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Economic Evaluation of Rice-Maize-Green Manure Cropping System under Different Tillage and Weed Management Practices in Conservation Agriculture

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A B S T R A C T

A field investigation was carried out at college farm, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad during 2014-15 and 2015-16 with five tillage treatments CT (transplanted), CT (transplanted), CT (direct-seeded), ZT (direct-seeded) and ZT+R (direct-seeded) for *kharif* rice fb CT, ZT, CT, ZT+R and ZT+R treatments for rabi maize in sequence as main treatments and 3 weed management practices (chemical method, IWM and weedy check) as subplots in split plot design replicated thrice. Mean data of system productivity (rice-maize-green manure (dhaincha) system) and economic analysis showed that, more system productivity, net returns and B C ratio was obtained under conventional tillage (CT) *kharif* transplanted rice followed by *rabi* maize under conventional tillage (12777 kg ha^{-1}, Rs 1, 09,003 ha^{-1} and 2.53) and zero tillage maize cultivation respectively (11455 kg ha^{-1}, Rs 93,994 ha^{-1} and 2.39). Integrated weed management practices recorded more system productivity, net returns and BC ratio (12126 kg ha^{-1}, Rs 1, 02, 625 ha^{-1} and 2.51) for *kharif* aerobic/transplanted rice (bispyribac sodium 25 g/ha as early PoE at 15 DAT fb HW at 40 DAT) followed by *rabi* maize (atrazine 1000 g ha^{-1}+paraquat 600g ha^{-1} as PE fb HW at 40 DAS) in sequence respectively.

Introduction

Post green revolution era has many challenges like stagnated net sown area, reduction in per capita land availability, climate change effects and deterioration of land quality. Conservation agriculture (CA) has emerged as an effective strategy to enhance sustainable agriculture worldwide. Rice-relay pulse crop is an important crop sequence covering 0.3 million ha area in Andhra Pradesh. For the past half decade, the greengram and blackgram were subjected to yellow vein mosaic and *Cuscuta* problem. In addition to this, since 2003 onwards in Krishna delta of Andhra Pradesh, due to late release of water, transplanting of rice is delayed and ultimately timely sowing of blackgram as relay crop is not possible. Then, farmers are switching over to non-traditional crop like maize in rice fallows as an alternative to blackgram. Under the emerging and potential crop sequence (rice-maize) in coastal region of Andhra Pradesh and Telangana state, conventional tillage maize after kharif rice under heavy textured soil needs 25-30% more energy for field preparation, which limits the farm profitability and delays maize sowing leading to lower productivity. Conservation agriculture (CA)-based technologies such as zero, reduced tillage facilitates timely sowing, increased yield, lower production costs and boost income. Further no till maize in rice fallow demonstrated a potential benefit of saving on cost of production ranging from Rs.3800-5500/ha. Weeds are the one of the biggest constraints of the adoption of conservation agriculture. Reduction in tillage intensity or frequency has an influence on weed management. Implementation of conservation agriculture has often caused yield reduction because reduced tillage failed to control weed interference. Crop yields can be similar for both conventional as well as in conservation tillage systems if weeds are controlled and crop stands are uniform (Mahajan *et al.*, 2002). From Chhattisgarh Pal *et al.*, (2015) reported conventional tillage practices performed better as compared to minimum tillage practices in terms of yields of various rabi crops. In view of this, the present experiment was conducted with an object to identify the economically viable tillage and weed management for resource conservation technologies.

Materials and Methods

The experiment was conducted at college farm, Professor Jayashankar Telangana State Agricultural university, Rajendranagar (PJTSAU), Hyderabad during 2014-15 and 2015-16 situated at an altitude of 542.3 m above mean sea level at $17^o19'$ N latitude and $78^o23'$ E longitude. The experiment was laid out in split plot design with 5 tillage treatments T_1:CT (transplanted), T_2:CT (transplanted+green manure), T_3:CT (direct-seeded), T_4:ZT (direct-seeded), T_5:ZT+R (direct -seeded) for *kharif* rice under transplanted and aerobic system fb T_1:CT, T_2:ZT, T_3:CT. T_4:ZT+R, T_5:ZT+R for *rabi* maize in sequence as main plots and 3 weed management treatments W_1:chemical (pendimethalin as PE 1000 g ha^{-1} (aerobic rice) /bensulfuron+pretilachlor 660 g ha^{-1} (transplanted rice) as PE at 3-5 DAT *fb* bispyribac sodium 25 g ha^{-1} *as* PoE at 20 -25 DAS (2-3 weed leaf stage), W_2:integrated weed management (bispyribac sodium 25 g ha^{-1} as early PoE at 15 DAS/DAT (2-3 weed leaf stge) fb HW at 40 DAS/DAT (aerobic and and transplanted rice) and W_3: weedy check for kharif rice and W_1: chemical (atrazine 1000 g ha^{-1} + paraquat 600 g ha^{-1} PE fb 2-4 D 1000 g ha^{-1} at 20-25 DAS as PoE, W_2:integrated weed management (atrazine 1000 g ha^{-1}+paraquat 600 g ha^{-1} PE fb HW at 40 DAS) and W_3: weedy check for rabi maize crop in sequence as subplots and replicated thrice with MTU-1010 and cargil 900M as test varieties for rice and maize respectively. During summer season greenmanure crop dhaincha was raised in all the treatments except in T_1 treatment in sequence for both rice and maize crops. The herbicide treatments were imposed as per the technical programme of the work, however paraquat did not apply to the conventional tillage maize treatments and the remaining package of practices were followed as per the recommendations of PJTSAU.

Rice equivalent yield (REY) was calculated to compare system performance by converting the yield of maize crop into equivalent rice yield on a price basis, using the formula:

RYE of maize - $Y_x (P_x/P_r)$

Where Y_x is the yield of crop maize (kg ha^{-1}), P_x the price of crop maize and P_r is the price of rice. Net return or profit was calculated by subtracting cost of cultivation from the gross returns, including by-product value to gross return. Prices used for harvest products were minimum support price during the experimental period. The benefit: cost ratio

(BCR) was calculated by dividing the gross return by the production cost for individual crops and for the system.

Results and Discussion

Kharif rice

Summary of *kharif* rice results in rice maize green manure sequence of two years revealed that, tillage and weed management treatments exerted significant influence on *kharif* rice yields (Table 1). Conventional tillage transplanted rice (T_2 and T_1) with summer green manure recorded slightly more yield over without green manure treatment for two years and were comparable with each other. The grain yield obtained from conventional tillage aerobic (T_3) and zero tillage aerobic (T_4 and T_5) is significantly less compared to CT transplanted rice (T_1 and T_2). Tillage treatment also showed similar trend on straw yield and HI as that of grain yield. Alam *et al.*, (2014) and Pal *et al*., (2015) also reported the yield increase in conventional tillage over conservation tillage practices.

Among the different weed management practices either IWM practice (bispyribac sodium 25 g ha^{-1} as early PoE at 15 DAS/DAT (2-3 weed leaf stage) fb HW at 40 DAS/DAT) or sequential application of herbicides (pendimethalin as PE 1000 g ha^{-1} (aerobic rice)/ bensulfuron+pretilachlor 666 g ha^{-1} (transplanted rice) proved to be equally effective to control weeds (data is not given) and to obtain significantly more yields over weedy check treatment. Straw yield and harvest index also showed the similar trend as that of grain yield. Yield reduction of 38.38% and 38.36% was noticed in weedy check treatment as minimum grain and straw yields was recorded under weedy check treatment due to more weed infestation resulted in poor crop growth and lower yield. These results are in accordance with findings of Gaurav *et al.*, (2015), who reported pre-emergence application of pendimethalin fb bispyribac sodium significantly reduced the density of grasses, sedges and broad leaf weeds and there by increased the grain yield. However rice grain yield was not affected due to interaction effect of tillage and weed management practices..

Rabi maize

Tillage and weed management practices exerted profound influence on *rabi* maize grain yield grown in sequence after *kharif* rice (Table 2). Maize crop raised under conventional tillage (CT) with preceded *kharif* conventional aerobic rice (T_3) and transplanted rice (T_1) treatments showed better performance with increased and comparable grain yield during 2014-15 (9072 kg and 8717 kg ha^{-1}) and 2015-16 (6572 kg and 6168 kg ha^{-1}) respectively. Grain yield from these treatments is significantly superior over grain yield recorded from maize crop grown under zero till condition. However the grain yield obtained from zero till treatments was comparable with each other. But any of the tillage treatments did not influence the stover yield, but HI followed the same trend as that of grain yield. Experimental results of Mukundam *et al.*, (2011) under clay loam soil showed the maximum plant height and yield of maize with conventional tillage than that under zero tillage.

Among the weed management practices pre emergence application atrazine 1000 g ha^{-1}+paraquat 600 g ha^{-1} fb HW at 40 DAS recorded significantly more grain yield and was comparable with sequential application of atrazine 1000 g ha^{-1}+paraquat 600 g ha^{-1} as PE fb 2-4D sodium salt 1000 g ha^{*1} at 20-25 DAS as post emergence application during two years of study. Yield reduction of 58.47% and 58.22% was noticed with weedy chek treatment during the study respectively due to season-long crop-weed competition. Stover yield was also affected by weed management treatments as that of grain yield with improved harvest index in similar treatments.

Table.1 Effect of tillage and weed management practices on grain yield, straw yield and harvest index of kharif rice in rice-maize-green manure cropping system (2014 and 2015)

	Treatments	Grain yield (Kg ha^{-1})	Grain yield (Kg ha^{-1})	Straw yield (Kg ha^{-1})	Straw yield (Kg ha^{-1})	HI	HI
		2014	2015	2014	2015	2014	2015
Main Plots							
T_1	CT (Transplanted)	3708	4996	5342	6,573	40.32	43.08
T_2	CT (Transplanted)	3783	5136	5301	6,266	42.71	44.49
T_3	CT (Direct-seeded)	874	1196	1868	2,351	31.69	31.91
T_4	ZT (Direct-seeded)	562	1076	1237	2,006	31.77	29.29
T_5	ZT(Direct-seeded)+R	593	895	1334	1,738	30.67	31.23
SEm+-			148		291		
C.D(0.05)		989	490	832	963		
Sub Plots							
W_1	Chemical	2468	3005	4121	3992	35	40.37
W_2	IWM	2229	3078	3540	4086	36	39.7
W_3	Un weeded	1015	1897	1773	3282	33	27.93
		210	190	131	226		
C.D(0.05)		622	564	389	671		
Interaction		NS		NS			

CT: Conventional tillage, Direct–seeded: Aerobic rice, ZT: Zero tillage, ZT+R: Zero tillage+rsidue

Table.2 Effect of tillage and weed management practices on grain yield, sover yield and harvest index of rabi maize in rice-maize-green manure cropping system (2014 and 2015)

	Treatments	**Grain yield** (Kg ha^{-1})	**Grain yield** (Kg ha^{-1})	**Stover yield** (Kg ha^{-1})	**Stover yield** (Kg ha^{-1})	**HI**	**HI**
		2014	**2015**	**2014**	**2015**	**2014**	2015
Main Plots							
$\mathbf{T_1}$	CT	8717	6168	8521	6691	49.96	46.44
$\mathbf{T_2}$	ZT	7505	4370	8267	6324	46.33	40.89
$\mathbf{T_3}$	CT	9072	6572	9063	6407	49.67	50.67
$\mathbf{T_4}$	ZT+R	7295	3764	8003	6255	46.08	36.78
$\mathbf{T_5}$	ZT+R	7537	4933	8047	7213	**47.00**	39.11
Sem		**336**	**369**	**486**	**538**		
C.D(0.05)		1065	1222	NS	NS		
Sub Plots							
$\mathbf{W_1}$	**Chemical**	9065	6087	9128	6818	49.59	46.733
$\mathbf{W_2}$	**IWM**	10605	6629	10172	8351	50.00	44.067
$\mathbf{W_3}$	**Unweeded**	4405	2769	5840	4565	42.00	37.533
		307	**302**	**308**	**392**		
C.D(0.05)		**905**	**897**	**915**	**1165**		
Interaction		NS	NS				

Table.3 Mean system productivity and economics of rice-maize-green manure cropping system (2014 and 2015)

	Kharif rice	*Rabi* maize	System yield (Kg ha^{-1})	Total CC (Rs ha^{-1})	GR (Rs ha^{-1})	NR (Rs ha^{-1})	B:C ratio
Main plots							
T_1	**CT (Transplanted)**	CT	12777	70475	179478	109003	2.53
T_2	**CT (Transplanted)**	ZT	11455	66900	160895	93994.5	2.385
T_3	**CT (Direct-seeded)**	CT	9419	64092	132277	68185	2.05
T_4	**ZT (Direct-seeded)**	ZT+R	6936	60517	97373	36856	1.595
T_5	**ZT(Direct-seeded) + R**	ZT+R	7567	60517	106258	45741.5	1.74
Sub plots							
W_1	**Chemical**	**Chemical**	11123	65505	156210.5	90705.5	2.38
W_2	**IWM**	**IWM**	12126	67670	170295	102625	2.51
W_3	**Unweeded**	**Unweeded**	5643	60325	79272	18947	1.31

In similar way Yield reduction of as high as 93% was observed due to uncontrolled weed growth during entire crop growth season from sandy clay loam soils (Pasha *et al.*, 2012).

System productivity

System productivity of rice-maize-green manure cropping system of two years was summerised (Table 3). Mean data of system productivity and economic analysis under different tillage practices showed that, more system productivity, gross returns, net returns and B C ratio was obtained in *kharif* rice under conventional tillage (CT) followed by *rabi* maize under conventional tillage (12777 kg ha^{-1}, Rs179478 ha^{-1}, Rs 109003 ha^{-1} and 2.53) and zero tillage maize cultivation practices respectively (11455 kg ha^{-}1, Rs 1, 60, 895 ha^{-1}, Rs 93, 994 ha^{-1} and 2.39). Even though more rabi maize grain yield was recorded in rabi conventional tillage with preceded kharif rice grown on CT aerobic(T_3) and CT transplanted (T_1) system, but the increased productivity in *kharif* rice (transplanted) fb rabi zero till maize was due decreased rice yields when crop grown under conventional aerobic system (T_3). This resulted in reduced productivity of CT direct seeded (T_3) fb CT maize. Total cost of cultivation under conventional tillage is 14.1% more than conservation tillage. But the increased system productivity was due to more grain yield obtained during both the season.

Regarding weed management practices more system productivity, gross returns, net returns and BC ratio was obtained with integrated weed management practice (12126 kg ha^{-1} Rs 1, 70,295 ha^{-1}, Rs 1, 02, 625 ha^{-1} and 2.51) for *kharif* aerobic and transplanted rice (bispyribac sodium 25 g ha^{-1} as early PoE at 15 DAT/2-3 weed leaf stage fb HW at 40 DAT) fb *rabi* maize (atrazine 1000 g ha^{-1}+paraquat 600 g ha^{-1} as PE fb HW at 40 DAS). This was followed by practicing of chemical methods in sequence for *kharif* rice and *rabi* maize (11123 kg ha^{-1} Rs 1, 56, 210 ha^{-1}, Rs 90,705 ha^{-1} and 2.38). Incurring of 10.85% and 7.9% money towards weed control either through integrated weed management practices or sequential application of herbicides increased the system productivity by 53.46 and 49.26% respectively.

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