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Impact of rice planting methods on root and physiological studies in chickpea

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Abstract

The field investigation was carried out during 2014-16 to evaluate the effect of rice establishment methods and crop management practices in chickpea under rice- chickpea cropping system on soil microbial properties. In this study, three rice establishment methods (puddled transplanting rice, unpuddled transplanted rice and direct seeded rice) were laid in main plot and crop management practices (rainfed farmer's practice, rainfed improved practice, farmer's practice with lifesaving irrigation and improved practice with lifesaving irrigation) in sub-plot of split plot design. The rooting depth, root volume and root dry weight were higher under direct seeded treatment in all the depths, at podding stage of chickpea. The relative water content and specific leaf weight were higher under direct seeded rice establishment than unpuddled and puddled transplanted rice establishment. The relative water content and specific leaf weight were significantly affected by different nutrient Management practices. The rooting depth, root volume, dry weight of root, root: shoot ratio, number of nodule and dry weight of nodule was significantly higher in improved practice with life-saving irrigation.

Keywords: chickpea, puddled, direct seeded, relative water content, specific leaf weight

Introduction

Rice is normally the best-adapted crop for the wet season, when intense and episodic rainfall is common in rainfed lowlands. The only feasible option for inclusion of legumes in eastern India is as a post-rice crop grown on residual soil water. Post-rice legumes can dramatically influence the accumulation, dynamics, and carryover of soil inorganic N to a subsequent rice crop (Buresh and De Datta, [5], Ladha *et al*., [13], A considerable area remains fallow after rice harvest in northern, central and eastern India, can be used for cultivation of pulses like chickpea (*Cicer arietinum* L.). Under this situation during post-rainy season, chickpea is normally grown on residual soil moisture mainly due to lack of irrigation facility and fast declining of ground water. In addition, a number of abiotic factors limit the productivity of chickpea on these lands after harvest of rice. Due to anaerobic conditions in rice cultivation, many of the organisms including rhizobia would not be able to survive (Doi *et al*., [6], Sridevi *et al*., [25]. The seed germination, seedlings emergence and crop establishment get adversely affected due to disruption of soil structure, poor aeration and mechanical impedance of seed zone as a result of puddling for rice transplanting. This hostile environment creates potential threat to microbial activities, nutrient availability and root growth of pulse crops. Under such situation, the improvement in soil physical properties either through unpuddle rice transplanting or direct seeded rice can help in better germination and growth of chickpea after rice. Further, the earlier maturity of direct seeded rice could also contribute to earlier establishment of chickpea and hence higher productivity of the post-rice chickpea can be obtained. Thus, this will increase the opportunities for system intensification and diversification of rice fallows lands in these regions. If ploughing is done after harvest of rice, sowing of chickpea is delayed and germination will also be affected due to formation of large size clods. Research evidence suggests that the residue retention has favourable effect on soil physico-chemical and biological properties of soil Aulakh *et al*., [2] Benbouali *et al*., [4], Smith *et al*., [24] Therefore, if crop residues are retained on the soil surface in combination with suitable planting techniques (zero-tillage) may alleviate terminal drought condition in chickpea by conserving soil moisture and bring overall improvement in resource management. Application of recommended fertilizer and foliar application of 2% urea at flowering and 10 days after are recommended to improve productivity in rainfed chickpea. Venkatesh and Basu PS. [26], Kumar and Gupta [12]. Further, pulse crops are known to improve soil physical properties due to its prolific deep tap root system. The 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* unoculated crop produces a 10-12% higher grain yield than a crop that has been inoculated Singh *et al*., [23]. The present investigation was carried out with the objectives on effect of rice establishment methods and crop management practices enhancing soil physical properties under rice chickpea system.

Materials and Methods

A field study was conducted for two consecutive years of 2014-16 in rice-chickpea cropping system at the research farm of Indira Gandhi Krishi Viswavidyalaya, Raipur, Chhattisgarh. The experimental site is situated in plains of Chhattisgarh at Eastern part of Raipur and it is located at $20^{0}4'$ North latitude and $81^{0}39'$ East longitudes and 293 m above mean sea level. The soil of experimental site is represented as a Typicchromesterts (Vertisols) (Arang-I series). It is locally called *Kanhar*. The soil is characterized by silty clay texture and moderate to slow internal drainage, medium to deep depth, and brownish gray in surface color, sub angular to angular, blocky structure and neutral in reaction. The characteristics of top-soil (0–15 cm layer) at the start of experiment was neutral in reaction (pH 6.95), electrical conductivity 0.14 dS/m, soil organic carbon 0.60%, available N 225 kg/ha. The decennial monthly minimum temperature fluctuates from 6.6 to 26.8^{0}C and maximum temperature from 28.5 to 44.8^{0}C in this region. The average annual rainfall is 1150 mm, and over 80% of this is received through northwest monsoon during July to September.

The experiment was laid out in a split-plot design with a total of twelve treatment combinations replicated three times. Main plot treatments were three rice establishment methods and the sub-plot treatments were four crop management options for chickpea. Three crop establishment methods include puddled transplanted rice (PTR), unpuddled transplanted rice (UTR) and direct seeded rice (DSR) whereas, crop management includes farmer's practice under rainfed (FPR), improved practice under rainfed (IPR), farmer's practice with lifesaving irrigation (FPLI) and improved practice with lifesaving irrigation (IPLI).In case of improved practice, chickpea was sown under conservation tillage (zero tillage + 30cm rice stubble) followed by recommended dose of fertilizers as basal dose and foliar application of 2% urea at flowering and 10 days after, whereas, under farmer's practice chickpea was sown under zero tillage without any rice residue, half dose of fertilizers and no foliar nutrition. All data were analyzed by two-way analyses of variance (ANOVA) in a 3 x 4 split-plot design. The treatment means were compared using least significant differences for the main effects as well as their interactions at 5% level of significance Gomez and Gomez [8].

Results and Discussion

Relative water content (%) and Specific leaf weight (mg).

Relative water content recorded at 30, 60 and 90 days after sowing have been presented in Table 1. It is evident from table that the relative water content increased consistently with increasing plant growth and the maximum relative water content was recorded under the treatment direct seeded rice at all the stages of crop growth during both the years. The significantly lower relative water content was recorded with puddled transplanted rice during both the years. It is also clear from the table that the relative water content increased with advancement in the age of the plant up to harvest stage of the crop under all the nutrient management practices during both the years of study. The crop grown under improved practice with lifesaving irrigation observed the maximum relative water content followed by farmer's practice with life-saving irrigation and rain fed farmer's practice and the lowest was recorded under rainfed farmer's practice at all the stages of crop growth during both the years. The interaction effect was found non-significant at 30 Days after sowing however, at 60 and 90 DAS the relative water content variation was found significantly at all the stages, of crop growth during both the years similar result was reported by Kumar *et al*., (2016)

The data in respect of specific leaf weight recorded at 30, 60 and 90 days have been presented in Table 2 the specific leaf weight increased consistently with increasing crop growth period and the maximum specific leaf weight was recorded at direct seeded rice treatment at all the stages of crop growth during both the years. The significantly lower specific leaf weight was recorded with puddled transplanted rice during both the years. It is also clear from the table that the specific leaf weight increased with advancement in the age of the plant up to harvest stage of the crop under all the nutrient management practices during both the years of study. The crop grown under improved practice with life-saving irrigation observed the maximum specific leaf weight followed by farmer's practice with lifesaving irrigation and rainfed farmer's practice and the lowest was recorded under rainfed farmer's practice at all the stages of crop growth during both the years. Rice establishment methods influenced by Specific leaf weight of chickpea was found higher under direct seeded rice similar results reported by Kumar *et al*., [11] and Mishra *et al*., [14].

Table 1: Effect of rice establishment method on Relative water content at different stage of chickpea.

Rice establishment methods	Relative water content (%) of chickpea								
	30 DAS			60 DAS			90 DAS		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
PTR	63.41	62.72	63.07	67.21	66.75	66.98	70.48	70.56	70.52
UPTR	63.68	63.52	63.60	67.53	68.36	67.95	70.8	70.8	70.80
DSR	64.31	64.69	64.50	69.7	70.91	70.31	72.97	74.59	73.78
CD (0.05)	NS	0.63	0.6	1.44	1.16	0.71	1.44	1.49	0.86
Water and nutrient management									
RFP	63.24	62.9	63.07	67.01	68.01	67.51	70.28	70.85	70.57
RIP	63.49	63.63	63.56	68	68.05	68.03	71.27	71.98	71.63
FPLSI	63.75	63.84	63.80	68.3	68.45	68.38	71.57	72.02	71.80
IPLSI	64.71	64.2	64.46	69.28	70.19	69.74	72.55	73.09	72.82
CD (0.05)	NS	0.92	0.76	0.77	0.81	0.56	0.77	0.8	0.7
Interaction CD (0.05)	NS	NS	NS	1.3	1.38	0.95	1.3	1.37	1.19

Note: PTR- Puddled transplanted rice , UPTR- Unpuddled Transplanted rice, Direct seeded rice, REP-Rainfed farmer practices, RIP-Rainfed improved practices, FPLSI- Farmer practices life-saving Irrigation, Improved practice life-saving irrigation

Table 2: Effect of rice establishment method on Specific leaf weight at different stage of chickpea.

Rice establishment methods	Specific leaf weight (mg)								
	30 DAS			60 DAS			90 DAS		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
PTR	0.047	0.046	0.047	0.061	0.056	0.059	0.09	0.085	0.091
UPTR	0.05	0.051	0.051	0.065	0.067	0.066	0.093	0.093	0.092
DSR	0.057	0.057	0.057	0.074	0.071	0.073	0.097	0.104	0.099
CD (0.05)	0.006	0.005	NS	0.005	0.013	0.011	NS	0.003	0.005
Water and nutrient management									
RFP	0.048	0.049	0.048	0.054	0.06	0.057	0.085	0.088	0.087
RIP	0.051	0.051	0.051	0.059	0.051	0.055	0.087	0.092	0.09
FPLSI	0.052	0.051	0.051	0.074	0.071	0.073	0.094	0.092	0.093
IPLSI	0.056	0.054	0.055	0.078	0.075	0.077	0.108	0.103	0.106
CD (0.05)	0.003	0.003	0.002	0.015	0.01	0.01	0.007	0.007	0.005
Interaction CD (0.05)	NS	NS	NS	0.02	NS	NS	0.01	0.013	NS

Note: PTR- Puddled transplanted rice, UPTR- Unpuddled Transplanted rice, Direct seeded rice, REP-Rainfed farmer practices, RIP-Rainfed improved practices, FPLSI- Farmer practices life-saving Irrigation, Improved practice life-saving irrigation.

Rooting depth (cm) and root volume (cm^{3}x10^{-3})

Rooting depth (cm) recorded at podding stage have been presented in Table 3. The rooting depth (cm) was recorded under direct seeded rice at crop growth during both the years. The significantly lower rooting depth (cm) was recorded with puddled transplanted rice during both the years. It is also clear from the table that the rooting depth (cm) was also influenced due to nutrient management practices during both the years of study. The crop grown under improved practice with life-saving irrigation recorded the maximum rooting depth (cm) followed by farmer's practice with life-saving irrigation and the lowest was recorded under rainfed farmer's practice during both the years. The interaction effect was found non-significant during both the years. The reason may be the high bulk density of the sub surface soil that restricted the root growth of puddled treatments to the upper layer. The data in respect of root volume (cm^{3}x10^{-3}) recorded at podding stage has been presented in Table 3. It is evident from the data given in table that the maximum root volume (cm^{3}x10^{-3}) was recorded under direct seeded rice at crop growth during both the years. Significantly the lower root volume (cm^{3}x10^{-3}) was recorded with puddled transplanted rice during both the years. It is also clear from the table that the root volume (cm^{3}x10^{-3}) was also influenced due to nutrient management practices during both the years of study. The crop grown under improved practices with life-saving irrigation recorded the maximum root volume (cm^{3}x10^{-3}) followed by farmer's practice with life-saving irrigation and the lowest root volume was recorded under rainfed farmer's practice during both the years. The interaction effect was found significant during both the years. The reason may be the high bulk density of the sub surface soil that restricted the root growth of puddled treatments to the upper layer (Kar *et al*., [10], Bajpai and Tripathi, [3] and Garg *et al*., [7]. The direct dry seeding facilitates the maximum root length density and root volume of wheat (Rath *et al*., [18]. Among the tillage practices, the conventional tillage and bed planting facilitated higher root growth in comparison to zero tillage and strip tillage up to the depth of 0.20 m after that the effect disappeared. The loosening of soil due to conventional mode of practice enhances rate of root growth (Sah [19], Akhtar *et al*., [1], and Qin [17].

Table 3: Effect of rice establishment method on maximum rooting depth and Root volume of Chickpea.

Rice establishment methods	Rooting depth (cm)			Root volume (cm^{3}x10^{-3})		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
PTR	30.3	30.4	30.3	9.81	10.57	10.2
UPTR	34.3	34.4	34.4	10.05	10.92	10.5
DSR	38.5	38.5	38.5	13.4	14.42	13.9
CD (0.05)	2.14	2.32	0.89	0.27	0.38	0.29
Water and nutrient management						
RFP	33.4	33.1	33.2	9.9	10.9	10.4
RIP	33.6	33.7	33.7	11.1	11.7	11.4
FPLSI	34.6	34.4	34.5	11.0	11.9	11.5
IPLSI	35.8	36.4	36.1	12.4	12.9	12.7
CD (0.05)	1.34	1.34	1.19	0.22	0.32	0.21
Interaction CD (0.05)	NS	NS	NS	0.38	0.54	0.35

Note: PTR-Puddled transplanted rice, UPTR- Unpuddled Transplanted rice, Direct seeded rice, REP-Rainfed farmer practices, RIP-Rainfed improved practices, FPLSI- Farmer practices life-saving Irrigation, Improved practice life-saving irrigation

Root: Shoot ratio and root dry weight (gm)

Root: Shoot ratio recorded at podding stage has been presented in Table 3. The maximum root: shoot ratio was recorded under direct seeded rice podding stage during both the years. The significantly the lower root: shoot ratio was recorded with puddled transplanted rice during both the years. It is also clear from the table that the root: shoot ratio was also influenced due to the nutrient management practices during both the years of study. The crop grown under improved practice with life-saving irrigation recorded the maximum root: shoot ratio followed by farmer's practice with irrigation and rainfed farmer's practice and the lowest was recorded under rainfed farmer's practice during both the years. The interaction effect was found non-significant during both the years. Similar results were revealed by Sharma *et al*., [1994]. At initial growth stage 30 days after transplanting the root length density, root volume and root dry weight under direct seeded plots was higher in comparison to the puddled treatments. This may be due to absence of transplanting shock that stimulates higher initial growth of direct dry seeding. At 70 DAT, the manual transplanting gave higher root length density, root volume and root dry weight than direct dry seeded up to 0.20 m depth. This may be related to the reduction in the bulk density, which facilitates the root growth. But at the lower depths these parameters were higher in direct dry seeding. The data in respect of root dry weight (gm) recorded at podding stage has been presented in Table 4. It is evident that the maximum root dry weight (gm) was recorded at direct seeded rice at podding stage during both the years. The significantly lower root dry weight (gm) was recorded with puddled transplanted rice during both the years. It is also clear from the table that the root dry weight (gm) was also influenced due to nutrient management practices during both the years of study. The crop grown under improved practice with life-saving irrigation recorded the maximum root dry weight (gm) followed by farmer's practice with life-saving irrigation and the lowest was recorded under rainfed farmer's practice during both the years. The interaction effect was found non-significant at before harvesting stage during both the years. Similar results were revealed by Sharma *et al*., [21]. At initial growth stage (30 DAT) the root length density, root volume and root dry weight under direct seeded plots was higher in comparison to the puddled treatments. This may be due to absence of transplanting shock that stimulates higher initial growth of direct dry seeding. At 70 DAT, the manual transplanting gave higher root length density, root volume and root dry weight than direct dry seeded up to 0.20 m depth. This may be related to the reduction in the bulk density, which facilitates the root growth. But at the lower depths these parameters were higher in direct dry seeding. The reason may be the high bulk density of the sub surface soil that restricts the root growth of puddled treatments to the upper layer (Kar *et al*., [10], Bajpai and Tripathi [3]. and Garg *et al*., [7]. The direct dry seeding facilitates the maximum root length density and root volume of wheat (Rath *et al*., [18]. Among the tillage practices, the conventional tillage and bed planting facilitated higher root growth in comparison to zero tillage and strip tillage upto the depth of 0.20 m after that the effect disappeared.

Table 4: Effect of rice establishment method on Root: Shoot ratio chickpea.

Rice establishment methods	Root: Shoot Ratio			Dry weight of root (gm)		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
PTR	0.51	0.52	0.52	2.02	2.08	2.05
UPTR	0.55	0.53	0.54	2.21	2.3	2.26
DSR	0.58	0.58	0.58	2.4	2.43	2.42
CD (0.05)	0.04	0.04	0.03	0.24	0.09	0.08
Water and nutrient management						
RFP	0.51	0.52	0.52	2.17	2.19	2.18
RIP	0.53	0.55	0.54	2.18	2.24	2.21
FPLSI	0.56	0.55	0.56	2.25	2.25	2.25
IPLSI	0.58	0.57	0.58	2.24	2.39	2.32
CD (0.05)	0.04	0.03	0.02	0.06	0.08	0.05
Interaction CD (0.05)	NS	NS	NS	NS	NS	NS

Note: PTR-Puddled transplanted rice, UPTR- Unpuddled Transplanted rice, Direct seeded rice, REP-Rainfed farmer practices, RIP-Rainfed improved practices, FPLSI- Farmer practices life-saving Irrigation, Improved practice life-saving irrigation

Table 5: Effect of rice establishment method on number of nodule plant^{-1} chickpea.

Rice establishment methods	Number of nodule plant^{-1}					
	45 DAS			75 DAS		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
PTR	14	13	14	28	30	29
UPTR	15	14	15	28	31	30
DSR	16	17	17	31	35	33
CD (0.05)	NS	2.27	N S	N S	NS	2.82
Water and nutrient management						
RFP	15	13	14	27	29	28
RIP	14	14	15	28	30	29
FPLSI	15	15	15	29	33	31
IPLSI	17	18	17	31	35	33
CD (0.05)	NS	2.34	1.73	2.271	2.271	1.757
Interaction CD (0.05)	NS	N S	NS	3.76	3.8	2.99

Note: PTR- Puddled transplanted rice, UPTR- Unpuddled Transplanted rice, Direct seeded rice, REP-Rainfed farmer practices, RIP-Rainfed improved practices, FPLSI- Farmer practices life-saving Irrigation, Improved practice life-saving irrigation

Table 6: Effect of rice establishment method on Dry weight of nodule plant^{-1} chickpea.

Rice establishment methods	Dry weight of nodule plant (mg plant^{-1})					
	45 DAS			75 DAS		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
PTR	6.65	6.11	6.38	15.9	16.4	16.2
UPTR	6.74	6.78	6.76	16.6	19.9	20.0
DSR	7.38	7.55	7.47	22.8	22.7	22.7
CD (0.05)	N S	0.36	NS	2.91	4.60	0.41
Water and nutrient management						
RFP	6.74	6.3	6.52	16.9	16.8	16.8
RIP	6.58	6.73	6.66	17.9	18.1	18.0
FPLSI	6.98	6.74	6.86	18.2	18.0	18.1
IPLSI	7.38	7.47	7.43	21.9	20.8	21.3
CD (0.05)	0.41	0.47	0.25	1.04	0.77	0.254
Interaction CD (0.05)	NS	NS	0.43	NS	1.311	0.432

Note: PTR- Puddled transplanted rice, UPTR- Unpuddled Transplanted rice, Direct seeded rice, REP-Rainfed farmer practices, RIP-Rainfed improved practices, FPLSI- Farmer practices life-saving Irrigation, Improved practice life-saving irrigation

Number of nodule and dry weight of nodule plant $^{-1}$

The data in respect of number of nodules plant^{-1} recorded at 45 and 75 DAS have been presented in Table 5. It is evident from the data that the number of nodules increased consistently with increasing days after sowing of chickpea and the maximum number of nodules was recorded at direct seeded rice treatment at both the stages of crop growth during both the years. The lowest numbers of nodules was recorded in puddled transplanted rice. The number of nodules increased with advancement in the age of crop under nutrient management practices during both the years of study. The maximum increase in number of nodules plant^{-1} was recorded under improved practices with life-saving irrigation. The lowest number of nodules plant^{-1} was recorded under the Rainfed farmer's practices at all the stages of crop growth during both the years of study. Further, it is reported that number of nodules at 75 DAS was significantly higher in Direct seeded rice (33) followed by unpuddled transplanted rice and puddled transplanted rice. The interaction effect of number of nodules was found significant at 75 DAS during both the years of experimentation. The data in respect of dry weight nodules plant^{-1} recorded at 45 and 75 DAS have been presented in Table 6. It is evident from the data that the dry weight of nodules increased consistently with increasing days after sowing of chickpea and the maximum dry weight of nodules was recorded in direct seeded rice treatments at both the stages of crop growth during both the years. The lowest dry weight of nodules was recorded in puddled transplanted rice. The dry weight of nodules increased with advancement in the age of crop under nutrient management practices during both the years of study. Among the nutrient management practices highest dry weight of nodules plant^{-1} was recorded under improved practices with life-saving irrigation.

The lowest dry weight of nodules plant^{-1} was recorded under the Rainfed farmer's practice at all the stages of crop growth during both the years of study. Further, it is reported that weight of nodules at 75 DAS was significantly higher in Direct seeded rice (22.7) followed by unpuddled transplanted rice and puddled transplanted rice. The interaction effect of dry weight of nodules was found significant at 75 DAS crop growth during the year 2015-16 of experimentation. These finding confirm the results reported by Siag *et al.*, [20].

Conclusion

Relative water content and specific leaf weight was significantly higher under direct seeded rice establishment method than puddled and unpuddled transplanted rice. Root nodule and dry weight of nodule significantly higher in direct seeded rice establishment methods as compare to puddled and unpuddled transplanted rice.

The rooting depth, root volume and root dry weight was significantly higher under direct seeded rice than the puddled treatments. Whereas, among water and nutrient management practices, viz. improved practices with life-saving irrigation produced higher root length and root volume in comparison to rainfed farmer's practices up to 30 cm depth.

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