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Impact of *Kharif* Rice Establishment Systems and Succeeding Tillage Practices on Rooting Behaviour of Succeeding Chickpea, Blackgram and Mustard

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ABSTRACT

Background: The present experiment was designed to evaluate the role of emerging rice establishment systems compared with succeeding tillage practices in supporting the rooting behaviour of chickpea, blackgram and mustard grown in succession.

Methods: The current experiment was conducted in *kharif* followed by *rabi* during 2021-22 and 2022-23 in a split-split plot design with three rice establishment methods as main plots during *kharif* followed by two tillage systems as sub plots and in each sub plot, chickpea, blackgran and mustard were grown as sub-sub plot during *rabi*, after the harvest of *kharif* rice.

Results: *Rabi* crops grown after dry direct seeded rice following conventional tillage has recorded highest root length and root volume in chickpea (23.83 and 22.97 cm; 13.57 and 13.13 cc), blackgram (20.70 and 20.13 cm; 12.43 and 12.03 cc) and mustard (37.43 and 36.27 cm; 21.50 and 20.80 cc) during successive years of study *i.e.*, 2021-22 and 2022-23, respectively.

Key words: Rice Establishment systems, Root length, Root volume, Sustainability, Tillage.

INTRODUCTION

Rice based cropping system in India is one of the mainstays and an important cropping system across the country. Rice being the largest grown crop in India with 45.76 million ha area and producing 124.36 million tonnes of grain annually (Indiaagristat, 2020) play a crucial role in sustaining agricultural economy and ecosystem in the country. Rice has been adjusted to aquatic/semi aquatic environment and to ensure sufficient water stand certain specialized operations like puddling have become part of rice agronomy. Although puddling aids in weed control and reduces water loss through percolation, it degrades the soil environment for growing of post-rice irrigated dry (I.D) crops (Sharma and De Datta, 1986). As a result of insufficient seed-to-soil contact, post-rice I.D crop stand establishment is irregular. Subsurface soil compaction produced by puddling may promote dryness in post-rice I.D crops by limiting root development (Kirchhof *et al*., 2000).

It was reported that productivity of the rice-rice cropping system had peaked and in some cases, was dropping, pushing the farmers to switch to an input-intensive production system. If not addressed, these productivity declines will have a negative impact on farmers' food security and livelihoods. To solve the issue, a production strategy based on the principle of minimal soil disturbance combined with effective crop combination/rotation should be promoted (Ladha *et al*., 2016). In the recent times different rice establishment systems like wet direct seeding, dry direct seeding has been surfaced across the rice growing regions and they are well proven to produce rice. Since these

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systems require less energy input compared to traditional puddled systems of production and growers are accepting it rapidly. As these new systems of rice cultivation involve a different kind of soil management, its worthiness in establishing and supporting other I.D crops in succession need to be evaluated. Keeping this broad idea in view the present experiment was designed to evaluate the impact of emerging rice establishment systems during *kharif* compared with tillage practices under taken in succeeding *rabi* on rooting behaviour of crops *viz*., chickpea, blackgram and mustard as the roots play an important role in establishing the crop.

MATERIALS AND METHODS

The current experiment was carried out at the Regional Sugarcane and Rice Research Station (PJTSAU), Rudrur, Nizamabad district (Telangana), with GPS coordinates of 18°33′55.01″ N latitude and 77°52′20.12″ E longitude and at an altitude of 401 m above mean sea level. Based on particle size distribution, the soil at the experimental site is silty clay and moderately alkaline in response, with a pH of 8.1 and EC of 1.94 dSm^{-1}. The experiment was conducted in *kharif* followed by *rabi* for two consecutive years (2021-22 and 2022-23) in a split-split plot design with three rice establishment methods as main plots, *viz*., machine Transplanting (M_1), wet direct seeding (M_2) and dry direct Seeding (M_3), followed by two tillage systems *viz*., Zero tillage with rice residue mulch (S_1) and conventional tillage (S_2) as sub plots and in each sub plot, three I.D crops namely, chickpea, blackgram and mustard were grown as sub-sub plot during *rabi* after the harvest of *kharif* rice. Except for seeding the crop, the soil in zero tillage plots was left undisturbed following rice harvest, but in conventional tillage plots a series of tillage operations were carried out using tractor drawn implement till the soil reached fine tilth. Irrigation was applied at IW: CPE ratio of 0.6 to all the plots and nutrient management was taken up as per the recommended rate for each crop.

The objective of the study was to understand the rooting behaviour of succeeding I.D crops (chickpea, blackgram and mustard) grown after *kharif* rice established under different systems and successive soil conservation practices. Root length and root volume at active vegetative stage (50 DAS in chickpea and Mustard; 40 DAS in blackgram) was recorded from the 5 plants pulled out of gross plot. Root length was measured using meter scale and expressed in cm whereas, water displacement method was adopted to record root volume and results were expressed in cc.

The results were statistically compared using the ANOVA technique of split plot design for each crop independently. Despite the fact that the experiment was designed in a split-split plot design, three crops were compared separately in different establishment and tillage systems since they are physiologically distinct entities.

RESULTS AND DISCUSSION

Puddling is beneficial for maintaining water levels in rice crops, however it leads to formation of a hard pan and poor soil structure which affects the performance of succeeding upland crops cultivated in rotation by reducing its root growth ultimately resulting in poor nutrient and water absorption (Kumar and Ladha, 2011; Joshi *et al*., 2013). In the present experiment it was observed that in all the three crops *viz*., chickpea, blackgram and mustard grown after *kharif* rice, the root length and root volume were greatly influenced by soil management practices (Fig 1 to 4). Among three rice establishment systems, chickpea grown in dry direct seeded rice followed by a series of tillage operations (conventional tillage) has recorded highest root length (23.83 and 22.97 cm) and root volume (13.57 and 13.13 cc) in two successive years of study *i.e*., 2021-22 and 2022-23, respectively. Whereas the lowest values of root length (16.37 and 15.13 cm) and root volume (8.90 and 8.37cc) were reported from wet direct seeding zero tillage (Table 1).

In case of blackgram and mustard also similar results were noticed where in growing of succeeding I.D crops in

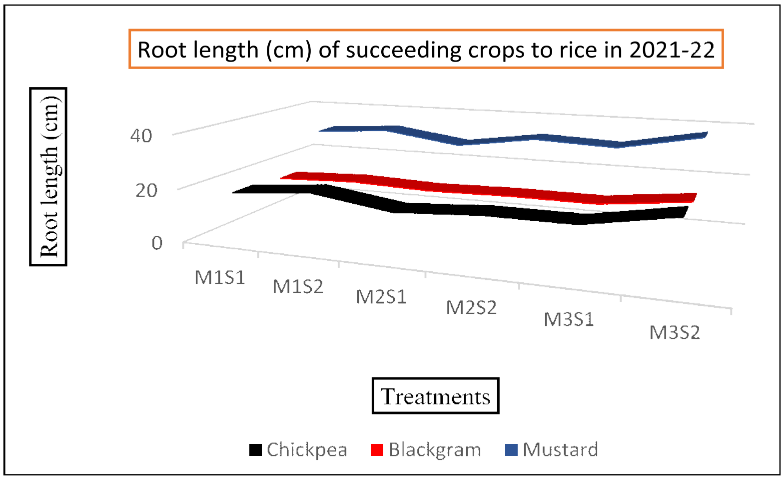

Fig 1: Root length (cm) of succeeding crops to rice in 2021-22.

dry direct seeded rice plots followed by a series of tillage operations (conventional tillage) has recorded highest root length and root volume in blackgram (20.70 and 20.13 cm; 12.43 and 12.03 cc) and mustard (37.43 and 36.27 cm; 21.50 and 20.80 cc) during successive years of study *i.e.*, 2021-22 and 2022-23, respectively. Whereas, the lowest root growth and volume was recorded from wet direct seeding followed by zero tillage (Table 2 and 3).

Puddling operation carried in wet direct seeding and machine transplanting of rice is accounted for the poor performance of succeeding crops. This is the result of accumulated effects like poor aeration, high soil penetration resistance and destroyed natural structure of soil resulting from puddling operation (Rawat *et al*., 1996; Mondal *et al*., 2016). On the other hand, in dry directed seeded rice establishment, the soil is not subjected to puddling there by it can maintain its natural state with favourable soil physical properties (Kato *et al*., 2009). Lower rooting depth in zero tilled plots might be also due to continues soil moisture available near the soil surface due to mulching effect, which is absent in conventional tilled plots and root went deep inside soil searching for moisture and moisture extraction was found to be greater from deeper layers under well tilled soils than untilled soil (Mishra and Tripathi 1993). Results from the present experiment will support the statement of usefulness of dry seeded rice in comparison to wet direct seeding and machine transplanting for growing successive I.D crops in rice based cropping system.

Table 1: Impact of *kharif* rice establishment methods and succeeding tillage practices on Root length (cm) and root volume (cc) at active vegetative stage of chickpea grown in succession to rice.

Treatments	Root length			Root volume		
	2021-22	2022-23	Mean	2021-22	2022-23	Mean
Main plot treatments (M)						
M_1	19.22	17.87	18.54	10.57	9.93	10.25
M_2	17.33	16.22	16.77	9.88	9.32	9.60
M_3	21.05	19.98	20.51	11.62	11.17	11.39
S.Em±	0.41	0.45	-	0.26	0.24	-
CD (P=0.05)	1.61	1.77	-	1.02	0.94	-
Sub plot treatments (S)						
S_1	17.49	16.24	16.86	9.34	8.78	9.06
S_2	20.91	19.80	20.35	12.03	11.50	11.76
S.Em±	0.19	0.20	-	0.16	0.16	-
CD (P=0.05)	0.67	0.71	-	0.57	0.56	-

Interaction (M×S) of chickpea root length during 2021-22					Interaction (M×S) of chickpea root length during 2022-23				
	M_1	M_2	M_3	Mean		M_1	M_2	M_3	Mean
S_1	17.83	16.37	18.27	17.49	S_1	16.60	15.13	17.00	16.24
S_2	20.60	18.30	23.83	20.91	S_2	19.13	17.30	22.97	19.80
Mean	19.22	17.33	21.05	19.20	Mean	17.87	16.22	19.98	18.02
	S.Em±		CD(P=0.05)			S.Em±		CD (P=0.05)	
S at same M	0.33		1.15		S at same M	0.35		1.23	
M at same S	0.47		1.81		M at same S	0.52		1.97	

Interaction in (M×S) of chickpea root volume during 2021-22					Interaction in (M×S) of chickpea root volume during 2022-23				
	M_1	M_2	M_3	Mean		M_1	M_2	M_3	Mean
S_1	9.47	8.90	9.67	9.34	S_1	8.77	8.37	9.20	8.78
S_2	11.67	10.87	13.57	12.03	S_2	11.10	10.27	13.13	11.50
Mean	10.57	9.88	11.62	10.69	Mean	9.93	9.32	11.17	10.14
	S.Em±		CD (P=0.05)			S.Em±		CD (P=0.05)	
S at same M	0.29		0.99		S at same M	0.28		0.97	
M at same S	0.33		1.23		M at same S	0.31		1.17	

M_1: Machine Transplanting; M_2: Wet direct seeding; M_3: Dry direct seeding;

S_1: Zero tillage with rice residue mulch; S_2: Conventional tillage

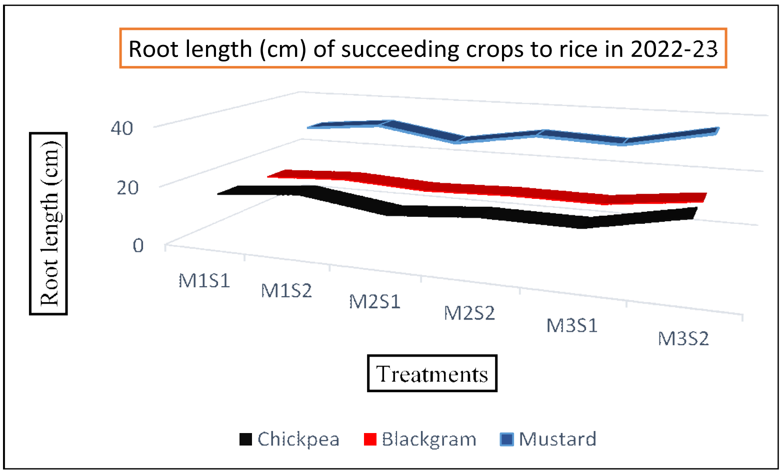

Fig 2: Root length (cm) of succeeding crops to rice in 2022-23.

Table 2: Impact of *kharif* rice establishment methods and succeeding tillage practices on Root length (cm) and root volume (cc) at active vegetative stage of blackgram grown in succession to rice.

Treatments	Root length			Root volume		
	2021-22	2022-23	Mean	2021-22	2022-23	Mean
Main plot treatments (M)						
M_1	17.03	16.63	16.83	9.43	9.03	9.23
M_2	16.92	16.28	16.60	8.93	8.47	8.70
M_3	18.90	18.35	18.62	10.60	10.17	10.38
S.Em±	0.41	0.33	-	0.24	0.22	-
CD (P=0.05)	1.60	1.28	-	0.94	0.87	-
Sub plot treatments (S)						
S_1	16.72	16.10	16.41	8.43	7.99	8.21
S_2	18.51	18.08	18.29	10.88	10.46	10.67
S.Em±	0.23	0.24	-	0.15	0.15	-
CD (P=0.05)	0.79	0.83	-	0.52	0.52	-

Interaction (M×S) of blackgram root length during 2021-22					Interaction (M×S) of blackgram root length during 2022-23				
	M_1	M_2	M_3	Mean		M_1	M_2	M_3	Mean
S_1	16.47	16.60	17.10	16.72	S_1	15.90	15.83	16.57	16.10
S_2	17.60	17.23	20.70	18.51	S_2	17.37	16.73	20.13	18.08
Mean	17.03	16.92	18.90	17.62	Mean	16.63	16.28	18.35	17.09
	S.Em±		CD (P=0.05)			S.Em±		CD (P=0.05)	
S at same M	0.39		1.36		S at same M	0.42		1.44	
M at same S	0.49		1.86		M at same S	0.44		1.63	

Interaction (M×S) of blackgram root volume during 2021-22					Interaction (M×S) of blackgram root volume during 2022-23				
	M_1	M_2	M_3	Mean		M_1	M_2	M_3	Mean
S_1	8.53	8.00	8.77	8.43	S_1	8.10	7.57	8.30	7.99
S_2	10.33	9.87	12.43	10.88	S_2	9.97	9.37	12.03	10.46
Mean	9.43	8.93	10.60	9.66	Mean	9.03	8.47	10.17	9.22
	S.Em±		CD (P=0.05)			S.Em±		CD (P=0.05)	
S at same M	0.26		0.90		S at same M	0.26		0.91	
M at same S	0.30		1.13		M at same S	0.29		1.08	

M_1: Machine Transplanting; M_2: Wet direct seeding; M_3: Dry direct seeding.

S_1: Zero tillage with rice residue mulch; S_2: Conventional tillage.

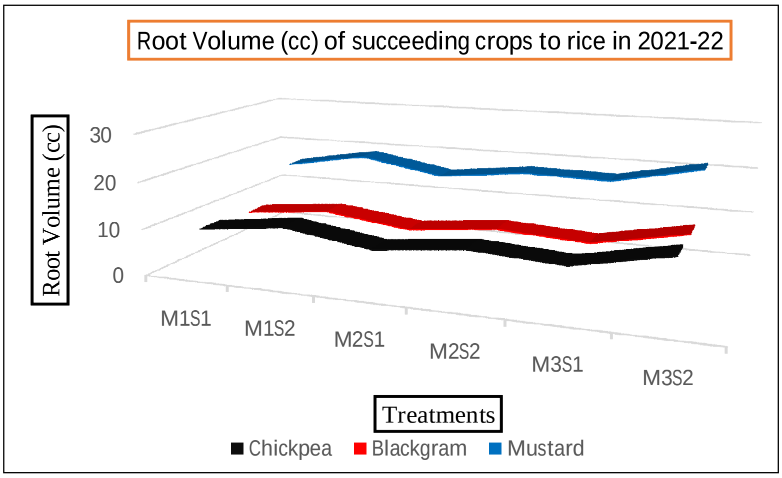

Fig 3: Root volume (cc) of succeeding crops to rice in 2021-22.

Table 3: Impact of *kharif* rice establishment methods and succeeding tillage practices on Root length (cm) and root volume (cc) at active vegetative stage of mustard grown in succession to rice.

Treatments	Root length			Root volume		
	2021-22	2022-23	Mean	2021-22	2022-23	Mean
Main plot treatments (M)						
M_1	31.60	30.45	31.02	17.57	16.92	17.24
M_2	30.63	29.37	30.00	16.93	16.28	16.60
M_3	34.48	33.32	33.90	19.57	18.77	19.17
S.Em±	0.66	0.57	-	0.43	0.37	-
CD (P=0.05)	2.59	2.24	-	1.67	1.43	-
Sub plot treatments (S)						
S_1	30.17	28.86	29.51	16.51	15.81	16.16
S_2	34.31	33.23	33.77	19.53	18.83	19.18
S.Em±	0.26	0.28	-	0.16	0.15	-
CD (P=0.05)	0.91	0.96	-	0.54	0.53	-

Interaction (M×S) of mustard root length during 2021-22

	M_1	M_2	M_3	Mean
S_1	30.53	28.43	31.53	30.17
S_2	32.67	32.83	37.43	34.31
Mean	31.60	30.63	34.48	32.24
	S.Em±		CD (P=0.05)	
S at same M	0.45		1.57	
M at same S	0.73		2.82	

Interaction (M×S) of mustard root length during 2022-23

	M_1	M_2	M_3	Mean
S_1	29.10	27.10	30.37	28.86
S_2	31.80	31.63	36.27	33.23
Mean	30.45	29.37	33.32	31.04
	S.Em±		CD (P=0.05)	
S at same M	0.48		1.67	
M at same S	0.66		2.52	

Interaction (M×S) of mustard root volume during 2021-22

	M_1	M_2	M_3	Mean
S_1	16.00	15.90	17.63	16.51
S_2	19.13	17.97	21.50	19.53
Mean	17.57	16.93	19.57	18.02
	S.Em±		CD (P=0.05)	
S at same M	0.27		0.93	
M at same S	0.47		1.79	

Interaction (M×S) of mustard root volume during 2022-23

	M_1	M_2	M_3	Mean
S_1	15.43	15.27	16.73	15.81
S_2	18.40	17.30	20.80	18.83
Mean	16.92	16.28	18.77	17.32
	S.Em±		CD (P=0.05)	
S at same M	0.26		0.92	
M at same S	0.41		1.57	

M_1: Machine Transplanting; M_2: Wet direct seeding; M_3: Dry direct seeding.

S_1: Zero tillage with rice residue mulch; S_2: Conventional tillage.

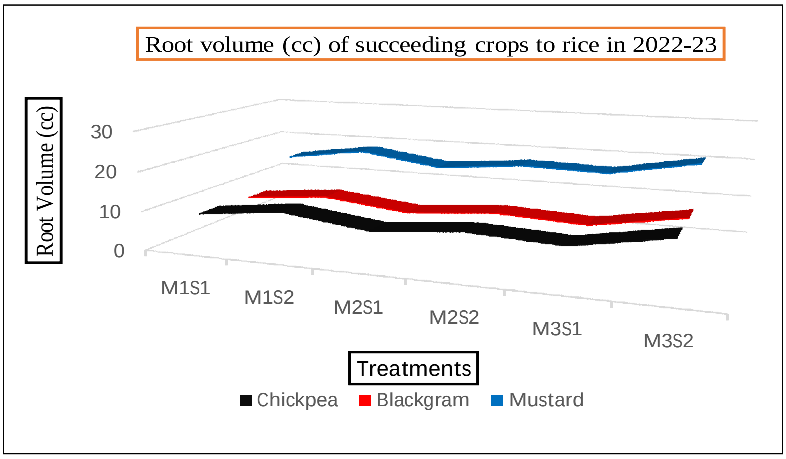

Fig 4: Root volume (cc) of succeeding crops to rice in 2022-23.

CONCLUSION

Latest rice establishment systems with altered management practices like dry direct seeded rice with a conventional tillage practice has a positive influence on succeeding crops with favourable soil physical conditions in comparison to wet direct seeding or machine transplanting. From the present study it can be concluded that dry direct seeding of rice followed by conventional tillage has best supported the succeeding chickpea, blackgram and mustard with respect to root length and root volume. Aim of diversifying the rice based cropping system in view of sustaining the soil and environment can be better achieved using dry direct seeded rice technique of crop establishment.

Conflict of interest: None.

REFERENCES

Indiaagristat, (2020). Area, Production and Productivity of Rice in India.

Joshi, E., Kumar, D., Lal, B., Nepaliya, V., Gautam, P. and Vyas, A.K. (2013). Management of direct seeded rice for enhanced resource - use efficiency. Plant Knowledge Journal. 2(3): 119-134.

Kato, Y., Okami, M. and Katsura, K. (2009). Yield potential and water use efficiency of aerobic rice (*Oryza sativa* L.) in Japan. Field Crop Research. 113(3): 328-334.

Kirchhof, G., Priyonob, S., Utomob, W.H., Adisarwantoc, Dacanayd, T.E.V. and Soa, H.B. (2000). The effect of soil puddling on the soil physical properties and the growth of rice and post-rice crops. Soil and Tillage Research. 56:37-50.

Kumar, V. and Ladha, J.K., (2011). Direct seeding of rice: Recent developments and future research needs. Advances in Agronomy. 111: 297-413.

Ladha, J.K., Rao, A.N., Raman, A.K., Padre, A.T., Dobermann, A., Gathala, M. Kumar, V. Saharawat, Y., Sharma, S., Piepho, H.P., Alam, M.M., Liak, R., Rajendran, R., Reddy, C.K., Parsad, R., Sharma, P.C., Singh, S.S., Saha, A. and Noor, S. (2016). Agronomic improvements can make future cereal systems in South Asia far more productive and result in a lower environmental footprint. Global Change Biology. 22: 1054-1074.

Mishra, J.P. and Tripathi, H.P. (1993). Effect of levels of nitrogen and spatial arrangements on growth, yield and quality of Indian mustard under dryland conditions. Ph D Thesis, NDUAT, Faizabad, India.

Mondal, S., Kumar, S., Haris, A., Dwivedi, S.K., Bhatt, B.P. and Mishra, J.S. (2016). Effect of different rice establishment methods on soil physical properties in drought-prone, rainfed lowlands of Bihar, India. Soil Research.https://doi.org/10.1071/SR15346.

Rawat, M.S., Tripathi, R.R. and Ram, N. (1996). Long term effect of puddling and fertilizer use in rice-wheat cowpea sequence on structural properties of soil. Journal of Indian Society of Soil Science. 44(3): 363-368.

Sharma, P.K. and De Datta, S.K. (1986). Physical properties and process of puddled rice soils. Advances in Soil Science. 5:139-178.