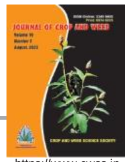
Journal of Crop and Weed, 19(2): 216-222 (2023)

ISSN- O : 2349 9400 ; P : 0974 6315



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An economic assessment of conservation agriculture in West Bengal

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Received : 01.02.2023 ; Revised : 12.06.2023 ; Accepted : 18.06.2023

DOI : https://doi.org/10.22271/09746315.2023.v19.i2.1724

ABSTRACT

The present study mainly focuses on the importance of promoting Conservation Agriculture (CA) in Nadia district of West Bengal. To judge the highest economic return under various cropping systems, an On-Station experimental trial was performed at Balindi Farm, BCKV in 2019-20 and 2020-21 sessions in order to evaluate the production, yield, and economic profitability of seven cropping systems and data were analysed on System Rice Equivalent Yield (kg/ha), System Gross Return(Rs. /ha), System Net Return (Rs. /ha) and System Return-Cost ratio for two years over three tillage operations and five doses of fertilizer treatments. A three factor (Cropping System, Tillage and Treatments) Randomized Complete Block Design (RCBD) pooled over two years (2019-20 and 2020-21) with three replications has been performed for the entire study. The critical differences of main and interaction effects have been analysed subsequently with Tukey's post hoc test.The result depicts that the second year of trial has achieved better system rice equivalent yield and economic return as well over previous year. Among seven cropping systems, Kharif Rice-Potato-Pumpkin has achieved the highest economic return pooled over years but differs individually as Kharif Rice-Maize-Cowpea exhibits better economic return on first year. Among the three tillage operations, conventional tillage has given highest economic return in both the years. In case of various treatments, 0% Residue + 100% RDF has achieved the highest economic return pooled over years but differs individually as 50% Residue + 100% RDF exhibits better economic return on first year. Pooled analysis over the years exhibits better economic return in Kharif Rice-Maize-Cowpea in conventional tillage with 100% Residue + 50% RDF which differs in the second year, resulting higher economic return in Kharif Rice-Potato-Pumpkin cropping system in conventional tillage with 50% Residue + 75% RDF. So, finally after two years of experimentations, farmers would be recommended to follow Kharif rice-Potato-Pumpkin with reduced tillage and 50% crop residue for betterment of Conservation Agriculture apparently different from the conventional one in Nadia district of West Bengal.

Keywords: Resource Conservation, Tillage, RCBD, Pooled analysis,Tukey's Post hoc

The recent transformation in Indian agriculture shows a change from the situation of 'farming for subsistence' to 'farming for profits' with the help of improved technology, cultivation of remunerative cash crops, application of complex fertilizers, bio-pesticides, assured irrigation facilities as well assound farm mechanization which resulted in ensuring expected supply of food grains for sustaining a quality life. However, with a shorter span of time, a negative impacts of declining resource base in terms of quality and quantity exists. While technical advancements in agriculture, industry, and infrastructure for human comfort are falling short of support systems, the need to worry about agricultural sustainability and the conservation of critical resources for a longer length of time is a wake-up call of the twentieth century (Hedge *et al*., 2016). The term 'Conservation Agriculture' refers to an integrated crop and soil management system that includes rotational crop variety, permanent soil covering by crops, cover crops, or crop leftovers, and little soil disturbance. (FAO, 2008). It was observed that 25-30% cost taken in land preparation than other operation as well as other improper traditional agricultural practices caused of soil degradation and impact on environment losses can be rectified by conservation practices. As per the conventional agronomic practices, tillage is one of the most basic activities in the preparation of land for the management of weed and some disease control as well. But according to various long-term studies, tillage is proven to be affecting the soil health negatively by changing the soil physical structure such as PH, organic compounds, available Nitrogen and Carbon, nutrient and micronutrient availabilities, such as Zn and Mn (Congreves *et al*., 2015; Grahmann *et al*., 2020) as well as increasing the incidences of soil degradation and wind erosion.

Apart from minimizing the tillage, plant residues are very crucial for soil structure regeneration and maintenance in a specific cropping system (Verma and Bhagat, 1992), however the amount of residue being returned to the soil is insufficient for a number of reasons. To enhance soil organic matter, as many leftovers as feasible should be left behind, and they should be distributed as uniformly and effectively. It is

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How to cite : Chakraborty, R. and Chatterjee, S. 2023. An economic assessment of conservation agriculture in West Bengal. *J. Crop and Weed*, 19(2): 216-222.

not advised to cut the remains, particularly in conditions where disintegration is quick and there is little residue present.

It is evident from the studies that research concerns have evolved drastically over the years, changing the view towards farming as well as sustainable cropping systems to maintain a range of ecological functions suitable for the ecosystem (Van Es and Karlen, 2019).Therefore, this paper reviews the impact of conservation agriculture on soil health in accordance with the various cropping systems that are commonly practiced in West Bengal.

OBJECTIVE

The study mainly focuses on the importance of promoting Conservation Agriculture in Nadia district of West Bengal by performing an On-Station experimental trial at Balindi Farm BCKV. The author has tried to evaluate the production, yield and economic profitability of various cropping system under conservation agriculture with a demonstration of cropping systems over two time periods (2019-20 and 2020-21).

MATERIALS AND METHODS

To identify the best cropping system under Conservation Agriculture in New Alluvial Zone particularly Nadia district of West Bengal, the experimental data were analyzed on System Rice Equivalent Yield (SREY) (kg ha^{-1}), System Gross Return (Rs. ha^{-1}), System Net Return (Rs. ha^{-1}) and System Return-Cost ratio for various cropping systems over tillage and doses of fertilizer treated. A three factor (Cropping System, Tillage and Treatments) Randomized Complete Block Design (RCBD) pooled over two years (2019-20 and 2020-21) with three replications has been performed for the entire study. The critical differences of main and interaction effects have been analysed subsequently with Tukey's post hoc test for the critical grouping of certain effects.Seven numbers of Cropping Systems (CS) were chosen with three types of tillage operations and fivefertilizer treatments has cited below:

A three-factor factorial RCBD, consisted of seven Cropping Systems denoted as CS_1, CS_2, CS_3, CS4, CS_5, CS_6 and CS_7, Three Tillage practices as Ti_1, Ti_2, and Ti_3 with Five Fertilizer treatments as T_1, T_2, T_3, T_4 and $T_5$is taken for the analytical discussion. These are treated as main effects while the three-factor interaction effect is represented as CS×Ti×T throughout the analysis.

RESULTS AND DISCUSSION

The analysis of variance (ANOVA) of system rice equivalent yield (SREY) along with system gross return, net return and return-cost ratio for different level of cropping systems, tillage as well as treatments combined over two years under experimental plots of Conservation Agriculture indicated marked responses (Table 2). While, significant changes among cropping systems with various level of tillage and treatments over the years occurred in all the traits for the main and interaction effects barring Year × Treatment interaction for the system rice equivalent yield.

Differential responses of SREY (kg ha^{-1}) with system gross return (Rs. ha^{-1}), system net return (Rs. ha^{-1}) and return-cost ratio over two years have been observed where SREY(kg ha^{-1}) for the year 2020-21 was found to be 4.28% higher than the previous year (2019-20). Likewise, a healthy 5.41% increase in system gross return (Rs. ha^{-1}) over previous year with a mammoth 16.06% hike in system profit (Rs. ha^{-1}) level have been registered. The return-cost ratio has moved up to 40 paise per rupee of investment (2.23 to 2.63).

While, judging the economic performance of individual cropping systems, all the systems have responded differentially where *kharif* rice-potato-pumpkin has registered the highest irrespective of all parameters; followed by *kharif* rice-maize-cow pea. However, rice-lentil cropping system with fallow in summer season has performed poorly in terms of system yield and economic return with *kharif* rice-mustard-black gram has the lowest return-cost ratio (1.06).

Though conventional tillage has secured the highest economic return over years; reduced tillage has registered better return-cost ratio (2.50) over

Table 1: Experimental design of On-Station Trial on Conservation Agriculture in Balindi Farm, BCKV, Nadia, W.B.

Cropping systems(7)	Tillage practices(3)	Treatments(5)
Kharif Rice- Mustard- Black Gram	Conventional Tillage	0% Residue+ 100% RDF
Kharif Rice- Potato- Pumpkin	Reduced Tillage	100% Residue+ 50% RDF
Kharif Rice- Maize- Cow Pea	Zero Tillage	100% Residue+ 75% RDF
Kharif Rice- Wheat- Green Gram		50% Residue+ 100%RDF
Kharif Rice- Lentil- Fallow		50% Residue+ 75% RDF
Kharif Rice- Onion- Dhaincha		
Kharif Rice- Cauliflower- *Boro* Rice		

Table 2: ANOVA for Main and Interaction Effects

Source	SREY (kgha^{-1})					System Gross Return (₹ ha^{-1})					System Net Return (₹ ha^{-1})					Return-Cost Ratio				
	DF	SS	MS	F value	Pr>F	DF	SS	MS	F value	Pr>F	DF	SS	MS	F value	Pr>F	DF	SS	MS	F value	Pr>F
Year	1	8.19×10^{7}	8.19×10^{7}	9.59	0.0021	1	3.70×10^{10}	3.70×10^{10}	250.13	<.0001	1	9.79×10^{10}	9.79×10^{10}	661.84	<.0001	1	2.51×10^{1}	2.51×10^{1}	2556.56	<.0001
Replication	2	1.62×10^{7}	8.14×10^{6}	0.95	0.3864	2	9.66×10^{6}	4.83×10^{6}	0.03	0.9679	2	9.66×10^{6}	4.83×10^{6}	0.03	0.9679	2	0.00	0.00	0.02	0.9817
CS	6	4.58×10^{10}	7.63×10^{9}	893.77	<.0001	6	1.34	2.23	15080.5	<.0001	6	1.18	1.97	13367.8	<.0001	6	6.83×10^{2}	1.13×10^{2}	11589.4	<.0001
Tillage	2	1.09×10^{9}	5.48×10^{8}	64.24	<.0001	2	4.01×10^{11}	2.00×10^{11}	1356.13	<.0001	2	2.40×10^{11}	1.20×10^{11}	811.84	<.0001	2	4.52	2.26	229.87	<.0001
Treatment	4	1.59×10^{8}	3.98×10^{7}	4.67	0.0011	4	2.27×10^{10}	5.68×10^{9}	38.40	<.0001	4	1.06×10^{10}	2.65×10^{9}	17.91	<.0001	4	0.30	0.07	7.76	<.0001
Year×CS	6	1.10×10^{10}	1.83×10^{9}	214.73	<.0001	6	3.30	5.50×10^{11}	3717.82	<.0001	6	3.81	6.36×10^{11}	4299.40	<.0001	6	3.72×10^{2}	6.20×10^{1}	6313.70	<.0001
Year×Tillage	2	1.20×10^{8}	6.00×10^{7}	7.03	0.0010	2	6.56×10^{10}	3.28×10^{10}	221.94	<.0001	2	6.18×10^{10}	3.09×10^{10}	208.96	<.0001	2	6.30	3.15	320.84	<.0001
Year×Treatment	4	7.83×10^{7}	1.95×10^{7}	2.29	0.0589	4	1.54×10^{10}	3.85×10^{9}	26.04	<.0001	4	1.80×10^{10}	4.50×10^{9}	30.43	<.0001	4	1.35	0.33	34.34	<.0001
CS×Tillage	12	1.31×10^{9}	1.09×10^{8}	12.84	<.0001	12	3.06×10^{11}	2.55×10^{10}	172.77	<.0001	12	3.12×10^{11}	2.60×10^{10}	175.90	<.0001	12	3.47×10^{1}	2.89	294.19	<.0001
CS×Treatment	24	9.57×10^{8}	3.98×10^{7}	4.67	<.0001	24	2.56×10^{11}	1.06×10^{10}	72.27	<.0001	24	2.68×10^{11}	1.11×10^{10}	75.47	<.0001	24	2.31×10^{1}	0.96	98.14	<.0001
CS×Tillage× Treatment	48	1.09×10^{9}	2.28×10^{7}	2.67	<.0001	48	2.00×10^{11}	4.16×10^{9}	28.16	<.0001	48	2.05×10^{11}	4.27×10^{9}	28.88	<.0001	48	2.14×10^{1}	0.44	45.55	<.0001
Tillage×Treatment	8	2.10×10^{8}	2.63×10^{7}	3.08	0.0022	8	3.47×10^{10}	4.34×10^{9}	29.37	<.0001	8	4.00×10^{10}	5.00×10^{9}	33.81	<.0001	8	3.41	0.42	43.47	<.0001
Year×CS× Tillage×Treatment	92	2.95×10^{9}	3.21×10^{7}	3.76	<.0001	92	6.26×10^{11}	6.81×10^{9}	46.04	<.0001	92	6.59×10^{11}	7.17×10^{9}	48.45	<.0001	92	7.89×10^{1}	0.85	87.30	<.0001
R-square	0.95	0.99	0.99	0.99																
Coefficient of Variation	16.99	4.18	7.25	4.08																
Root MSE	2922.78	12165.64	12165.64	0.09																

Note: CS (Cropping System), MSE (Mean Squared Error), SREY (System Rice Equivalent Yield)

conventional after two years of experimentation which is a good sign in the context of resource conservation. Statistically conventional and reduced tillage have shown apparently at par significance level with marked difference in economic profit.

Differential outcomes among T_3 (100% Residue+75% RDF) and T_4 (50% Residue+100% RDF) treatments has also been visualized with marked variation. However, T_1 (0% Residue+100% RDF) is statistically indifferent with T_5 (50% Residue+75% RDF) in respect of SREY. Regarding economic return; highest gross return (Rs.297064 ha^{-1}) over two years has been achieved under T_1 (0% Residue+100% RDF) followed by T_4 (50% Residue+100% RDF) (Rs. 296540 ha^{-1}) which are statistically at par. Three treatments (T_1: 0% Residue+100% RDF; T_4: 50% Residue+100% RDF and T_5: 50% Residue+75% RDF) have shown higher level of economic profit over cost incurred with no significant change. T_5: 50% Residue+75% RDF has registered the highest return-cost ratio 2.46 irrespective of all treatments with T_4 (50% Residue+100% RDF) and T_1 (0% Residue+100% RDF) (Both have return-cost ratio 2.43) are apparently statistically indifferent (Table 3).

Coming to the variation in interaction effect of Cropping System (CS)× Tillage (Ti) × Treatment (T) pooled over two years; it was found that $CS_2Ti_1T_5$ (*Kharif* rice-Potato-Pumpkin with conventional tillage and 50% Residue+75% RDF) has been registered the highest SREY (38385.0 kg ha^{-1}) which is statistically different from other combinations. $CS_2Ti_2T_2$ (*Khaif*rice-Potato-Pumpkin with reduced tillage and 100% Residue+50% RDF) and $CS_3Ti_1T_3$ (*Kharif*rice-Maize-Cowpea with conventional tillage and 100% Residue+75% RDF) are exhibited better SREY (29321.0 kg ha^{-1} and 29200.0 kg ha^{-1}) which are statistically indifferent. Regarding economic indicators; $CS_2Ti_1T_5$ (*Kharif*rice-Potato-Pumpkin with conventional tillage and 50% Residue+75% RDF) too has exhibited highest system gross return (₹ 653289.0 ha^{-1}), system net return (₹ 510976.0 ha^{-1}) and system return-cost ratio (4.79) over two years of experimentation with statistical identity from other combinations. Also,$CS_2Ti_2T_3$ (*Kharif*rice-Potato-Pumpkin with reduced tillage and 100% Residue+75% RDF) and $CS_2Ti_1T_4$ (*Kharif* rice-Potato-Pumpkin with conventional tillage and 50% Residue+100% RDF) has shown marked significance prominence among all the combinations of experimentation (Table 4).

CONCLUSION

With two years of experimentation of Conservation Agriculture with seven cropping systems, three tillage operations and five recommended residual treatments

Table 3: Tukey's grouping for main effects

Main effects	SREY (kg ha^{-1})	System Gross Return (Rs. ha^{-1})	System Net Return (Rs. ha^{-1})	Return-Cost
Year				
Y_1: 2019-20	16842^{B}	283251^{B}	155229^{B}	2.22^{B}
Y_2: 2020-21	17563^{A}	298582^{A}	180168^{A}	2.62^{A}
Minimum Significant Difference	457.79	1905.5	1905.5	0.02
CS				
CS_1: Kharif Rice- Mustard- Black Gram	8203^{F}	139647^{F}	6624^{G}	1.06^{G}
CS_2: Kharif Rice- Potato- Pumpkin	29231^{A}	497560^{A}	364568^{A}	3.87^{A}
CS_3: Kharif Rice- Maize- Cow Pea	25924^{B}	441578^{B}	325627^{B}	3.71^{B}
CS_4: Kharif Rice- Wheat- Green Gram	11217^{E}	190872^{E}	76873^{E}	2.03^{D}
CS_5: Kharif Rice- Lentil- Fallow	6488^{G}	110455^{G}	18581^{F}	1.32^{F}
CS_6: Kharif Rice- Onion- Dhaincha	14967^{D}	241072^{D}	117665^{D}	1.94^{E}
CS_7: Kharif Rice- Cauliflower- Boro Rice	24388^{C}	415236^{C}	263953^{C}	3.04^{C}
Minimum Significant Difference	1290.9	5373.1	5373.1	0.044
Tillage				
Ti_1: Conventional	18229^{A}	310358^{A}	183182^{A}	2.48^{A}
Ti_2: Reduced	18039^{A}	307125^{B}	179765^{B}	2.49^{A}
Ti_3: Zero	15339^{B}	255268^{C}	140149^{C}	2.31^{B}
Minimum Significant Difference	670.9	2792.5	2792.5	0.02
Treatments				
T_1: 0% Residue+ 100% RDF	17450^{BA}	297064^{A}	172158^{A}	2.43^{BA}
T_2: 100% Residue+ 50% RDF	16482^{B}	280608^{C}	160855^{C}	2.42^{BC}
T_3: 100% Residue+ 75% RDF	16965^{B}	288831^{B}	165338^{B}	2.39^{C}
T_4: 50% Residue+ 100% RDF	17992^{A}	296540^{A}	170606^{A}	2.43^{BA}
T_5: 50% Residue+ 75% RDF	17125^{BA}	291542^{B}	169537^{A}	2.46^{A}
Minimum Significant Difference	1008.9	4199.2	4199.2	0.03

Note: Data in the interaction analyzed with Least Squares Means and means separated with Tukey's post hoc test,at $p \leq .05$.
CS (Cropping System), MSE (Mean Squared Error), SREY (System Rice Equivalent Yield)Y1 (First year- 2019-20), Y2 (Second year- 2020-21)
CS1-7 (CS1: Kharif Rice- Mustard- Black Gram, CS2: Kharif Rice- Potato- Pumpkin, CS3: Kharif Rice- Maize- Cow Pea, CS4: Kharif Rice- Wheat- Green Gram, CS5: Kharif Rice- Lentil- Fallow, CS6: Kharif Rice- Onion- Dhaincha,CS7: Kharif Rice- Cauliflower- Boro Rice), Ti1-3 (Ti1: Conventional, Ti2: Reduced,Ti3: Zero), T1-5 (T1: 0% Residue+ 100% RDF, T2: 100% Residue+ 50% RDF, T3: 100% Residue+ 75% RDF, T4: 50% Residue+ 100% RDF, T5: 50% Residue+ 75% RDF)

it was found that conservation agriculture has gained 4.28% more system productivity in the second year (2020-21) as compared to first (2019-20). The gain continues for the economic indicators with a healthy 5.41% and 16.06% increase in system gross and net return (ha^{-1}) over previous year. The return-cost ratio has moved up to 40 paise per rupee of investment (2.23 to 2.63). However; considering main effects under cropping systems, tillage and various residual treatments, *Kharif* rice-Potato-Pumpkin has registered the highest irrespective of all parameters with conventional tillage operations and 0% Residue+100% RDF. But however; T_4 (50% Residue+100% RDF) has shown significantly better result for SREY as well as economic indicators. Regarding interaction effect, a combination of $CS_2Ti_1T_5$ (*Kharif* rice-Potato-Pumpkin with conventional tillage and 50% Residue+75% RDF) has registered the highest system rice equivalent yield (SREY) as well as system return. So, farmers would be recommended to follow *Kharif* rice-Potato-Pumpkin with reduced tillage and 50% crop residue for betterment of Conservation Agriculture apparently different from the conventional one in Nadia district of West Bengal.

Table 4: Interaction Effects Pooled over Two Years (2019-20 and 2020-21)

Interaction Effects (CS×Tillage×Treatment)	SREY (kgha^{-1})	System Gross Return (Rs. ha^{-1})	System Net Return (Rs. ha^{-1})	Return-Cost
$CS_1Ti_1T_1$	8700^{CZXEDYBA}	148131^{PQNJLOKMR}	7600^{LPONQRM}	1.06^{LIKJMN}
$CS_1Ti_1T_2$	9314^{CZXEWDYBA}	158539^{GHNJLOKMI}	22659^{LJONKM}	1.21^{LIKJH}
$CS_1Ti_1T_3$	7327^{CZEDBA}	124759^{QSTR}	-12583^{PQR}	0.91^{OMN}
$CS_1Ti_1T_4$	8174^{CZXEDYBA}	139197^{PQNSOMR}	-815^{POQR}	1.00^{LKOMN}
$CS_1Ti_1T_5$	8850^{CZXEDYBA}	150665^{PQNJLOKMI}	13383^{LPONQM}	1.12^{LIKJMN}
$CS_1Ti_2T_1$	7724^{CZEDYBA}	131505^{PQSOTR}	-9395^{PQR}	0.94^{LOMN}
$CS_1Ti_2T_2$	7595^{CZEDYBA}	129279^{PQSOTR}	-5287^{POQR}	0.97^{LKJMN}
$CS_1Ti_2T_3$	8419^{CZXEDYBA}	143332^{PQNSLOKMR}	5573^{LPONQRM}	1.05^{LKJMN}
$CS_1Ti_2T_4$	10242^{CZXEWDYBVA}	174316^{GHJFKEI}	34812^{LJIHK}	1.28^{IJH}
$CS_1Ti_2T_5$	9738^{CZXEWDYBVA}	165759^{GHJLFKMI}	30850^{LJINKM}	1.24^{IKJH}
$CS_1Ti_3T_1$	7441^{CZEDBA}	126695^{PQSTR}	3071^{PONQRM}	1.04^{LKJMN}
$CS_1Ti_3T_2$	7291^{CZEDBA}	124142^{QSUTR}	6436^{LPONQRM}	1.07^{LIKJMN}
$CS_1Ti_3T_3$	7375^{CZEDBA}	125577^{PQSTR}	351^{PONQR}	1.01^{LKOMN}
$CS_1Ti_3T_4$	8543^{CZXEDYBA}	145459^{PQNJLOKMR}	18362^{LPONKM}	1.15^{LIKJM}
$CS_1Ti_3T_5$	6305^{CED}	107354^{VWUT}	-15654^{QR}	0.88^{ON}
$CS_2Ti_1T_1$	30909^{EBDFC}	526172^{ED}	379971^{D}	3.69^{JHIG}
$CS_2Ti_1T_2$	26116^{ELKJDIFHG}	444676^{NLKM}	303498^{KNLM}	3.18^{NPO}
$CS_2Ti_1T_3$	31645^{EBDAC}	538695^{CD}	396473^{CD}	3.87^{FHEG}
$CS_2Ti_1T_4$	3364^{BAC}	572629^{B}	426548^{CB}	4.08^{DE}
$CS_2Ti_1T_5$	38385^{A}	653289^{A}	510976^{A}	4.79^{A}
$CS_2Ti_2T_1$	26051^{ELKJDIFHG}	443528^{NLKM}	305234^{KNMJL}	3.28^{NPMO}
$CS_2Ti_2T_2$	29321^{EBDFHCG}	499123^{EGF}	368074^{EDF}	3.94^{FEG}
$CS_2Ti_2T_3$	34263^{BA}	583150^{B}	452424^{B}	4.69^{BA}
$CS_2Ti_2T_4$	28201^{EBDIFHCG}	480108^{JHIGF}	344134^{GF}	3.65^{JHI}
$CS_2Ti_2T_5$	32811^{BDAC}	558476^{CB}	425997^{CB}	4.44^{BC}
$CS_2Ti_3T_1$	25709^{ELKJDIFHG}	437549^{NLOM}	309568^{KNIMJL}	3.50^{JLMK}
$CS_2Ti_3T_2$	19447^{PLKTNSORMQ}	331052^{S}	209466^{SR}	2.75^{Q}
$CS_2Ti_3T_3$	25067^{ELKJIFHMG}	426634NO	307347^{KNMJL}	3.72^{JHIG}
$CS_2Ti_3T_4$	29985^{EDBFCG}	510231^{EDF}	388200^{D}	4.46^{BC}
$CS_3Ti_3T_5$	26919^{EBJDIFHCG}	458080^{JILKM}	340615^{HIGF}	4.09^{DE}
$CS_3Ti_1T_1$	27832^{EBDIFHCG}	474068^{JHIGK}	341623^{HGF}	3.50^{JLMK}
$CS_3Ti_1T_2$	25361^{ELKJIFHMG}	432081^{NOM}	305077^{KNMJL}	3.26^{NPMO}
$CS_3Ti_1T_3$	29200^{EBDFHCG}	497359^{EGF}	367771^{EDF}	3.77^{FHIG}
$CS_3Ti_1T_4$	26022^{ELKJDIFHG}	443228^{NLKM}	311537^{KHIMJL}	3.30^{NPMO}
$CS_3Ti_1T_5$	27851^{EBDIFHCG}	474338^{JHIGK}	345489^{GF}	3.64^{JHIK}
$CS_3Ti_2T_1$	29206^{EBDFHCG}	497439^{EGF}	382476^{D}	4.28^{DC}
$CS_3Ti_2T_2$	28569^{EBDIFHCG}	486562^{HIGF}	378106^{ED}	4.47^{BC}
$CS_3Ti_2T_3$	26961^{EBJDIFHCG}	459257^{JILKM}	348440^{EGF}	4.01^{FE}
$CS_3Ti_2T_4$	27067^{EBJDIFHCG}	461085^{JHILKM}	346122^{GF}	3.85^{FHEG}
$CS_3Ti_2T_5$	25550^{ELKJDIFHG}	435260^{NLOM}	325877^{KHIGJL}	3.80^{FHIG}
$CS_3Ti_3T_1$	26329^{ELKJDIFHCG}	448417^{NLKM}	331057^{KHIGJ}	3.78^{FHIG}
$CS_3Ti_3T_2$	22211^{PLKJNIOHM}	378377^{QP}	265742^{QP}	3.29^{NPMO}
$CS_3Ti_3T_3$	22384^{LKJNIOHM}	381277^{QP}	279768^{QNPO}	3.68^{JHI}
$CS_3Ti_3T_4$	21698^{PLKJNIOMQ}	369631^{Q}	268130^{QPO}	3.48^{JLMK}
$CS_3Ti_3T_5$	22614^{LKJNIOHMG}	385284^{QP}	287187^{QNPMO}	3.70^{JHIG}
$CS_4Ti_1T_1$	11614^{CZXUEWDYBVA}	197625^{BCDAE}	75078^{EDCBFG}	1.96^{BZAXY}
$CS_4Ti_1T_2$	9595^{CZXEWDYBA}	163315^{GHJKLFKMI}	45058^{JIHKG}	1.61^{FED}
$CS_4Ti_1T_3$	10114^{CZXEWDYBVA}	172148^{GHJKLFKEI}	53624^{JIHFG}	1.68^{FCED}
$CS_4Ti_1T_4$	10772^{CZXUEWDYBVA}	183327^{GHDFE}	60230^{EDIHFG}	1.75^{BACED}
$CS_4Ti_1T_5$	10282^{CZXEWDYBVA}	175014^{GHJFEI}	55903^{IHFG}	1.69^{CED}
$CS_4Ti_2T_1$	12295^{CZXUTWDYBVA}	209204^{BCDAZ}	89740^{DCBA}	2.08^{WUVXY}
$CS_4Ti_2T_2$	10703^{CZXUEWDYBVA}	182146^{GHDFE}	64645^{EDCHFG}	1.84^{BZACYD}
$CS_4Ti_2T_3$	10735^{CZXUEWDYBVA}	182703^{GHDFE}	66632^{EDCFG}	1.79^{BZACED}
$CS_4Ti_2T_4$	13796^{ZXUTWSYBVA}	234743^{XYWZ}	115280^{ZYXA}	2.33^{UST}

Table 4 Cont..

Table 4 Cont…

Interaction Effects (CS×Tillage×Treatment)	SREY (kgha^{-1})	System Gross Return (Rs. ha^{-1})	System Net Return (Rs. ha^{-1})	Return-Cost
$CS_4Ti_2T_5$	$10666^{CZXUEWDYBVA}$	181532^{GHDFEI}	68128^{EDCFG}	1.79^{BZACED}
$CS_4Ti_3T_1$	$11413^{CZXUEWDYBVA}$	194128^{BCDFE}	87836^{EDCBA}	2.43^{RST}
$CS_4Ti_3T_2$	$14013^{ZXUTWSYBVA}$	238358^{XYWZ}	138042^{VXW}	3.15^{NPO}
$CS_4Ti_3T_3$	$9578^{CZXEWDYBA}$	$162987^{GHNJLFKMI}$	57008^{EIHFG}	1.89^{BZACY}
$CS_4Ti_3T_4$	$11092^{CZXUEWDYBVA}$	188724^{GCDFE}	81207^{EDCBF}	2.17^{WUVXT}
$CS_4Ti_3T_5$	$11587^{CZXUEWDYBVA}$	197130^{BCDAE}	94686^{ZCBA}	2.38^{ST}
$CS_5Ti_1T_1$	$8148^{CZXEDYBA}$	$138709^{PQNSOMR}$	53924^{JIHFG}	1.87^{BZACY}
$CS_5Ti_1T_2$	$7744^{CZEDYBA}$	$131824^{PQNSOTR}$	50073^{JIHFG}	1.86^{BZACYD}
$CS_5Ti_1T_3$	6871^{CEDBA}	116987^{VSUTR}	33839^{LJIHKM}	1.56^{FGE}
$CS_5Ti_1T_4$	$9187^{CZXEWDYBA}$	$156355^{PHNJLOKMI}$	71571^{EDCBFG}	2.18^{WUVXT}
$CS_5Ti_1T_5$	$8284^{CZXEDYBA}$	$141008^{PQNSLOMR}$	58747^{EDIHFG}	1.95^{BZAXY}
$CS_5Ti_2T_1$	6054^{CED}	103072^{XVWUT}	-8497^{POQR}	0.93^{OMN}
$CS_5Ti_2T_2$	6641^{CEDB}	113083^{VSUT}	$5638^{LPONQRM}$	1.07^{LIKJMN}
$CS_5Ti_2T_3$	6111^{CED}	104070^{XVWUT}	16^{PONQR}	1.00^{LKOMN}
$CS_5Ti_2T_4$	6984^{CEDBA}	118912^{SUTR}	$14782^{LPONQKM}$	1.14^{LIKJM}
$CS_5Ti_2T_5$	6983^{CEDBA}	118886^{SUTR}	16842^{LPONKM}	1.17^{LIKJM}
$CS_5Ti_3T_1$	4596^{E}	78244^{XW}	$8079^{LPONQRM}$	1.31^{IGH}
$CS_5Ti_3T_2$	4713^{E}	80256^{XW}	13596^{LPONQM}	1.31^{IGH}
$CS_5Ti_3T_3$	5491^{ED}	93469^{XVWU}	-5563^{POQR}	0.94^{OMN}
$CS_5Ti_3T_4$	5137^{ED}	87463^{XVW}	-11795^{PQR}	0.88^{ON}
$CS_5Ti_3T_5$	4375^{E}	74485^{X}	-22542^{R}	0.77^{O}
$CS_6Ti_1T_1$	$14073^{ZXUTWSYRVA}$	239541^{XYWZ}	122722^{ZYXW}	2.07^{WVXY}
$CS_6Ti_1T_2$	$14681^{ZXUTWSYRVQ}$	249873^{XYWV}	137123^{VXW}	2.24^{WUVST}
$CS_6Ti_1T_3$	$13980^{ZXUTWSYBVA}$	237964^{XYWZ}	117307^{ZYXA}	1.97^{BZAXY}
$CS_6Ti_1T_4$	$13107^{CZXUTWSYBVA}$	223136^{BXYAZ}	102161^{ZYBA}	1.85^{BZACYD}
$CS_6Ti_1T_5$	$13790^{ZXUTWSYBVA}$	234747^{XYWZ}	115802^{ZYXA}	1.97^{BZAXY}
$CS_6Ti_2T_1$	$16388^{PUTWSORVQ}$	278899^{UTV}	145083^{VXW}	2.04^{WZVXY}
$CS_6Ti_2T_2$	$15382^{PXUTWSORVQ}$	261782^{UWV}	133208^{VYXW}	2.00^{WZAXY}
$CS_6Ti_2T_3$	$17107^{PUTNSORVQ}$	291168^{UT}	159471^{VU}	2.19^{WUVXT}
$CS_6Ti_2T_4$	$14884^{PXUTWSYRVQ}$	253358^{XWV}	119040^{ZYXA}	1.89^{BZACY}
$CS_6Ti_2T_5$	$13262^{CZXUTWXYBVA}$	225756^{XYAZ}	95866^{ZCBA}	1.74^{BCED}
$CS_6Ti_3T_1$	$13820^{ZXUTWXYBVA}$	235155^{XYWZ}	121798^{ZYXW}	2.09^{WUVXY}
$CS_6Ti_3T_2$	$15289^{PXUTWSORVQ}$	260151^{UVW}	151183^{VUW}	2.40^{ST}
$CS_6Ti_3T_3$	$12991^{CZXUTWSYBVA}$	221094^{BYAZ}	94587^{ZCBA}	1.72^{BCED}
$CS_6Ti_3T_4$	$24848^{ELKJIFHMG}$	217984^{BCAZ}	88855^{DCBA}	1.65^{FCED}
$CS_6Ti_3T_5$	$10901^{CZXUEWDYBVA}$	185466^{GHDFE}	60762^{EDIHFG}	1.42^{FGH}
$CS_7Ti_1T_1$	$29452^{EBDFHCG}$	501347^{EGF}	341844^{HGF}	3.33^{NLMO}
$CS_7Ti_1T_2$	$27153^{EBJDIFHCG}$	462340^{JHILKM}	309192^{KNMJL}	3.38^{NLMK}
$CS_7Ti_1T_3$	$26722^{EKJDIFHCG}$	454953^{JNLKM}	298487^{NMOL}	3.18^{NPO}
$CS_7Ti_1T_4$	$26419^{ELKJDIFHCG}$	449762^{JNLKM}	289924^{NPMO}	3.04^{P}
$CS_7Ti_1T_5$	$26706^{EKJDIFHCG}$	454731^{JNLKM}	299548^{NML}	3.31^{NMO}
$CS_7Ti_2T_1$	$27238^{EBDIFHCG}$	463751^{JHILK}	308069^{KNMJL}	3.33^{NMO}
$CS_7Ti_2T_2$	$25743^{ELKJDIFHG}$	438326^{NLOM}	284326^{QNPMO}	3.13^{PO}
$CS_7Ti_2T_3$	$25870^{ELKJDIFHG}$	440562^{NLM}	287886^{QNPMO}	3.38^{NLMO}
$CS_7Ti_2T_4$	$28847^{EBDIFHCG}$	491182^{HGF}	335165^{HIGJ}	3.59^{JLIK}
$CS_7Ti_2T_5$	$23964^{LKJNIFHMG}$	408067^{PO}	257032^{Q}	3.15^{NPO}
$CS_7Ti_3T_1$	$21449^{PLKJNIORMQ}$	365165^{QR}	218430^{R}	2.68^{RQ}
$CS_7Ti_3T_2$	$19236^{PLTNSORMQ}$	327492^{S}	192099^{SRT}	2.72^{Q}
$CS_7Ti_3T_3$	$18052^{PUTNSORMQ}$	307297^{ST}	163233^{VUT}	2.27^{UVST}
$CS_7Ti_3T_4$	$19176^{PLTNSORMQ}$	326510^{S}	179273^{SUT}	2.46^{RS}
$CS_7Ti_3T_5$	$19795^{PLKJNSORMQ}$	337054^{SR}	194794^{SR}	2.66^{RQ}

Note: Data in the interaction analyzed with Least Squares Means and means separated with Tukey's post hoc test, at $p \leq .05$
CS (Cropping System), Ti (Tillage), T (Treatment), SREY (System Rice Equivalent Yield, SD (Standard Deviation)
$CS_{1\text{-}7}$ (CS_1: Kharif Rice- Mustard- Black Gram, CS_2: Kharif Rice- Potato- Pumpkin, CS_3: Kharif Rice- Maize- Cow Pea, CS_4: Kharif Rice- Wheat- Green Gram, CS_5: Kharif Rice- Lentil- Fallow, CS_6: Kharif Rice- Onion- Dhaincha, CS_7: Kharif Rice- Cauliflower- Boro Rice), $Ti_{1\text{-}3}$ (Ti_1: Conventional, Ti_2: Reduced, Ti_3: Zero), $T_{1\text{-}5}$ (T_1: 0% Residue+ 100% RDF, T_2: 100% Residue+ 50% RDF, T_3: 100% Residue+ 75% RDF, T_4: 50% Residue+ 100% RDF, T_5: 50% Residue+ 75% RDF)

ACKNOWLEDGMENT

The authors are kind enough to acknowledge the entire Faculty staffs, Department of Agricultural Economics, BCKV, Mohanpur, West Bengal for their support and help in preparing the manuscript.

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