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IMPACT OF CONSERVATION TILLAGE PRACTICES IN RICE-BLACKGRAM CROPPING SYSTEM

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Abstract

Field experiments were conducted with two tillage practices in rice (Puddled and Non- puddled) during rainy season and three seed priming methods (Bio-seed priming with *Rhizobium*, hydropriming and no seed priming) and two foliar spray (2% DAP and 2% urea) during post rainy seasons in blackgram. The results indicated that the soil penetration resistance was found to be lesser in the soils of non-puddled tillage. The rice yield reduction due to NPTR was non-significant (less than 3 per cent). However, the soil penetration resistance was higher with the soils of blackgram sown as succeeding crop in the PTR. The blackgram yield obtained under NPTR was 10.6 per cent higher than PTR system. Bio seed priming with *Rhizobium* increased the yield by 26.0 per cent over no seed priming. The study indicated that NPTR showed a positive impact on the yield in the rice-blackgram relay cropping system.

Introduction

Rice is traditionally grown by transplanting seedlings in puddle fields where the water requirement is 1500 mm, out of which 200-250 mm is used for carrying out puddling operation only. Puddling also affects the soil health due to dispersion of soil particles, increase the soil compaction and make tillage operations difficult in succeeding crops requiring much energy. However, puddle transplanted rice requires large amounts of energy, water and labour, which are becoming increasingly scarce and expensive (Bhushan *et al*. 2007). In puddled soil, physical properties were adversely affected due to disturbance in the soil aggregates, permeability in subsurface layers and formation of hard pans at shallow depths (McDonald *et al.* 2006). Hence there has been increasing trend towards conservation agriculture in many countries over the past few years (Chhokar *et al*. 2007). Research reports have indicated that non-puddle transplanted rice produced yields similar to that under conventional puddling with minimized expenses on field preparation (Haque 2009). Since blackgram is grown under zero tillage condition as relay crop, the impact of non-puddled transplanted rice cultivation on the yield of succeeding blackgram grown under zero tillage condition is unknown, which needs to be assessed in rice-blackgram cropping system.

Soil compaction is commonly known to be caused by different tillage methods, use of either power operated or bullock drawn machineries for puddling, transplanting, intercultural operations and surface (Batey 2009). To quantify the vertical stress in terms of degree of compaction especially in adoption of no tillage immediately after employing combine harvester, measurement of soil penetration resistance (SPR) to quantify the soil quality and to identify the layers with increased degree of compaction would be a meaningful approach (Moraes *et al*. 2013). Soil Penetration Resistance (SPR) is a rapid method to assess and characterize the changes in soil compaction or soil strength within the soil profile in different depths (Koolen and Kuipers 1983), which is a function of several mechanical properties.

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Application of foliar nutrients at appropriate stages of growth become important for their efficient utilization and better performance of the crops especially in rice fallow pulses (Ganapathy *et al*. 2008). Though application of DAP (2%) during flowering and 15 days after first spray is recommended to increase the yield of rice fallow black gram application problems in DAP restricts its wider use. In addition, higher cost of DAP and its limited availability in the market in is one of the reasons for its non-adoption. However, Das and Jana (2015) earlier observed 5.8 per cent higher yield in blackgram due to foliar spray of 2 % urea over DAP. Seed priming is a pre sowing seed treatment method, which enhances germination, crop establishment and seedling vigour (Musa *et al*. 2001). Choudhry *et al.* (2017) observed that Bio-priming with *Rhizobium* significantly increased seed yield of greengram as compared to un-inoculated treatments. Therefore, an experiment was conducted to study the impact of tillage practices adopted in the rice crop along with bio-priming and foliar spray of nutrients on the succeeding blackgram grown as relay cropping under no till condition.

Materials and Methods

Field experiments were conducted for 4 years during the rainy (August-December) and post rainy seasons of 2016-2017,2017-2018,2018-2019 and 2019-2020 (December- March) at Tamil Nadu Rice Research Institute, Aduthurai (11^0 01" N, 79^0 48" E, 19.5 m altitude). The study area is characterized by a tropical climate with distinct wet and dry seasons with annual rainfall of 1169.4 mm (Subrahmaniyan *et al*. 2021). The experiment was laid out in split plot design (SPD) with two tillage systems *viz.*, Puddle (PTR) and Non puddle transplanting (NPTR) for rice and three seed priming methods (bio-seed priming, hydropriming and no priming) in main plots and two foliar spray of nutrients (DAP 2% and Urea 2%) in sub plots for blackgram. The study commenced with transplanting of rice variety (CR 1009) in puddle and non-puddled condition during South West Monsoon season (August- December). The plot size for rice was 40x25 m each for puddled and non-puddled treatments. The bio priming and foliar spray of nutrients were imposed in blackgram by maintaining a plot size of 5x4 m. All the treatments were replicated thrice. In non-puddled condition, minimum tillage of dry ploughing with cultivator followed by rotavator was done. Subsequently after a simple wetting of soil with 50 mm of irrigation water, transplanting was done with paddy transplanter. The black gram cultivar ADT-3 was sown 7-10 days prior to harvest of paddy crop by adopting a seed rate of 30 kg/ha. Bio-seed priming with *Rhizobium* and hydropriming for 2 hrs and No priming (control) was done prior to sowing. Foliar application of DAP 2 % spray and 2 % urea was done at flowering and 15 days after. The treatments were replicated thrice. Soil of the experimental site was clayey soil with a pH 7.4, low in organic carbon (0.30 %) and medium in available nitrogen (270 kg/ha), high in available phosphorus (30 kg/ha) and medium in available potassium (280 kg/ha). Seedling establishment and germination count was taken on 15 days of after transplanting (DAT) and sowing (DAS) respectively in rice and blackgram.

The soil penetration resistance (SPR) sampling was performed with Hand penetrometer Eijkelkamp, minimal design (measuring at each point, reaching up to 1.0 m. depth. with an accuracy of 1000 MPa. to measure the penetration resistance in each treatment randomly in six points at three depths (0-5, 5-10 and 10-15 cm). At each sampling points, the measurements were made with constant speed at different soil depths. The soil penetration resistance in each treatment is the mean of the six measurements in each depth. The growth and yield attributes data were observed at the time of rice and blackgram harvest. The grain yield was measured as total yield per plot and converted to kg/ha. Data were analysed statistically as per the method suggested by Gomez and Gomez (1984).

Results and Discussion

The pooled mean of three years data is presented here and discussed. The data on SPR in rice soils indicated that tillage practices showed a great influence on soil penetration resistance irrespective of the soil depth (Table 1). No significant difference in soil penetration resistance at 0-10, 10-20 and 20-30 cm soil depths at the time of planting was observed between NPTR and PTR. Whereas soil penetration resistance observed at 30 DAT indicated that the soil penetration resistance was higher with PTR in all the three depths though it was non-significant. However, the soil penetration resistance at 60 DAT and harvest was significantly higher with PTR at all the three depths. The blocking of macropores and translocation of dispersed particles during puddling had created soil compaction and the creation of impermeable zone just below the puddled layer in PTR would have increased the soil penetration resistance at all the three depths. Similarly, Rezaei *et al.* (2012) observed a dense plough pan due to puddling in which soil has been softened by flooding for several days and layer of soft mud was created. In contrast to the present finding, the decrease in penetration resistance by puddling due to loosening and softening of the paddled layer has also been reported by Hemmat and Taki (2003). Irrespective of the tillage practices, the soil penetration resistance increased with depths at all the stages of observation.

The growth and yield attributes were not significantly influenced by the tillage practices techniques (Table 2). Data on plant density at 15 DAT indicated that establishment of seedlings were uniform in both PTR and NPTR. No significant variation was found in the number of hills/m^2 which indicated that the suitability of non-puddled soils for machine transplanting which could able to maintain the population per unit area. Though PTR had more number of panicles/m^2 (324), number of grains/panicle (188) and higher 1000 grain weight (24.87 g) as compared to NPTR, the difference was non-significant. Similarly, no variation between NT and PT was also observed on the number of effective tiller $hill^{-1}$ and 1000 grains mass by Haque and Bell (2019). The grain yield obtained with PTR (6440 kg/ha) was comparable with NPTR (6288 kg/ha) and the yield improvement over NPTR was very meagre was (< 3.0 %). The lesser reduction in rice grain yield with NPTR was associated with no significant reduction in number of panicles/m^2 and 1000 grain weight which might be due to less post anthesis crop stress. Sharma *et al.* (1995) compared the performance of full soil puddling with single tillage in transplanted rice and reported similar rice yield in PTR and NPTR. Baker and Saxton (2007) also observed that though slight reduction in the yield in the first year, which could be overcome or even averted with increase in soil fertility. Haque *et al.* (2016) also reported that NPTR establishment had no negative effect on rice yields across the seasons and due to reduced cost of production, higher net income was obtained with NPTR.

The soil penetration resistance increases as the crop stage advances (Table 3). Significant increase in the soil penetration resistance due to puddling was observed at all the stages irrespective of the depths. The soil penetration resistance at the time of sowing of blackgram sowing was equal at 0-5 cm depth in both non-puddled and puddled soils. While at 5-10 cm and 10-15 cm depth, it was 40 and 70 Mpa, respectively with non-puddled soils as compared to puddled soils (50 and 80 Mpa). In the modified tillage method of non-puddled soils, the soil penetration resistance at 30 DAS was 520, 540 and 640 Mpa at 0-5, 5-10 and 10-15 cm soil depth, respectively was lesser as compared to puddled soil (600, 620 and 680 Mpa). Similarly, the soil penetration resistance at the time of harvest was also highest with the puddled soils, 720,760 and 770 Mpa at 0-5, 5-10 and 10-15 cm soil depth, respectively. Earlier Adamchuck *et al.* (2004) also reported that number of passes of agricultural machinery creates mechanical resistance in the surfaces of soil and thick layers of soil under plough pan due to soil compaction.

Table 1. Soil Penetration Resistance (Kpa) as influenced by tillage practices in rice crop

Treatments	0- 10 cm				10-20 cm				20-30 cm			
	0 DAT	30 DAT	60 DAT	Harvest	0 DAT	30 DAT	60 DAT	Harvest	0 DAT	30 DAT	60 DAT	Harvest
PTR	13	107	110	130	23	133	147	157	33	193	200	210
NPTR	6	73	93	93	17	107	107	173	26	130	140	147
CD (0.05)	NS	11	12	12	NS	8	14	10	NS	12	16	16

DAT- Days after transplanting NS- Non-significant

Table 2. Growth and yield attributes and yield of rice as affected by different tillage practices.

Treatments	Plant density /m^2	DMP at harvest (kg/ha)	No. of panicles/m^2	No. of grains / panicle	1000 grain weight (g)	Yield (kg/ha)
PTR	33	9876	324	188	24.68	6440
NPTR	33	9788	320	186	24.63	6288
CD (0.05)	NS	NS	NS	NS	NS	NS

NS- Non-significant

Table 3. Soil Penetration Resistance (Kpa) as influenced by tillage practices, seed priming and foliar spray in blackgram.

Treatments	0-5 cm			5-10 cm			10-15 cm		
	0 DAS	30 DAS	Harvest	0 DAS	30 DAS	Harvest	0 DAS	30 DAS	Harvest
Tillage practices									
PTR	20	600	720	50	620	740	80	680	770
NPTR	20	520	600	40	540	640	70	640	760
CD (0.05)	NS	20	44	NS	28	42	NS	NS	NS
Seed priming									
Bio priming	30	540	660	45	580	690	50	660	765
Hydropriming	30	540	660	45	580	690	50	660	765
Control	30	540	660	45	580	690	50	660	765
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Foliar spray									
DAP 2 %	30	560	660	45	580	690	75	660	765
Urea 2%	30	560	660	40	580	690	75	660	765
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

DAS- Days after sowing NS- Non-significant

Table 4. Growth and yield parameters and yield of blackgram as influenced by tillage practices, seed priming and foliar spray.

Treatments	Plant density/m^2	Plant height at harvest (cm)	No. of Pods/plant	No. of seeds / pod	100 seed weight (g)	Yield (kg/ha)
Tillage practices						
Puddled TP	27	27.0	24	6.2	4.73	536
Unpuddled TP	25	26.8	27	6.2	4.70	595
CD (0.05)	NS	NS	0.8	NS	NS	12
Seed priming						
Bio priming	26	27.0	30.0	6.7	4.86	640
Hydropriming	26	27.2	24.0	6.2	4.64	548
Control	26	26.5	22.5	5.7	4.50	508
CD (0.05)	NS	0.2	0.4	0.1	0.16	20
Foliar spray						
DAP 2 %	26	26.0	24	6.1	4.62	540
Urea 2%	26	27.8	27	6.3	4.81	590
CD (0.05)	NS	0.2	0.2	0.04	0.11	NS

NS- Non-significant

The grain yield of blackgram varied significantly between the two tillage systems due to the variations in the growth and yield parameters (Table 4). NPTR had favoured the succeeding blackgram by obtaining a yield of 595 kg/ha as compared to PTR (536 kg/ha). Similarly, Fujisaka *et al*. (1994) also reported that puddled transplanted rice cultivation results in lower grain yield of wheat in the rice–wheat system, mainly due to weakening of soil structure and the development of sub-surface hardpans. Irrespective of the tillage system bio-seed priming significantly increased the grain yield which was 16.7 and 26.0 per cent increase over hydro priming and no seed priming, respectively. Umair *et al*. (2011) observed that bio-seed priming increased the seed yield of greengram considerably through significant increase in nodulation, nitrogen fixation and nutrient uptake. Between the two foliar spray of macro nutrients, though no significant difference in yield parameters was observed, urea 2 % increased the grain yield by 9.2 per cent over DAP 2 %. The foliar nutrients might have supplemented the nutrient demand of the crop at the critical stage, resulting in better growth and development of the crop and ultimately the yield attributing characters and enhanced positive source-sink gradient of photosynthates translocation guaranteeing seed formation and better grain-filling (Mohan Raj *et al.* 2018).

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