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Research Article

Yield Attributes and Yield of Rice (*Oryza sativa*) as Influenced by Tillage and Weed Management Practices Under Conservation Agriculture

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Abstract

The Present study was carried out to evaluate the effect of different tillage methods and weed management practices on yield and yield attributes of rice in rice-maize-greenmanure system of conservation agriculture. The present study is from the 5th year of experiment. A field experiment was conducted during *kharif*-2018, at AICRP on Weed Management, College of Agriculture, Professor JayashankarTelanagana State Agricultural University, Hyderabad. The experiment was laid out in split plot design with five main plots, three sub-plots and three replications. The main plots included five tillage practices such as i) conventional tillage transplanted rice *fb* conventional tillage maize, ii) Conventional tillage transplanted rice *fb* zero tillage maize, iii) conventional tillage direct seeded rice *fb* conventional tillage maize, iv) zero tillage direct seeded rice *fb* zero tillage maize with residue cover and v) zero tillage direct seeded rice with residue cover fb zero tillage maize with residue cover and sub plots including three weed management practices i.e., chemical weed management with recommended herbicides, Integrated Weed Management (IWM) and unweeded control. Transplanted rice recorded higher number of panicles, panicle length, panicle weight, test weight and lowest sterility percentage over direct seeded rice. Integrated weed management (IWM) recorded significantly superior number of panicles and panicle length whereas in terms of panicle weight and test weight, IWM and chemical weed management were comparable to each other. Significantly higher grain and straw yield was observed with transplanted rice. Within the direct seeded rice, conventional tillage direct seeded rice recorded superior grain and straw yield. Among the weed management practices IWM recorded significantly higher grain and straw yield.

Keywords: Rice; Tillage; Weed Management; Conservation Agriculture; Direct Seeded Rice; Yield; Yield Attributes

Abbreviations

TPR: Transplanted Rice; DSR: Direct Seeded Rice; CT: Conventional Tillage; ZT: Zero Tillage; PE: Pre-Emergence; PoE: Post-Emergence; IWM: Integrated Weed Management; HW: Hand Weeding, +R: Residue Cover

Introduction

The area under rice cultivation in India accounts for 45.07 M ha with an average production of 122.27 M t with productivity of 2.71 t ha^{-1}. Out of the total area of rice grown 85% is transplanted rice and 12% is under upland direct seeded rice. In Telangana, total area

under rice cultivation is 2.31 M ha with production of 7.7 M tonnes and productivity of 3.32 t ha^{-1} during 2020-21 [1]. In India, rice is cultivated by transplanting 25-30 days old seedlings in the puddled field. The advantage of puddling is effective weed control, reduces percolation, improves nutrient availability by creating anaerobic conditions and facilitates easy seedling establishment. Besides these advantages, the main disadvantage is higher requirement of labour, water etc. and this led to a substantial rise in the production cost [17]. These factors necessitated several researchers to study the possibility of rice cultivation under irrigated dry conditions.

Direct seeded rice (DSR) can be sown under conventional tillage or under zero-till conditions. The main advantage is it requires less labor and fuel compared to conventional tillage systems. When rainfall at planting time is highly variable, direct seeding may help reduce the production risk [13]. Weed control is a challenge in DSR systems because of the diversity and severity of weed infestation. [3] have observed that in direct seeded rice yield reduction was 36.7% than transplanted rice.

In Tripura, [21] have noticed that there is no significant difference in the yield parameters i.e., productive tillers m^{-2}, the number of grains per panicle and 1,000 grain weight among different tillage practices but as the duration advanced yield under zero tillage direct seeded rice has increased compared to conventional tillage.

"Conservation agriculture (CA) is a resource saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving environment" [4]. The main principles of conservation agriculture include reduced tillage systems, permanent soil cover, effective use of crop rotations including intercrops and cover crops and reducing the fallow period. In low intensity tillage or no tillage associated with conservation agriculture weeds are the major biological constraints towards the large scale adoption of it [20]. One of the ways to control weeds is to use the selective herbicides. Thus, post-emergence spray of such herbicides will help to manage weeds. Hence, in order to achieve maximum production from low tillage systems or direct seeded rice systems proper control of weeds is necessary to achieve acceptable profits.

The present investigation is carried out to know the effect of different tillage and weed management practices on yield and yield attributes of rice in rice-maize-green manure system of conservation agriculture.

Materials and Methods

Site description

A field experiment was conducted during *kharif*-2018, at AICRP on Weed Management, College of Agriculture, Professor Jayashankar Telanagana State Agricultural University, Hyderabad, Telangana, India (17°19' N and 78°24' E). The field was under conservation agriculture with rice-maize-green manure system since 2014 (5 years). The present study was in fifth year of experimentation in rice.

Treatment details

The experiment was laid out in split plot design with three replications. Main plot treatments were five tillage practices and sub-plot treatments were three weed management practices. Five tillage practices consists of conventional tillage transplanted rice *fb* conventional tillage maize in rabi and fallow in summer (CT - CT of TPR) (T_1), conventional tillage transplanted rice *fb* zero tillage maize in rabi and green manure (*Sesbania*) in summer(CT - ZT of TPR) (T_2), conventional tillage direct seeded rice *fb* conventional tillage maize in *rabi* and green manure in summer(CT - CT of DSR) (T_3), zero tillage direct seeded rice *fb* zero tillage maize in *rabi* and green manure in summer (ZT - ZT of DSR) (T_4) and zero tillage direct seeded rice with residue cover *fb* zero tillage maize with residue cover in *rabi* and green manure in summer (ZT+R - ZT+R of DSR) (T_5). Weed management practices included chemical weed management *i.e.,*Bensulfuron methyl (0.6%) + pretilachlor (6%) 0.66 kg ha^{-1} as PE at 3-5 DAT *fb* bispyribac sodium 10% SC 25g ha-1 as PoE at 2-3 weed leaf stage for transplanted rice whereas Pendimethalin 30% EC 1000g ha^{-1} as PE *fb*bispyribac sodium 10% SC 25g ha^{-1} as PoE at 2-3 weed leaf stage for direct seeded rice (W_1), Integrated weed management (IWM) *i.e.,*Bispyribac sodium 10% SC 25 g ha^{-1} as early PoE at 2-3 weed leaf stage *fb* HW at 40 DAT (W_2) and Unweeded control (W_3). For residue cover treatments previous season green manure was spread as mulch in between rows of current season crop.

Crop management

Rice variety MTU-1010 was sown with a seed rate of 50 kg ha^{-1} for transplanted rice and 70 kg ha^{-1} for dry direct seeded rice, spacing of 20 X 10 cm was followed. 30 days old rice seedlings were transplanted in the main field for transplanted rice. For dry direct seeded rice, seeds were directly sown in plots by following line sowing on the same day of nursery raising for transplanted rice.

Recommended fertilizer dose 120 kg N + 60 kg P + 40 kg K to transplanted rice and 100 kg N + 50 kg P + 50 kg K to direct seeded rice was applied. Remaining agronomic practices were carried out as per the recommendations.

For test weight random grain samples were taken from the produce of each net plot. Out of the samples, 1000 grains were counted from each net plot and same were dried and weighed, the weight was considered as test weight.

Observations on yield attributes *i.e.,* no. of panicles, panicle weight, panicle length, test weight and yield *i.e.,* grain and straw yield were recorded at the time of harvest to draw valid conclusions.

Results and Discussion

Yield attributes

Number of panicles, Panicle length, Panicle weight as well as Test weight of rice are significantly influenced by tillage and weed management practices. Transplanted rice recorded more number of panicles $m^{-2,}$ longer panicle length, higher panicle weight and higher test weight compared to direct seeded rice irrespective of the tillage practices (Table 1). In TPR, CT - CT system recorded yield attributes on par with CT - ZT system. In DSR, CT - CT system Number of panicles, Length of Panicle and Panicle weight are superior over zero tillage system with and without residue cover. Whereas test weight of all tillage practices of DSR are comparable to each other.

Treatments		Yield attributes			
Tillage	**Weed Management**	**Panicles (m^{-2})**	**Panicle length (cm)**	**Panicle weight (g)**	**Test weight (g)**
T_1- CT (TPR) - CT (maize)	W_1	315.0	19.61	2.60	21.01
	W_2	325.0	18.69	2.70	21.41
	W_3	213.9	19.27	2.38	20.38
T_2- CT (TPR) - ZT (maize) - GM	W_1	310.7	19.30	2.48	20.91
	W_2	321.3	20.03	2.71	21.29
	W_3	200.8	19.73	2.26	20.79
T_3- CT (DSR) - CT (maize) - GM	W_1	209.3	15.71	1.14	16.93
	W_2	224.0	14.43	1.19	17.40
	W_3	146.0	12.11	0.71	16.13
T_4- ZT (DSR) - ZT (maize) - GM	W_1	141.3	14.91	0.96	15.72
	W_2	152.0	14.72	0.94	16.87
	W_3	81.3	11.55	0.63	15.64
T_5- ZT+R (DSR)- ZT+R (maize) - GM	W_1	153.0	13.14	0.99	16.86
	W_2	160.0	12.70	0.99	17.22
	W_3	88.7	10.65	0.64	15.54
Mean					
Tillage (Main plots)					
T_1 - CT (TPR) - CT		284.6	19.19	2.56	20.93
T_2 - CT (TPR) - ZT - GM		277.6	19.69	2.48	21.00
T_3 - CT (DSR) - CT - GM		193.1	14.08	1.01	16.82
T_4 - ZT (DSR) - ZT - GM		124.9	13.73	0.84	16.08
T_5 - ZT+R (DSR) - ZT+R - GM		133.9	12.16	0.87	16.54
Weed management (Sub plots)					

W_1 - Chemical management	225.9		16.54		1.63		18.29	
W_2 - IWM	236.5		16.11		1.71		18.84	
W_3 - Unweeded control	146.1		14.66		1.32		17.70	
	SE (m) ±	CD (P = 0.05)	SE (m) ±	CD (P = 0.05)	SE (m) ±	CD (P = 0.05)	SE (m) ±	CD (P = 0.05)
Tillage	4.69	15.52	0.40	1.31	0.04	0.15	0.23	0.77
Weed management	2.83	8.41	0.36	1.07	0.06	0.17	0.20	0.60
SUB AT SAME LEVEL OF MAIN	8.12	19.77	0.68	NS	0.08	NS	0.40	NS
MAIN AT SAME LEVEL OF SUB	6.98	21.79	0.77	NS	0.12	NS	0.43	NS

Table 1: Yield attributes of rice as influenced by tillage and weed management in rice under conservation agriculture (kharif, 2018).

CT: Conventional Tillage; TPR: Transplanted Rice; DSR: Direct Seeded Rice; ZT: Zero Tillage; R: Residue Cover; GM: Green Manure (*Sesbania*).

Among the weed management practices, IWM recorded significantly higher number of panicles, weight and more test weight followed by chemical weed management. Highest panicle length was observed in chemical weed management which was on par with IWM. The unweeded control found to be inferior in all yield attributes.

Interaction effect of tillage and weed management practices was found to be significant in number of panicles. In length of panicle, panicle weight and test weight interaction of tillage and weed management is non-significant.

Lower number of panicles in direct seeded rice could be due to uneven depth of sowing, higher infestation of weeds. In transplanted rice, favorable soil conditions, sufficient space and moisture availability might have resulted in higher number of panicles. Timely control of weeds in IWM and chemical weed management reduced the weed density and might have facilitated the crop plants to have sufficient space, light, nutrient and moisture resulting in production of higher number of panicles than the unweeded control. This finding is in conformity with that of [12,17].

Higher panicle length in TPR might be due to increased nutrient availability under submerged conditions, weed suppression and favorable conditions for growth and better translocation of photosynthates to panicle which ultimately resulted in length of panicle. Decreased panicle length under DSR in conventional as well as in zero tillage could be due to moisture stress at critical stages such as panicle initiation and flowering, iron deficiency and heavy weed competition. Similar results were reported by [5,15].

Higher panicle weight as well as test weight under transplanted rice was due to the fact that better translocation of nutrients due to favorable soil conditions resulted in production of higher number as well as effective filling of grains which resulted in increase of panicle weight and test weight. In conventional tillage direct seeded rice better soil conditions and good establishment of plants resulted in panicle weight and test weight greater than zero tillage direct seeded rice.Under direct seeded zero tillage rice lesser number of grains and higher sterility percentage lead to the decrease in panicle weight and test weight. In unweeded control higher weed competition hindered proper uptake of nutrients by rice which resulted in higher sterility percentage and lesser number of grains which might lead to decrease of panicle weight as well as test weight. Similar findings were reported by [2,8,9].

Grain Yield (kg ha^{-1})

Grain yield depicts the amount of dry matter converted as economic produce which is always influenced by many crop production aspects and in particular weed infestation. Rice grain yield was significantly influenced by tillage and weed management practices (Table 2). TPR recorded significantly higher grain yield compared to DSR. Among the tillage practices, significantly higher grain yield was recorded in TPR under CT - CT system (4765 kg ha^{-1}) which was comparable to grain yield of CT - ZT system (4625 kg ha^{-1}). In DSR, CT - CT system recorded significantly superior grain yield (1789 kg ha^{-1}) than zero tillage system. DSR under zero tillage with or without residue cover recorded significantly lower grain yield. Among the weed management practices, significantly highest grain yield was recorded under IWM (3339 kg ha^{-1}) which was 8.8% higher than chemical weed management (3067 kg ha^{-1}). Unweeded control reported the lowest grain yield (1453 kg ha^{-1}). IWM and chemical weed management resulted 129.8% and 111.08% increase of yield respectively over unweeded control.

Treatments		Grain yield (kg ha$^{-1)}$		Straw yield (kg ha^{-1})		Harvest Index (%)	
Tillage	Weed Management						
T_1- CT (TPR) - CT (maize)	W_1	5397		7078		43.28	
	W_2	5752		7487		43.42	
	W_3	3145		4510		41.09	
T_2- CT (TPR) - ZT (maize) - GM	W_1	5234		6869		43.24	
	W_2	5690		7437		43.34	
	W_3	2951		4233		41.11	
T_3- CT (DSR) - CT (maize) - GM	W_1	2236		3365		40.03	
	W_2	2509		3630		40.86	
	W_3	622		1057		37.36	
T_4- ZT (DSR) - ZT (maize) - GM	W_1	1125		1652		40.47	
	W_2	1313		1914		40.52	
	W_3	252		552		31.76	
T_5- ZT+R (DSR)- ZT+R (maize) - GM	W_1	1343		1955		40.74	
	W_2	1431		2064		41.14	
	W_3	293		607		32.84	
MEAN							
Tillage (Main plots)							
T_1 - CT (TPR) - CT		4,765		6,340		42.60	
T_2 - CT (TPR) - ZT - GM		4,625		6,176		42.56	
T_3 - CT (DSR) - CT - GM		1,789		2,670		39.41	
T_4 - ZT (DSR) - ZT - GM		896		1,375		37.58	
T_5 - ZT+R (DSR) - ZT+R - GM		1,022		1,536		38.24	
Weed Management (Sub plots)							
W_1 - Chemical Management		3067		4195		41.55	
W_2 - IWM		3339		4490		41.86	
W_3 - Unweeded control		1453		2174		36.83	
		SE (m)±	CD (P = 0.05)	SE (m)±	CD (P = 0.05)	SE (m) ±	CD (P = 0.05)
Tillage		76.9	254.6	94.3	312	0.89	2.93
Weed Management		63.7	189.2	78.5	233	0.66	1.95
SUB AT SAME LEVEL OF MAIN		133.2	437.8	163.4	540	1.53	NS
MAIN AT SAME LEVEL OF SUB		139.4	428.5	171.6	527	1.49	NS

Table 2: Grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) and harvest index of rice as influenced by tillage and weed management (*kharif,* 2018).

CT: Conventional Tillage; TPR: Transplanted Rice; DSR: Direct Seeded Rice; ZT: Zero Tillage; R: Residue Cover; GM: Green Manure (*Sesbania*)

Interaction effect of tillage and weed management practices on grain yield was found to be significant with highest grain yield obtained under IWM of transplanted rice under CT - CT system (5752 kg ha^{-1}). Lowest yield was recorded with combination of unweeded control in zero tillage with or without residues.

Higher grain yield under conventional puddled TPR over DSR might be due to availability of sufficient space to individual plants in transplanted rice compared to direct seeded rice resulting in higher number of effective tillers m^{-2}, higher number of grains per panicle and lower sterility percentage owing to better soil conditions and increased nutrient availability. All these factors together helped in better translocation of nutrients from source to sink. These results are in tune with findings of [6,19]. Lowest yields under zero tillage conditions could be due to adverse soil conditions such as soil compaction, weed competition, presence of weed seeds near soil surface and slow nitrogen mineralization rates which might have caused relatively lower biomass accumulation. These results were in conformity with the findings of [10]. Yield under zero tillage with residue cover was 14% more than zero tillage without residue cover which might that presence of residue cover helps in addition of organic matter to soil and suppress development of weeds to some extent by obstructing sunlight reaching the soil.

Higher yield under IWM might be due to effective control of weeds which produced more panicles m^{-2} and grains panicle^{-1} which resulted in more yield. Lesser grain yield under chemical weed management than IWM might be due to presence of late emerged weeds after herbicide treatment. These results are in agreement with the findings of [11,14]. Combined effect of favorable soil conditions under transplanted rice and effective weed management helped in better nutrient availability to crop and resulted in higher yields. Similar results were reported by [18].

Straw yield (kg ha^{-1})

Straw yield was significantly influenced by both tillage and weed management practices (Table 2). Among the tillage practices, significantly higher straw yield was recorded in CT - CT system (6340 kg ha^{-1}) which was on par with CT - ZT system (6176 kg ha^{-1}) of TPR. In DSR, CT - CT system recorded significantly superior straw yield (2670 kg ha^{-1}) than zero tillage. Significantly lower straw yield was recorded under zero tillage with and without residue of DSR. Among the weed management practices significantly higher straw yield was obtained in IWM (4490 kg ha^{-1}) followed by chemical weed management (4195 kg ha^{-1}). Unweeded control has recorded significantly lowest straw yield. Interaction effect of tillage and weed management practices was significant with highest straw yield obtained from the combination of IWM of CT - CT system and it was comparable to CT - ZT system of TPR. Lowest straw yield was obtained in all tillage practices of DSR combined with unweeded control. Straw yield in IWM and chemical weed management was found to be on par with each other.

Higher straw yield under transplanted system could be due to favorable soil conditions which helped in better nutrient uptake and increased growth and development with more number of tillers and dry matter production. Similar results were reported by [17]. Effective control of weeds in IWM and chemical weed management compared to unweeded control which could have resulted in more number of tillers, plant height, dry matter production and ultimately higher straw yield. Similar findings were reported by [7].

Harvest Index (%)

Harvest index denotes the translocation of photosynthates from source to sink. With respect to tillage practices, harvest index was significantly higher under CT - CT (42.60%) and in CT - ZT systems (42.56%) of transplanted rice both were on par with each other (Table 2). In direct seeded rice, CT - CT (39.41%) recorded significantly superior harvest index than the zero tillage direct seeded rice. Lowest harvest index was obtained under zero tillage with and without residue cover.

Among the weed management practices maximum harvest index was observed in IWM (41.86%) and on par with chemical weed management (41.55%). Unweeded control has recorded the lowest harvest index. Better control of weeds under IWM and chemical weed control helped in attaining more biological and economical yield which was also reported by [16]. Interaction of tillage and weed management practices was non-significant.

Conclusion

Transplanted rice proved to be superior in terms of yield attributes compared to direct seeded rice irrespective of method of tillage adopted in direct seeded rice. Within direct seeded rice, conventional tillage direct seeded rice was superior over zero tillage direct seeded rice. Integrated Weed Management with one post-emergence herbicide application *fb* hand weeding was best compared to chemical weed management. Integrated Weed Management combined with conventional tillage transplanted rice *fb* conventional tillage maize or conventional tillage transplanted rice *fb* zero tillage maize in Transplanted rice proven to be the best practice for higher grain and straw yield.

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