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Effect of resource conservation technologies on growth and yield of rice under transplanted condition

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Abstract
The present study entitled "Effect of resource conservation technologies (RCTs) on growth and yield of rice under transplanted condition" was conducted during Kharif season in 2018-19 at the research farm of National Rice Research Institute, Cuttack, Odisha with rice variety *Pooja*. The experiment was laid out in Randomized complete block design (RBD) with seven treatments and three replications in transplanted condition of rice (TPR). The treatments under TPR followed: T1- control (no N), T2- conventional transplanting (CT)+100% RDF-N, T3- residue incorporation (RI)+75% RDF-N, T4- green manuring (GM) +75% RDF-N, T5- zero tillage transplanting (ZT)+100% RDF-N, T6- mechanical transplanting (McT)+100% RDF-N, T7- McT+ 100% RDF-N+ Customized leaf colour chart (CLCC). Results indicated a significant effect of different RCTs on growth and yield parameters of TPR. Effect of ZT+100% RDF-N was found significantly higher on plant height (cm) and leaf chlorophyll content (SPAD value) than other treatments in TPR. Effect of McT+100% RDF-N+CLCC in TPR was found significantly higher on number of tillers per hill, number of leaves per hill, dry root weight (g) per hill and leaf area index (LAI). Dry matter accumulation (g m^{-2}) was influenced significantly by GM+75% RDF-N in TPR, as compared to other treatments. Yield attributing characters and grain and straw yield was recorded highest in McT+100% RDF-N+CLCC in TPR.

Keywords: RCTs, conventional transplanting, residue incorporation, green manuring, zero tillage, mechanical transplanting and customized leaf colour chart

1. Introduction
India is an agricultural country as its security related with food, nutrition, livelihood and economy continues to be proclaimed by the performance of agriculture sector and this situation is not likely to change in near future because 72 per cent of the country's population lives in villages and about 58 per cent are engaged directly or indirectly in agriculture. As per the report of Fourth Advance Estimates for session 2016-17, production of rice has been approximated around 110.15 million tonnes, about 3.50 million tonnes higher than the former record production of 106.65 million tonnes attained during 2013- 14 and has increased by 5.74 million tonnes than the production of 104.41 million tonnes during session 2015-16 (Annual Report 2017-18, Department of Agriculture, Cooperation and Farmers Welfare). This growth in agricultural production is due to increase in yield with contribution from area expansion, which is projected to further decline. Also, in intensive agricultural production areas, partial factor productivity is diminishing with higher input use and hence, future expansion in production has to come from productivity increase, which can be possible only through technological advancement. Common feature of ancient agriculture was broadcasting seeds and harvesting inadequate yields. While, substantial yield gain by using improved seeds, fertilizers, pesticides, systematic irrigation, and mechanization (Foresight, 2011) [8] was the main drive of modern agriculture. Therefore, agriculture in present era is an energy intensive farming system (Khan *et al*., 2010) [15]. Although modern technology model remained successful in achieving targeted food demand, yet it has brought to several problems related with environment like deprivation of biodiversity and loss of soil fertility, salinization, and water scarcity etc. (McIntyre *et al*., 2009) [17]. Conventional or modern agriculture is mainly characterized by tillage which includes loosening of soil and levelling it for seed bed preparation, mixing fertilizer, control of weeds and management of crop residue (Hobbs *et al*., 2008) [12]. However, uninterrupted use of conventional tillage (CT) with conventional farming

practices and burning of crop residues has resulted in degradation of soil resources (Montgomery, 2007) [18]. Degradation stepped up by about 67%, accompanying decrease in crop production capacity (World Resources Institute, 2000) [25]. Also, yield growth has been going down, which is particularly true for rice in Asia (Pandey *et al*., 2010) [20].

The present situation of stepping up fuel, fertilizer and several other input costs, demands the efficient consumption of energy and other critical resources in agriculture. Without sustainable boost to productivity, agricultural supply will find it difficult to keep pace with the rapidly rising demand due to growth of population, income and changing consumer preferences (Foresight, 2011) [8]. Present challenges related with agricultural are resource exhaustion with decreasing factor productivity, decreasing human resources and their rising costs and socioeconomic changes (Erenstein, 2011; Gathala *et al*., 2011a) [7, 9]. Thus, there is an alarming need of an energy, water and labor efficient alternate system that helps to produce more at less cost and sustain soil and environmental quality, for a sustainable and ecologically safe rice farming (Jat *et al*., 2011; Gathala *et al*., 2011b) [14, 10]. The conservation agriculture based Resource Conservation Technologies (RCTs), adopted in an estimated 100 M ha area worldwide and over a variety of climatic, soil and geographic zones (Derpsch and Friedrich, 2009) [6], have proved to be energy and input efficient, besides addressing the emerging environment and soil health problems (Saharawat *et al*., 2010) [22]. The conservation agriculture technologies implicating no- or minimum tillage with direct seeding and bed planting, residue management (mainly residue retention) and diversification of crop (Gupta and Sayre, 2007) [11] have capability for increasing productivity and soil quality, mainly by boosting soil organic matter (SOM) (Bhattacharyya *et al*., 2013a,b) [5, 4]. The RCTs provide many possible benefits like reduced water and energy use, reduced greenhouse gas (GHG) emissions, soil erosion and degradation of the natural resource base, increased yields and farm incomes, and reduced labor shortages (Pandey *et al*., 2012) [19].

2. Materials and methods

2.1 Site characters

The experiment was conducted at the research plots of National Rice Research Institute, Cuttack, Odisha (20° 44′ N, 85° 94′ E; 24 m above mean see level) in tropical India, is characterized by monsoon climate with an average annual rain fall of 1500 mm, soil texture being sandy clay loam (Aeric Endoaquept) with, bulk density of 1.39 Mg m^{-3}, electrical conductivity (EC) was 0.39 dS m^{-1} and pH (using 1:2.5, soil: water suspension) was in the range of 5.0 to 5.7. Organic C, total N, available P, and available K content were 6.5 g Kg^{-1}, 0.73 g Kg^{-1}, 30.2 kg ha^{-1} and 162 kg ha^{-1}, respectively.

2.2 Treatment details and crop management

The study was conducted in wet season during 2018 with the rice cultivar *Pooja*. Five resource conservation technologies along with conventional methods were tested with 3 replications with randomized block design (RBD) being used. The treatments under transplanted condition followed: T1- Conventional Transplanting (CT) +No N; T2- CT+ 100% RDF-N; T3- Crop Residue Incorporation (RI) +75% RDF-N; T4- Green Manuring (GM) + 75% RDF-N; T5- Zero Tillage Transplanting (ZT) + 100% RDF-N; T6- Mechanical Transplanting (McT) + 100% RDF-N; T7- McT+100%RDF-N + CLCC. Twenty one to twenty five days old seedlings of rice were transplanted at a spacing of 20 cm× 15 cm with one to two seedlings per hill and chemical fertilizers were applied as recommended dose of fertilizer in this region at the rate of 80:40:40 Kg/ha.($N:P_2O_5:K_2O$). Urea was applied in three equal splits: one as basal, and two at active tillering and panicle initiation stage of crop growth. In RI treatment; rice straw (C:N:P:K content 382:4.2:1.4:17.8 g kg^{-1}) was incorporated (5 t ha^{-1}) before one week of puddling as source of nitrogen was applied. Similarly in GM treatment, dhaincha (*Sesbania aculeata*) (C:N:P:K content 368:32:2.1:22.6 g kg^{-1}) was grown as source of N before one month of puddling and the seed rate was 5 kg ha^{-1}.

2.3 Growth parameters

The growth parameters that were recorded included dry matter accumulation (in g m^{-2}), number of tillers and number of leaves per hill, dry root weight (in g) per hill and plant height (in cm), in which five random plants from each plot were selected and the concerned readings were taken and then average was taken for representing the respective plot Leaf area index (LAI) was recorded with the help of LAI meter. Leaf chlorophyll content (SPAD value) was recorded with the help of SPAD meter in sunlight from a fully expanded leaf from each plant. Three SPAD values per leaf, including one value around the midpoint of the leaf blade and two values 3 cm apart from the midpoint, were averaged between the midrib and leaf margin as the mean SPAD value of the leaf (Peng *et al*., 1993) [21]. SPAD values from each selected plant were then averaged out to represent SPAD reading of the respective plot. All the readings were taken at 60DAS or maximum tillering stage.

2.4 Yield parameters

The yield parameters that were recorded included number of effective tillers per hill, panicle length (in cm), number of grains per panicle, number of fertile grains per panicle, 1000 grain weight (in g), grain yield(t ha^{-1}) and straw yield(t ha^{-1}). Bundle weights of harvest from a net plot area of 90 m^2 were taken after sun drying and grain yield was recorded after hand threshing and straw yield was determined as the difference between bundle weight and grain yield.

3. Results and discussion

3.1 Growth parameters

Data regarding the effect of different RCTs on growth parameters of transplanted rice are given in Table 1. Plant height was recorded highest in ZT+100% RDF-N (91.1cm), while the lowest was observed in control plot with no N (81.4cm). This might be due to high organic matter available from residues retained from ZT and thus resulting in good crop growth and development. Further, number of tillers and number of leaves per hill was recorded highest in McT+100% RDF-N+CLCC (13.7, 62.7), while the lowest was recorded in control plot with no N, which might be due to favourable soil tilth and demand based application of nitrogenous fertilizers synchronizing crop needs in McT+100% RDF-N+CLCC. However, highest dry matter accumulation was recorded in GM+75% RDF-N (385.2 g m^{-2}) and the lowest was recorded in control plot with no N (298.7 g m^{-2}), which can be due to better plant density and crop growth in GM treatment. Further, dry root weight (g) per hill was recorded to be highest in McT+100%RDF-N+CLCC (6.2 g), which was at par with GM+75% RDF-N (5.7 g) and the lowest was recorded in control plot with no N (2.9 g). Leaf area index was recorded highest in McT+100% RDF-N+CLCC (3.67), which was at par with GM+75% RDF-N (3.50) and RI+75% RDF-N (3.32), while the lowest was recorded in control plot with no N (2.50). This might be due to good vegetative growth in McT+100%RDF-N+CLCC as a result of demand based supply of nitrogenous fertilizers. However, SPAD value was recorded significantly highest in ZT+100% RDF-N (40) and the lowest was observed in control plot with no N (27). Higher SPAD value in ZT+100% RDF-N under both transplanted rice may be due to higher nitrogen (N) availability in soil, resulting in greater N uptake by the crop, while lower SPAD value in control might be due to no N application in the plot and hence less N uptake by the crop. Similar findings were reported by Mahajan *et al*., (2010) [16]; Huang *et al*., (2008) [13]; Balasubramaniam *et al*., (2000) [2], and Vaiyapuri *et al*., (1998) [24].

3.2 Yield parameters

Data regarding yield attributes, grain and straw yield of transplanted rice are given in Table 2. Number of ear bearing tillers per hill, number of grains per panicle, number of fertile grains per panicle, grain yield and straw yield showed significant variation within the treatments; while panicle length and 1000 grain weight showed non-significant variation within the treatments. The treatment McT+100% RDF-N+CLCC gave higher number of ear bearing tillers per hill (14.3), number of grains per panicle (148), number of fertile grains per panicle (124), over other treatments and due to this highest grain and straw yield was recorded higher under McT+100% RDF-N+CLCC (6.18 t ha^{-1} and 7.92 t ha^{-1}), which was at par with GM+75% RDF-N (5.92 t ha^{-1} and 7.54 t ha^{-1}), while the lowest was observed in control plots. This indicated improvement in yield attributes and grain and straw yield under RCT over conventional methods, which might be due to the demand based supply of nitrogenous fertilizers resulting in better vegetative growth. Similar findings were reported by Bhattacharyya *et al*., (2012a, and 2013) [3, 5], and Tajuddin and Rajendran (2002) [23]. The treatments differed significantly in all the yield attributing parameters, grain and straw yield, except in panicle length (cm) and 1000 grain weight (g).

Table 1: Effect of different RCTs on growth parameters in transplanted rice at maximum tillering stage

Treatments	Plant height (cm)	No. of tillers per hill	No. of leaves per hill	Dry matter accumulation (g/m^2)	Dry root weight (g) per hill	LAI	SPAD value
Control	81.4	9.3	45.3	298.7	2.9	2.50	27.0
CT+100%RDF	82.7	12.0	53.7	328.5	4.8	3.20	31.0
RI+75%RDF	90.2	12.3	54.0	338.6	5.2	3.32	36.6
GM+75%RDF	87.9	13.3	58.3	385.2	5.7	3.50	36.2
ZT+100%RDF	91.1	11.0	53.0	340.6	3.9	2.93	40.0
McT+100%RDF	85.5	10.7	46.3	330.5	3.2	2.65	33.0
McT+100%RDF+ CLCC	86.4	13.7	62.7	336.4	6.2	3.67	34.6
CD at 5%	2.6	0.8	1.9	19.4	0.5	0.39	2.8

Table 2 Effect of different RCTs on yield attributes, grain yield and straw yield of transplanted rice

Treatments	No. of ear bearing tillers/hill	No. of grains/panicle	No. of fertile grains/panicle	Panicle Length (cm)	1000 Grain Wt(g)	Grain Yield (t h^{-1})	Straw Yield (t h^{-1})
Control	10.3	138	108	26.6	22.4	3.07	4.59
CT+100%RDF	12.3	142	118	26.4	22.7	5.43	6.52
RI+75%RDF	12.3	144	121	26.4	22.9	5.64	7.23
GM+75%RDF	13.3	147	122	26.0	23.4	5.92	7.54
ZT+100%RDF	11.7	140	117	25.6	23.8	5.37	6.48
McT+100% RDF	11.7	139	112	26.7	22.1	5.23	6.16
McT+100% RDF+ CLCC	14.3	148	124	26.4	22.5	6.18	7.92
CD at 5%	1.5	7.5	9.9	NS	NS	0.53	0.26

3. Conclusion

Resource conservation technologies improve growth and yield parameters in rice-green gram cropping system and is also found to save energy, labour and soil carbon and thus can be a better alternative for conventional method of practices which involve more labour, energy and C loss.

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