of Singh *et al*. (2005).

The data revealed that Table 2, residual effect of rice establishment methods in chickpea at both stage (Initial and Growth stage) *Rhizobium* population (7.54 x 10^4 and 7.79 x 10^4 CFU/gm) of soil was significantly higher under transplanted rice fallows chickpea and lowest (7.13 and 7.38x 10^4 CFU /

Table 1: Physical properties of soil influence by residual effect of rice establishment methods.

Rice establishment methods	Infiltration rate (mm/hr)	Bulk density (Mg/m3)
Transplanted rice fallows	23	1.34
Direct seeded rice fallows	32	1.30
CD (0.05)	1.29	0.003
Nutrient management practices		
Rainfed (Farmer practice)	25	1.32
Rainfed (Improved practice)	25	1.33
Farmer practice with life saving irrigating	25	1.33
Improved practice with life saving irrigating	25	1.32
CD (0.05)	0.607	0.002
Interaction CD (0.05)	NS	0.005

Table 2: Residual effect of rice establishment methods on microbial characteristics of soil during chickpea

Rice establishment methods	Dizoptrophs (Initial)10^5 (CFU/gm of soil)	Dizoptrophs (GP)10^5 (CFU/gm of soil)	Rhizobium (Initial)10^4 (CFU/gm of soil)	Rhizobium (GP)10^4 (CFU/gm of soil)	PSB (Initial) 10^5 (CFU/ gm of soil)	PSB (GP) 10^5 (CFU/ gm of soil)	Dehydrogenase activity (Initial) (µg TPF/ soil/day)	Dehydrogenase activity (GP) (µg TPF/ soil/day)
Transplanting rice fallows	2.73	3.38	7.54	7.79	4.98	5.23	72.15	74.52
Direct seeded rice fallows.	2.56	3.23	7.13	7.38	4.71	4.96	67.73	70.10
CD (0.05%)	NS	NS	0.171	0.172	0.123	0.123	0.07	0.040
Nutrient management practices								
Rainfed farmer practice	2.56	3.17	7.28	7.53	4.52	4.77	68.75	71.65
Rainfed Improved practice	2.58	3.25	7.31	7.56	4.83	5.08	70.07	71.12
Life saving irrigating farmer practice	2.62	3.30	7.17	7.42	4.77	5.02	69.27	72.44
Life saving irrigating Improved practice	2.77	3.40	7.58	7.83	5.00	5.25	70.96	73.34
CD (0.05%)	0.114	0.122	0.168	0.168	0.239	0.239	0.005	0.039
Interaction CD (0.05%)	0.218	NS	NS	NS	NS	NS	0.012	0.013

CFU = Colony forming unit. TPF = Tri phenyl farmazon. GP = growth phase

Table 3: Residual effect of rice establishment methods on root and dry weight of nodules and yield characteristics of chickpea

Rice establishment methods	Root length (cm)	Root volume (cm^{3}x10^{-3})	Root : Shoot ratio	Dry weight of nodule per plant (mg) (45DAS)	Dry weight o f nodule per plant (mg) (75DAS)	Chickpea seed Yield (kg/ha)
Transplanting rice fallows	34.3	10.0	0.57	6.65	25.9	1890
Direct seeded rice fallows	38.5	10.4	0.58	7.38	32.7	1740
CD (0.05%)	2.203	0.307	NS	NS	2.98	NS
Nutrient management practices						
Rainfed farmer practice	33.4	9.9	0.55	6.58	26.8	1702
Rainfed Improved practice	35.8	10.1	0.55	6.98	28.1	1786
Life saving irrigating farmer practice	33.6	10.0	0.58	6.74	28.0	1753
Life saving irrigating Improved practice	34.6	10.4	0.59	7.38	30.8	1997
CD (0.05%)	1.353	0.221	0.034	0.416	1.05	99.66
Interaction CD (0.05%)	NS	0.425	0.067	0.832	NS	NS

DAS = Days after sowing CD- critical difference.

gm) under direct seeded rice fallows. Hence the nutrient management improved practice with life saving irrigation (7.58 and 7.83 x 10^4 CFU/gm) showed significantly higher transplanted rice fallows chickpea and lower in farmer practice with life saving irrigation (7.17 and 7.42 x 10^4 CFU/gm) treatments in soil. Similar result reported by Biswas *et al*., (2000), Valverde *et al.,*(2006) and Prasad *et al.,*(2014).

The data presented in table 2, residual effect of rice establishment methods in chickpea at both stages (Initial and Growth), the *Phosphorus solublizing b*acteria population (4.98 and 5.23 x 10^4 CFU/gm) of soil was significantly higher under transplanted rice fallows chickpea and the lowest (4.71, and 4.96x 10^4 CFU /gm) under direct seeded rice fallows chickpea. Hence, the nutrient management improved practice with life saving irrigation (5.0 and 5.25 x 10^4 CFU/gm) showed significantly higher under transplanted rice fallows chickpea and the lower in rainfed farmer practice (4.52 and 4.77 x 10^4 CFU/gm) treatments in soil. It was also found from the study that combination of *Rhizobium* and phosphorus solublizing bacteria were most effective in promoting, the root length and root mass of chickpea plants. These changes in root architecture of inoculated plants may be attributed to bacterial activity. The similar result reported by Biswas *et al.* (2000) and Valverde *et al.* (2006).

The data showed that Table 2, The *Dehydrogenase activity* is commonly used as an indicator of biological activity in soil as this enzyme is known to oxidize soil organic matter, the *Dehydrogenase* activity was found highest under transplanted rice fallows chickpea crop at initial stage (*72.15* µg TPF/soil/day) and growth stage (74.52 µg TPF/soil/day), the lowest was found under direct seeded rice fallows chickpea, shows that the soil in the treatment has more potential to support biochemical processes which are essential for maintaining fertility as well as soil health. Hence, nutrient management practices *dehydrogenase activity* higher was found under treatment improved practice with life saving irrigation at initial (70.96 µg TPF/soil/day) and growth stage (73.34 µg TPF/soil/day). The minimum was found under rainfed improved practice. The similar finding reported by Valverde *et al*. (2006), Bedi *et al*. (2009), Rai and Yadav (2011) and Nath *et al*. (2012).

Root dynamics

The root length data showed *Table 3,* the residual effect of rice establishment method that roots were mainly confined to direct seeded rice fallows chickpea crop was found higher root length 38.5cm. The lower root length found under transplanted rice fallows chickpea 34.3 cm. Thus, the nutrient management practices, rainfed improved practice show that significantly higher in root length (35.8 cm). The lowest was found in rainfed farmer practice (33.4cm). The similar finding higher root length of chickpea has been reported by Gangwar *et al. (*2004), Singh *et al*. (2015).

The root volume data showed *Table 3* residual effect of rice establishment method, direct seeded rice fallows chickpea found significantly higher root volume (10.4 cm^{3}x10^{-3}) and the lowest was found under transplanted rice fallows chickpea (10 cm^3x10^{-3}). Thus, the nutrient management improved practice with life saving irrigation show that significantly higher under root volume (10.4 cm^3x10^{-3}). The lowest was found in rainfed farmer practice (9.9 cm^3x10^{-3}). The similar finding higher root volume of chickpea has been reported by Gangwar *et al., (*2004) and Singh *et al.,* (2015).

The root shoot ratio data showed *Table 3* residual effect of rice establishment method, direct seeded rice fallows chickpea found higher root shoot ratio (0.58) and the lowest was found under transplanted rice fallows chickpea (0.57). Thus, the nutrient management improved practice with life saving irrigation show that significantly higher root: shoot ratio (0.59). The lowest was found under rainfed farmer practice (0.55). The similar finding root: shoot ratio of chickpea have been reported by Gangwar *et al.,* (2004) and Singh *et al.,* (2015).

The data revealed that table 2, residual effect of rice establishment methods in chickpea at 45DAS and 75DAS dry weight of nodule per plant (7.38 and 32.7 mg) was significantly higher under direct seeded rice fallows chickpea and the lowest (6.65 and 25.9 mg) under transplanted rice fallows chickpea. Hence, the nutrient management improved practice with life saving irrigation (7.38 and 30.8 mg) showed significantly higher dry weight of nodule per plant in chickpea and the lowest was found in rainfed farmer practice (6.58 and 26.8). The similar result reported by Biswas *et al.* (2000), Valverde *et al.* (2006) and Ray *et al.* (2012).

Yield

The data revealed that table 3, the seed yield of chickpea was not influenced by the residual effect of rice establishment practices. However, the highest seed yield of chickpea (1890 kg/ha) was obtained under transplanted rice residue and the lowest seed yield under (1740 kg/ha) direct seed rice residue. However, the nutrient management practice, improved practices with life saving irrigation chickpea observed significantly higher seed yield (1997 kg/ha) as compared to rain-fed improved and farmers practice (1702 kg/ha). Thus the study, suggested that the residual effect rice establishment method did not influence the yield subsequent chickpea crop. Similar findings regard higher seed yield of chickpea due to improved practice with life saving irrigation have been reported by Gangwar *et al.* (2008), Panigrahi *et al.* (2012) and Singh *et al.* (2015).

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