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Conservation Agriculture Practices on Physiological Indices of Rice in Rice Based Cropping System

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Authors' contributions

This work was carried out in collaboration between both authors. Author CD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author SA is the supervisor and major guide of this research. Both authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at Agronomy farm, Kerala Agricultural University during 2019-2021 to develop an eco friendly conservation method for upland rice based cropping system. Rice-okra cropping system with conservation practices were compared with conventional practice. Treatments consisted of planting methods like flat bed and raised bed with either*insitu*green manuring or brown manuring and with minimum soil disturbance. Various conservation practice significantly influenced the physiological parameters of rice under rice based cropping system. Highest leaf area index crop was recorded in direct seeding rice in flat bed + in situ green manuring at all stages of crop growth and it was statistically superior over other treatments. The crop growth rate, relative growth rate and net assimilation rate up to 60DAS recorded highest in direct seeding rice in flat bed +*insitu*green manuring but at 90-120DAS the highest was found in direct seeding rice in raised bed + green manuring. Growing green manure crops along with ricecrop raised in flat bed or raised bed had significant influence on the growth indices of rice.

Keywords: Crop growth rate; leaf area index; net assimilation rate; relative growth rate.

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1. INTRODUCTION

Conservation agriculture is an approach for enhancing the food production and it is gaining importance in worldwide due to increasing awareness about soil health. It emphasizes minimum soil disturbance, permanent soil cover and diversified crop rotation. In changing climate scenario there is an urgent need for developing and promoting technologies like conservation practices for reversing the processes leading to resource degradation. These technologies not only conserve the resources but also it provides environmental sustainability.

Rice is an important food crop grown in India and Kerala. However the area of rice in Kerala is decreasing in alarming rate. Upland rice is a better option for water scarcity area as it conserves the water and there by decreases the water requirement [1]. But there is a lacuna for better conservation practices for upland rice because of the dearth of knowledge about the conservation practices like bed planting, brown manuring, green manuring etc among the farmers. Therefore in present study the effect of conservation practices for physiological indices of rice in rice-okra cropping system was carried out.

2. MATERIALS AND METHODS

The field experiment was conducted at Agronomy Farm, College of Agriculture, Vellanikkara located at 10° 31¹ N latitude and 76° 13¹E from May 2019 to March 2021. Experimental site soil was sandy loam. In this upland rice based cropping system rice is grown as first crop during May followed by okra in September as second crop and cowpea was raised in January as third green manure crop .The experiment was repeated for two years by keeping the same layout for both the years. Rice crop was grown with six treatments and each replicated thrice in randomised block design. Treatments consists of T1-Direct seeding rice in flat bed + Brown manuring., T2-Direct seeding rice in flat bed + green manuring T3- Direct seeding rice in raised bed + brown manuring, T4-Direct seeding rice in raised bed + green manuring ,T5-Direct seeding rice in flat bed, T6-Direct seeding rice in raised bed. Paddy variety Vaisakh was used for this study. Field was ploughed by tractor in the first year. Weeds and previous crop residues were removed and leveled. Rice seeds were planted in flat bed and raised bed. The plot size of flat bed was 5mx 4 m. Three raised beds of 5 m x1 m x 30 cm each was taken in a plot area of 5 mx4m. The same layout was used for raising the subsequent crops with minimum soil disturbance. Paddy seeds were dibbled @ 80 kg/ha at a spacing of 20×10 cm. Cowpea seeds were also dibbled in alternate rows in treatments T1 to T4 for brown manuring and *in situ* green manuring. *In situ* green manuring was done by uprooting the cowpea plants at 25DAS and placed between the paddy row as mulch. For brown manuring cowpea was incorporated by spraying of 2, 4- D @ 1.25 kg/ha at 25 DAS. Uniform hand weeding was done in all the plots at 30DAS. Destructive sampling of five plants was done at different growth stages like 30DAS,60DAS,90DAS and at harvest. Plants collected were oven dried at 70 °C to attain constant dry weight for calculating the dry matter. Leaf area at these stages was also calculated. Physiological indices like leaf area index, crop growth rate,relative growth rate and net assimilation rate was calculated from the dry matter and leaf area as follows

2.1 Leaf Area Index

The leaf area index was calculated by dividing the total leaf area with the corresponding ground area

$$LAI = \frac{\text{Total leaf area of a plant}}{\text{Ground area occupied by the plant}}$$

2.2 Crop Growth Rate

The CGR explains the dry matter accumulated per unit land area per unit time

$$CGR = \frac{(W_2 - W_1)}{\rho\,(t_2 - t_1)}$$

Where, W_1 and W_2 are whole plant dry weight at time $t_1 - t_2$ respectively ρ is the ground area Unit: g m^{-2} day^{-1}

2.3 Net Assimilation Rate

Dry matter increment per unit leaf area per unit of time.

The NAR is a measure of the average photosynthetic efficiency of leaves in a crop community.

$$NAR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{(\log_e L_2 - \log_e L_1)}{(L_2 - L_1)}$$

Where, W_1 and W_2 is dry weight of whole plant at time t_1 and t_2

L1 and L2 are leaf area at t_1 and t_2 respectively unit : g g^{-1} day^{-1} / gcm^{-2} day^{-1}

2.4 Relative Growth Rate (RGR)

Index of amount of growing material per unit dry weight of plant per unit time

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where, W_1 and W_2 are whole plant dry weight at t_1 and t_2 respectively t_1 and t_2 are time interval in days Unit: mg g^{-1} day^{-1}

Data pertaining to different observations were tabulated and subjected to statistical analysis by Wasp 2.0. and the significance among the treatments was estimated at 5 per cent of probability and pooling was done for two years data .

3. RESULTS AND DISCUSSION

3.1 Leaf Area Index of Rice

Data on leaf area index at 30,60,90 DAS and at harvest are given in Table -1. Leaf area index was significantly influenced by all the treatments at 30, 60, 90 DAS and at harvest. Direct seeding rice in flat bed + green manuring (T2) recorded highest leaf area index of 2.34 at 30DAS, 6.65 at 60DAS, 8.73 at 90 DAS and 4.31 at harvest and it was significantly superior over other treatments. This may be due to the highest leaf area and high photosynthetic activity in conservation treatment. As leaf area is more in the earlier stages the leaf area index also showed an increase in trend in earlier stages up to 90DAS and thereafter in later stages due to reduction in leaf area it decreases. The result of the present study are in consonance with the findings of Islam et al., [2]they reported that practice of green manuring increased the leaf area index at initial stage in rice plants and decreased at later stage [3] also reported higher leaf area index incorporation of cowpea residue compared to no residue incorporation in aromatic hybrid rice. Direct seeding rice in flat bed (T5) recorded lowest leaf area index of 1.53 at 30DAS, 4.73 at 60DAS, 5.56 at 90DAS and 3.42 at harvest .

3.2 Crop Growth Rate (CGR) of Rice

Effect of treatments on crop growth rate of rice at various stages are depicted in Table-3.CGR is most meaningful growth function which represents the net photosynthesis and dry weight gained by a unit area of crop at unit time. Direct seeding rice in flat bed + green manuring (T2) recorded highest crop growth rate of 9.49 at 0-30DAS and 47.68 g/m^2/day at 30-60DAS respectively and it showed significant difference over other treatments. The highest CGR might be due to the high dry matter accumulation in early stages and the decrease in later stages (Table-2) and the results are similar to the findings of [4] that the dry matter reduction causes decrease in crop growth rate at later stages of crop growth. The lowest CGR was registered in direct seeding rice in flat bed (T5) of 6.00 g/m^2 /day at 0-30DAS and 31.32 g/m^2 /day at 0- 30-60DAS. CGR was significantly influenced by the green manure treatments [4,5]. CGR showed no significant variation during both years at 60-90 DAS. The highest crop growth rate of 7.38 g/ m^2/day was recorded in direct seeding rice in raised bed + green manuring (T4) at 90-120DAS and it was found to be significantly superior over other treatments .This may be due to the enhanced growth, dry matter accumulation and increase in photosynthesis by in cooperation of green manure crops(Table 2).

3.3 Relative Growth Rate (RGR) of Rice

Data on relative growth rate of rice at various stages are depicted in Table-4. It indicates the amount of growing material per unit dry weight of plant per unit time. At 0-30DAS the highest relative growth rate was recorded at direct seeding rice in flat bed + green manuring (T2) (25.17 mg/g/day) and showed significant difference over other treatments. The lowest relative growth rate was registered in direct seeding rice in flat bed (T5) (18.52 mg/g /day). At 30-60 DAS highest relative growth rate was recorded at direct seeding rice in flat bed + green manuring (T2) (26.66 mg/g/day).Green manuring accelerated the relative growth rate similar results was reported by [6]. Like the crop growth rate relative growth rate failed to create significant variation at 60-90DAS during both the years. The highest relative growth rate of 1.90 mg/g/day was recorded at 90-120DAS in direct seeding rice in raised bed + green manuring (T4) and it was found to be significantly superior over other treatments but there was an alarming decrease of RGR in later stages .Abscission of leaves in later stages decreases the plant dry weight and there by decreases the relative growth rate [6,7].The lowest relative growth rate at this stage was registered in direct seeding rice in flat bed + brown manuring (T1) (0.56 mg/g/day).

Table 1. Effect of treatments on leaf area index of rice at different growth stages

Treatments	30DAS			60DAS			90DAS			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1-Direct seeding rice in flat bed + Brown manuring	2.11^{b}	2.11^{b}	2.11^{b}	6.66^{ab}	6.13^{a}	6.40^{a}	8.30^{a}	8.22^{b}	8.26^{a}	4.06^{ab}	4.13^{ab}	4.10^{ab}
T_2-Direct seeding rice in flat bed + Green manuring	2.36^{a}	2.32^{a}	2.34^{a}	7.10^{a}	6.21^{a}	6.65^{a}	8.70^{a}	8.75^{a}	8.73^{a}	4.28^{a}	4.35^{a}	4.31^{a}
T_3-Direct seeding rice in raised bed + Brown manuring	1.73^{d}	1.76^{d}	1.74^{d}	5.80^{c}	5.45^{b}	5.62^{b}	7.03^{b}	7.12^{c}	7.08^{b}	3.75^{cd}	3.70^{cd}	3.73^{cd}
T_4- Direct seeding rice in raised bed + Green manuring	2.00^{c}	1.96^{c}	1.98^{c}	5.95^{bc}	5.50^{b}	5.73^{b}	7.04^{b}	7.55^{c}	7.30^{b}	3.95^{bc}	3.90^{bc}	3.93^{bc}
T_5- Direct seeding rice in flat bed	1.56^{e}	1.492^{e}	1.53^{e}	4.85^{d}	4.50^{c}	4.68^{c}	5.28^{c}	5.83^{d}	5.56^{c}	3.47^{d}	3.38^{e}	3.42^{e}
T_6- Direct seeding rice in raised bed	1.59^{e}	1.57^{e}	1.58^{e}	4.98^{d}	4.73^{c}	4.86^{c}	5.75^{c}	5.85^{d}	5.80^{c}	3.50^{d}	3.51^{de}	3.51^{de}
SEm	0.13	0.13	0.13	0.36	0.29	0.32	0.55	0.49	0.52	0.13	0.15	0.14
CD(0.05)	0.11	0.13	0.07	0.74	0.47	0.46	0.77	0.48	0.53	0.31	0.33	0.30

Table 2. Effect of treatments on dry matter production (kg/ha) of rice at different growth stages

Treatments	30DAS	60DAS	90DAS	Harvest
	Pooled	Pooled	Pooled	Pooled
T_1-Direct seeding rice in flat bed + Brown manuring	2589.83^{b}	15941.67^{b}	18675.00^{a}	19416.67^{a}
T_2-Direct seeding rice in flat bed + Green manuring	2846.67^{a}	17150.00^{a}	18383.33^{a}	19587.50^{a}
T_3-Direct seeding rice in raised bed + Brown manuring	2326.67^{c}	13088.33^{d}	14736.67^{c}	16050.83^{c}
T_4- Direct seeding rice in raised bed + Green manuring	2516.67^{bc}	13966.67^{c}	16100.00^{b}	18312.50^{b}
T_5- Direct seeding rice in flat bed	1800.00^{e}	11195.00^{e}	12941.67^{d}	14150.00^{d}
T_6- Direct seeding rice in raised bed	1995.00^{d}	11801.67^{e}	13866.67^{cd}	14483.33^{d}
SEm	159.26	950.49	967.23	993.57
CD(0.05)	193.34	655.44	1285.91	790.87

Table 3. Effect of treatments on crop growth rate (g/m^2/day) of rice at different growth stages

Treatments	0-30DAS			30-60DAS			60-90DAS			90-120 DAS		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1-Direct seeding rice in flat bed + Brown manuring	8.53^{b}	8.73^{b}	8.63^{b}	46.58^{a}	42.43^{a}	44.51^{b}	7.22	11.00	9.11	1.39^{c}	3.55^{b}	2.47^{c}
T_2-Direct seeding rice in flat bed + Green manuring	9.53^{a}	9.44^{a}	9.49^{a}	50.02^{a}	45.33^{a}	47.68^{a}	1.78	6.44	4.11	5.14^{b}	2.88^{b}	4.01^{b}
T_3-Direct seeding rice in raised bed + Brown manuring	7.39^{c}	8.12^{c}	7.75^{c}	36.31^{bc}	35.43^{bc}	35.87^{c}	4.54	6.44	5.49	3.32^{cd}	5.42^{a}	4.37^{b}
T_4- Direct seeding rice in raised bed + Green manuring	8.28^{bc}	8.50^{bc}	8.39^{bc}	39.28^{b}	37.06^{b}	38.17^{c}	4.67	9.55	7.11	8.42^{a}	6.33^{a}	7.38^{a}
T_5- Direct seeding rice in flat bed	6.11^{d}	5.89^{e}	6.00^{e}	31.02^{d}	31.61^{d}	31.32^{d}	6.01	5.64	5.83	4.31^{bc}	3.64^{b}	3.98^{b}
T_6- Direct seeding rice in raised bed	6.30^{d}	7.00^{d}	6.65^{d}	32.88^{cd}	32.50^{cd}	32.69^{d}	7.27	6.50	6.89	2.00^{de}	5.22^{a}	3.61^{bc}
SEm	0.55	0.52	0.53	3.09	2.23	2.66	-	-	-	1.04	0.55	0.67
CD(0.05)	0.96	0.54	0.64	4.35	3.23	2.43	NS	NS	NS	1.78	1.23	1.33

Table 4. Effect of treatments on relative growth rate (mg/g/day) of rice at different growth stages

Treatments	0-30DAS			30-60DAS			60-90DAS			90-120 DAS		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1-Direct seeding rice in flat bed + Brown manuring	23.62^{ab}	23.97^{b}	23.80^{b}	27.02	25.60^{ab}	26.31^{a}	1.79	2.82	2.31	0.32^{e}	0.79^{c}	0.56^{e}
T_2-Direct seeding rice in flat bed + Green manuring	25.24^{a}	25.10^{a}	25.17^{a}	26.53	26.79^{a}	26.66^{a}	0.42	1.62	1.02	1.17^{c}	0.67^{c}	0.92^{d}
T_3-Direct seeding rice in raised bed + Brown manuring	21.53^{c}	22.93^{c}	22.23^{c}	25.76	24.31^{b}	25.04^{b}	1.40	2.00	1.70	1.00^{c}	1.49^{a}	1.25^{bc}
T_4- Direct seeding rice in raised bed + Green manuring	23.17^{bc}	23.59^{bc}	23.38^{bc}	25.33	24.30^{b}	24.82^{b}	1.31	2.76	2.04	2.21^{a}	1.58^{a}	1.90^{a}
T_5- Direct seeding rice in flat bed	18.78^{d}	18.27^{e}	18.52^{e}	25.12	26.45^{ab}	26.29^{a}	2.17	2.01	2.09	1.41^{b}	1.20^{b}	1.31^{b}
T_6- Direct seeding rice in raised bed	19.25^{d}	20.76^{d}	20.01^{d}	26.44	25.06^{b}	25.75^{ab}	2.42	2.20	2.31	0.65^{d}	1.56^{a}	1.11^{c}
SEm	1.04	1.02	1.02	-	0.38	0.30	-	-	-	0.27	0.16	0.18
CD(0.05)	1.80	0.98	1.21	NS	1.48	0.94	NS	NS	NS	0.20	0.12	0.14

Table 5. Effect of treatments on net assimilation rate (g/m^2/day) of rice at different growth stages

Treatments	0-30DAS			30-60DAS			60-90DAS			90-120 DAS		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1-Direct seeding rice in flat bed + Brown manuring	10.60^a	10.85^b	10.72^b	5.11^a	4.89^a	5.00^a	0.42	0.67	0.55	0.10	0.27	0.19
T_2-Direct seeding rice in flat bed + Green manuring	10.82^a	10.84^b	10.83^{ab}	5.06^a	4.98^a	5.02^a	0.10	0.37	0.24	0.37	0.20	0.29
T_3-Direct seeding rice in raised bed + Brown manuring	10.87^a	11.77^a	11.32^a	4.68^b	4.72^{ab}	4.70^b	0.32	0.45	0.39	0.28	0.46	0.37
T_4- Direct seeding rice in raised bed + Green manuring	10.77^a	11.26^{ab}	11.01^{ab}	4.72^b	4.69^b	4.70^b	0.31	0.64	0.48	0.69	0.50	0.60
T_5- Direct seeding rice in flat bed	9.76^b	9.78^c	9.77^c	4.65^b	5.05^a	4.85^{ab}	0.51	0.47	0.49	0.43	0.36	0.40
T_6- Direct seeding rice in raised bed	9.92^b	11.13^{ab}	10.53^b	4.82^b	4.93^b	4.88^{ab}	0.60	0.54	0.57	0.19	0.50	0.35
SEm	0.20	0.27	0.22	0.08	0.12	0.06	-	-	-	-	-	-
CD(0.05)	0.67	0.78	0.49	0.21	0.26	0.20	NS	NS	NS	NS	NS	NS

Table 6. Effect of treatments on economics of rice

Treatments	Cost of cultivation (Rs./ha)			Gross return (Rs. /ha)			Net return (Rs. /ha)			B:C ratio		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1-Direct seeding rice in flat bed + brown manuring	59797	52197	55997	137758	123597	130678	77962	71400	74681	2.30	2.37	2.34
T_2-Direct seeding rice in flat bed + green manuring	58196	52077	55137	153638	132493	143066	95442	80416	87929	2.64	2.54	2.59
T_3-Direct seeding rice in raised bed + brown manuring	58697	54797	56747	116233	98867	107550	57537	44070	50803	1.98	1.80	1.89
T_4- Direct seeding rice in raised bed + green manuring	57177	53625	55401	131648	120650	126149	74471	66473	70472	2.30	2.25	2.28
T_5- Direct seeding rice in flat bed	75677	69177	72427	90623	73703	82163	14946	4526	9736	1.20	1.07	1.13
T_6- Direct seeding rice in raised bed	66877	61177	64027	109500	87153	98327	42623	25976	34299	1.64	1.42	1.53

3.4 Net Assimilation Rate (NAR) of Rice

The photosynthetic ability of plant is indicated by net assimilation rate .At 0-30DAS the highest net assimilation rate of 11.32 g/m^2/day was recorded at direct seeding rice in raised bed + brown manuring (T3) and showed significant difference over other treatments and it was at par with direct seeding rice in raised bed + green manuring (T4) (11.01 g/m^2/day) and direct seeding rice in flat bed+ green manuring (T2) (10.83 g/m^2/day) (Table 5.).This result was similar with the findings of Islam et al., [2] that the rate of net assimilation was significantly affected by *insitu* green manuring. The lowest net assimilation rate was registered in direct seeding rice in flat bed (T5) (9.77 g/m^2 /day). At 30-60 DAS the the highest net assimilation rate was recorded at direct seeding rice in flat bed + green manuring (T2) (5.02 g/m^2/day). Net assimilation rate wasfound to be non-significant during both years at 60-90 DAS and 90-120 DAS. While compare to the initial stages the net assimilation rate showed a decrease in trend that might be due to the mutual shading of older leaves which decreases the photosynthetic activity.

3.5 Economics of Rice

Direct seeding rice in flat bed + green manuring recorded highest B:C ratio of 2.59 followed by direct seeding rice in flat bed + brown manuring .These results are in consonance with the findings of Sahoo et al., [8] that insitu green manuring in rice gives highest net returns and high benefit cost ratio. The lowest B:C ratio was recorded in conventional practice *ie* direct seeding rice in flat bed (1.13)(Table -6). Similar to this Jat et al., [9] reported that in rice the conservation practices has recorded the highest B:C ratio than conventional practice.

4. CONCLUSION

The study indicated that conservation treatments had significant effect on physiological indices like leaf area index, crop growth rate, relative growth rate and net assimilation rate. Higher leaf areaindex, crop growth rate, relative growth rate and net assimilation rate in green manuring treatments indicated that cowpea grown along with rice had no competition with rice for growth resources. The practice of green manuring either in flat bed or raised bed is a recommended as a better conservation practice for rice based cropping.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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