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Original Research Article

Interaction of Irrigation and Weed Control Options on Weed Management and Yield of Dry Sown Rice (*Oryza sativa* L.)

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A B S T R A C T

A field experiment was carried out during the year 2016-17 at Agricultural Research Station, Jangamaheshwarapuram. Guntur, Andhra Pradesh to study the growth and yield attributes of dry sown rice (*oryza sativa* L.) . The treatments consisted of four irrigation schedules (I_1-1.5 IW/CPE ratio, I_2-2.0 IW/CPE ratio, I_3-3.0 IW/CPE ratio and I_4-continuous submergence from 25 DAS) assigned to main plots and five weed management treatments (W_1-control, W_2 -hand weeding at 20 DAS and 35 DAS, W_3 - pendimethalin @ 1 kg a.i. ha^{-1} (PE) *fb.* hand weeding at 25 DAS, W_4 - pendimethalin @ 1kg a.i. ha^{-1} (PE) *fb.* bispyribac sodium 25 g a.i. ha^{-1} at 15- 20 DAS, W_5 - pendimethalin @ 1 kg a.i. ha^{-1} (PE) *fb.* bispyribac sodium 25 g a.i. ha^{-1} at 15 – 20 DAS *fb.* metsulfuron methyl + chlorimuron ethyl 8 g a.i. ha^{-1} at 35 – 40 DAS as sub plots. The maximum grain yield produced under continuous submergence (I_4) was comparable with that of 3.0 IW/CPE ratio (I_3). Difference between irrigation levels scheduled at IW/CPE ratio 1.5 (I_1) and 2.0 (I_2) was not significant in increasing the grain yield. Similarly, the straw yield produced by irrigation at I_3 (3.0 IW/CPE) found significantly superior to other irrigation levels (I_2 and I_1). The maximum harvest index was computed with irrigation with 1.5 IW/CPE ratio. Among the herbicide control treatments pre-emergence application of pendimethalin + one HW at 25 at DAS (W_3) observed with the lowest weed density and drymatter compared with the rest of the treatments. It was closely followed by hand weeding twice at 20 and 35 DAS (W_2) and found superior over other treatments at 30 DAS. Alternatively at 60 and 90 DAS two hand weeding found significant with lower weed density and dry matter compared to all other treatments. Similarly pendimethalin with one hand weeding (W_3) found superior with less weed density and drymatter over W_4 and W_5 treatments. Pendimethalin + one HW at 25 DAS (W_3) recorded higher weed control efficiency (52.4%) followed by (W_2) two hand weedings at 20 and 35 DAS (41.7%). Lowest weed control efficiency was recorded in W_4 when compared to other treatments at 30 DAS. Hand weeding twice at 20 and 35 DAS (W_2) recorded with significantly higher weed control efficiency of 63.8 % at 60 DAS and 66.6 % at 90 DAS over other weed management options which was closely followed by pendimethalin + hand weeding (W_3). Though manual weeding is the most effective weed control method with higher WCE, integration of manual weeding with pre-emergence herbicide or sequential application of herbicides might be the alternative to control weeds in dry sown rice, wherein, 30- 40 % of WCE is observed in these treatments.

Keywords

Dry sown rice, IW/CPE ratio, Hand weeding, Weed control efficiency, Weed density, Weed index

Introduction

Rice (*Oryza sativa* L.) is the most important, staple and extensively grown food crop in India, occupying an area of 44.1 million hectares with a production of 105.5 million tonnes and productivity of 2500 kg ha^{-1}. Andhra Pradesh is the third largest rice growing state after West Bengal and Uttar Pradesh in India, where it is cultivated mainly as transplanted crop. It is grown in an area of 25.84 lakh hectares with a production of 9.18 million tonnes and productivity of 3.7 t ha^{-1} (Agriculture action plan 2015-16, Department of Agriculture, A.P).

In the present scenario, looming scarcity of water and labour due to population explosion and urbanization, poses a serious threat to sustainability of traditional methods of rice production. Direct-seeded rice (DSR) can address these problems, as it is economically feasible and technically viable alternative to transplanted rice, as cost of cultivation was 15% less in DSR. Moreover, technical efficiency of DSR was found to be 92% whereas it was 87% in case of TPR. It was observed that farmers could save 55% human labour, 10% machine labour and 33% irrigation water in DSR compared to transplanted rice (Mehala *et al*., 2016).

In India, 7.1 million ha rice is under direct seeding (Moorthy and Saha, 2002). In direct seeding, there are two methods (dry and wet seeding) based on the physical condition of seedbed and seed (pre germinated or dry). Direct seeding of rice however, offers certain advantages timely sowing, less drudgery, early crop maturity by 7-10 days, high tolerance to water deficit, low production cost, less methane emission etc., It also preserves natural resources especially underground water and maintains physical properties of soil. Whenever, hairline cracks appear on the soil, it is the criteria for irrigation scheduling in DSR. However, exact time interval for irrigation depends on particular soil type and evaporation demand in the atmosphere at that place.Weeds are the major hurdle for cultivation of direct-seeded rice. Weeds compete with direct-sown rice and reduce yield upto 30.17 per cent (Singh *et al*., 2005). The simultaneous emergence of weeds with rice seedlings makes weed control in dry sown rice a complex phenomenon due to over lapping of planting and need for weed control. Manual weeding in direct-seeded rice fields is labour oriented and expensive. The traditional hand weeding practice needs to be substituted by herbicides to control weeds timely and economically.

Materials and Methods

A field trail was conducted during *kharif*, 2016-17, experiment was laid out in the B - block of Agricultural Research Station, Jangamaheswarapuram, Gurazala, Guntur district, Andhra Pradesh. The experimental site was situated at an altitude of 349 m above mean sea level, 16^0 31' Northern latitude and 79^0 38' Eastern longitude. It is located in the Krishna Agro-climatic zone of Andhra Pradesh. The experiment was laid out in split plot design with irrigation schedules in main plots (I_1-1.5 IW/CPE ratio, I_2-2.0 IW/CPE ratio, I_3-3.0 IW/CPE ratio and I_4- continuous submergence from 25 DAS) and weed management options in sub plots using three replications. W_1-control, W_2 - hand weeding at 20 DAS and 35 DAS, W_3 - pendimethalin @ 1 kg a.i. ha^{-1} (PE) *fb*. hand weeding at 25 DAS, W_4 - pendimethalin @ 1kg a.i. ha^{-1} (PE) *fb*. bispyribac sodium 25 g a.i. ha^{-1} at 15- 20 DAS, W_5 - pendimethalin @ 1 kg a.i. ha^{-1} (PE) *fb*. bispyribac sodium 25 g a.i. ha^{-1} at 15 – 20 DAS *fb*. metsulfuron methyl + chlorimuron ethyl 8 g a.i. ha^{-1} at 35 – 40 DAS as sub plots. The rice variety BPT 5204 (Samba Mashuri) was sown on 2nd

August 2016. A total of 905.7 mm rainfall received during crop growth period. Sowing was done manually by dibbling. The irrigation water was applied on the basis of pan evaporation data using (USWB class A pan evaporimeter). Pendimethalin @ 1kg a.i. ha^{-1} was applied immediately after sowing as pre-emergence application; bispyribac sodium @ 25g a.i. ha^{-1} was applied as post emergence application at 15-20 DAS and metsulfuron methyl + chlorimuron ethyl @ 8 g a.i. ha^{-1} at 35-40 DAS. Hand weeding operation was also carried at 20, 25 and 35 DAS as per treatment. The data on weed density, weed flora, weed dry matter and weed control efficiency were recorded as per standard statistical procedures adopting Gomez and Gomez (1984) standard procedures.

Results and Discussion

Effect of irrigation and weed management options

The data pertaining to total weed density (No m^{-2}) and weed drymatter at 30, 60 and 90 DAS is presented in Tables 1 and 2, revealed that weed density and drymatter were affected by irrigation schedules and weed management treatments; whereas, their interaction influenced the weed density at 30 and 60 DAS only and at 90 DAS weed density and drymatter were affected by weed management treatments only.

Continuous submergence of irrigation schedule (I_4) recorded significantly lower weed density (4.02) which was comparable with 3.0 (I_3) and 2.0 (I_2) IW/CPE ratios at 30 DAS. Whereas, in case of weed drymatter, continuous submergence (I_4) treatment smothered the weeds significantly over rest of the irrigation levels. Irrigation schedule (I_1) 1.5 IW/CPE ratio recorded significantly the maximum weed density and drymatter over rest of the treatments all the stages of crop growth. Whereas, significant differences in weed density were not observed between continuous submergence and 3.0 IW/CPE ratio and found significantly lower compared to 2.0 and 1.5 IW/CPE ratios at 60 and 90 DAS. Similar trend as that of weed density was observed except at 60 DAS where I_4 found superior to other levels of irrigation in reducing weed dry matter.

Water, as flooding has been known as the most effective weed control tool in rice fields. However, under direct-seeded rice systems, weeds are the number-one biological constraint to the production and adoption of DSR. The risk of greater crop yield losses due to weed competition in direct-seeded rice systems than in transplanted rice is mainly because of the absence of the seedling size difference between rice plants and weeds and the absence of the suppressive effect of standing water on weed emergence and growth of crop at emergence time (Bhagirath Singh Chauhan, 2012). Among the herbicide control treatments pre-emergence application of pendimethalin + one HW at 25 at DAS (W_3) observed with the lowest weed density and drymatter compared with the rest of the treatments. It was closely followed by hand weeding twice at 20 and 35 DAS (W_2) and found superior over other treatments at 30 DAS. Alternatively at 60 and 90 DAS two hand weeding found significant with lower weed density and dry matter compared to all other treatments. Similarly pendimethalin with one hand weeding (W_3) found superior with less weed density and drymatter over W_4 and W_5 treatments. Apart from the superiority of two hand weedings, Thimmegowda *et al*.(2009), Pandey *et al*. (2009) and Walia *et al*. (2008) also supported the effect of one pre emergence herbicide application followed by a hand weeding in aerobic rice. On the other hand, application of three

herbicides (W_5) recorded significantly lower weed density and drymatter over application of two herbicides (W_4) at all the stages of crop growth.

However, it was the treatment W_2 with two hand weedings found with significantly lesser weed density presented in Table 1 at 60 DAS and drymatter presented in Table 1 and 2. Data on weed control efficiency at 30, 60 and 90 DAS are presented in Table 3. Hand weeding twice at 20 and 35 DAS (W_2) recorded with significantly higher weed control efficiency of 63.8 % at 60 DAS and 66.6 % at 90 DAS over other weed management options which was closely followed by pendimethalin + hand weeding (W_3). While, sequential application two herbicides (W_4) recorded significantly the lowest weed control efficiency of 21.8% when compared to other treatments at 60 DAS. But at 90 DAS W_4 recorded the lowest weed control efficiency of 30.7% when compared to other treatment, though the difference between W_4 and W_5 are not significant. Though manual weeding is the most effective weed control method with higher WCE, integration of manual weeding with pre-emergence herbicide or sequential application of herbicides might be the alternative to control weeds in dry sown rice, wherein, 30- 40 % of WCE is observed in these treatments. Similar observations are also reported by Ramana *et al*. (2007), Pandey *et al*. (2009) and Sreedevi *et al*. (2016).

The data on weed index (%) is presented in Table 3, The weed index (WI) is the per cent reduction in crop yield due to the presence of weeds in comparison with weed free check. All the weed control treatments recorded significantly lower weed index than weed control (W_1) except application of pendimethalin + bispyribac sodium (W_4). Application of pendimethalin + hand weeding (W_3) recorded significantly the lowest weed index (19.2 %) on a par with that of sequential application of three herbicides (21%) over application of two herbicides (W_4) and weedy check (W_1). Weed index indicates the yield loss over weed free plot. Hence, application of Pre-emergence herbicide along with manual weeding (W_3) or sequential application of three herbicides (W_5) with lower weed index found to be as alternative weed management options in dry sown rice. These views are in corroboration with the findings of Ramana *et al*. (2007), Sunil *et al*. (2010) and Jaya Suria *et al*.(2011).

However, it was the treatment W_2 with two hand weedings found with significantly lesser weed density presented in Table 1 at 60 DAS and drymatter presented in Table 2. Across all the irrigation schedules over rest of weed management options. It was closely followed by the treatment W_3 over other herbicide application treatments (W_4 and W_5) at all the levels of irrigations. Though the weed density with 3 herbicides sequential application seems lower compared to two herbicides application (W_4), the difference was not significant across irrigations scheduled at I_4, I_3 and I_1. Alternatively in case of weed drymatter these differences were significant across the irrigation levels based on IW/CPE only.

Effect on yield of dry sown rice

Number of filled grains per panicle was influenced by the effect irrigation and weed management options presented in Table 4, continuous submergence of irrigation from 25 DAS (I_4) produced maximum number of filled grains panicle^{-1} (122.5) compared to that of rest of the irrigation levels. However, the number of filled grains panicle^{-1} recorded with irrigation at 3.0 IW/CPE ratios (I_3) was found comparable with that of continuous submergence (I_4).

Table.1 Weed density per m^2 in dry sown rice influenced by irrigation schedules and weed management options at different stages of crop growth

Treatments	Weed density per m^2		
	30 DAS	**60 DAS**	**90DAS**
Irrigation schedules			
I_1 -1.5 IW /CPE ratio	2.60 (6.35)	3.06 (9.86)	3.60 (13.3)
I_2 -2.0 IW /CPE ratio	2.34 (5.55)	2.9 (9.1)	3.40 (12.5)
I_3 - 3.0 IW /CPE ratio	2.19 (4.66)	2.7 (7.5)	3.19 (11.0)
I_4 -Continuous submergence	2.10 (4.20)	2.6 (6.9)	2.18 (8.9)
SEm±	**0.07**	**0.04**	**0.03**
CD (p=0.05)	**0.26**	**0.16**	**0.11**
CV %	**12.6**	**6.4**	**3.6**
Weed management options			
W_1 –Control	3.09 (9.19)	3.79 (14.1)	4.30 (18.5)
W_2 -2 HW at 20 & 35 DAS	2.14 (4.02)	1.40 (1.40)	1.49 (1.80)
W_3 -PM + HW at 25 DAS	1.50 (1.75)	2.10 (3.90)	2.69 (6.80)
W_4 -PM + Bis. Sodium	2.14 (4.33)	3.59 (12.8)	4.00 (15.8)
W_5 -PM + Bis. sodium + Metsulfuron &Chlorimuron	2.68 (6.66)	3.16 (9.58)	3.79 (14.2)
SEm±	**0.04**	**0.04**	**0.05**
CD (p=0.05)	**0.13**	**0.14**	**0.15**
CV%	**6.7**	**6.1**	**5.3**
Interaction (I×W)	**S**	**S**	**NS**

The data are arc sine transformed. The figures in parenthesis are original values

Table.2 Weed drymatter (g m^{-2}) in dry sown rice influenced by irrigation schedules and weed management options at different stages of crop growth

Treatments	Weed drymatter (g m^{-2})		
	30 DAS	**60 DAS**	**90DAS**
Irrigation schedules			
I_1 -1.5 IW /CPE ratio	3.26 (11.1)	3.85 (15.1)	3.93 (15.8)
I_2 -2.0 IW /CPE ratio	3.18 (10.6)	3.51 (12.3)	3.82 (14.9)
I_3 - 3.0 IW /CPE ratio	3.23 (10.9)	3.26 (10.7)	3.70 (14.0)
I_4 -Continuous submergence	2.36 (5.25)	2.84 (8.16)	3.52 (13.0)
SEm±	**0.11**	**0.03**	**0.009**
CD (p=0.05)	**0.40**	**0.12**	**0.03**
CV %	**15.0**	**3.9**	**1.2**
Weed management options			
W_1 –Control	4.03 (16.3)	4.25 (17.7)	4.78 (22.4)
W_2 -2 HW at 20 & 35 DAS	2.84 (7.79)	1.97 (3.43)	2.51 (3.60)
W_3 -PM + HW at 25 DAS	1.96 (3.67)	3.23 (10.1)	3.80 (13.8)
W_4 -PM + Bis. Sodium	2.68 (7.30)	3.83 (14.5)	4.03 (16.5)
W_5 -PM + Bis. sodium + Metsulfuron &Chlorimuron	3.54 (12.3)	3.53 (12.3)	4.04 (15.9)
SEm±	**0.06**	**0.07**	**0.04**
CD (p=0.05)	**0.18**	**0.19**	**0.12**
CV%	**7.2**	**6.7**	**3.9**
Interaction (I×W)	**S**	**S**	**NS**

The data are arc sine transformed. The figures in parenthesis are original values

Table.3 Weed control efficiency (%) in dry sown rice influenced by irrigation schedules and weed management options at different stages of crop growth and weed index

Treatments	Weed control efficiency (%)			
	30 DAS	60 DAS	90DAS	Weed index
Irrigation schedules				
I_1 -1.5 IW /CPE ratio	32.7 (43.5)	33.1 (35.4)	32.3 (33.7)	16.4
I_2 -2.0 IW /CPE ratio	32.0 (41.5)	22.7 (22.3)	32.9 (34.6)	21.1
I_3 - 3.0 IW /CPE ratio	32.9 (44.0)	29.9 (31.9)	33.6 (35.7)	19.5
I_4 -Continuous submergence	27.8 (31.8)	40.2 (46.9)	35.3 (37.8)	16.2
SEm±	**0.81**	**2.18**	**0.36**	**1.41**
CD (p=0.05)	**2.7**	**7.5**	**1.3**	**NS**
CV %	**9.9**	**26.8**	**4.2**	**30.0**
Weed management options				
W_1 –Control	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	27.2
W_2 -2 HW at 20 & 35 DAS	41.7 (53.4)	63.8 (80.4)	66.6 (84.0)	0.0
W_3 -PM + HW at 25 DAS	52.4 (83.8)	40.5 (42.5)	38.2 (38.3)	19.2
W_4 -PM + Bis. Sodium	36.6 (41.7)	21.8 (18.2)	30.7 (26.2)	24.2
W_5 -PM + Bis. sodium + Metsulfuron &Chlorimuron	26.2 (22.0)	31.1 (29.5)	32 (28.7)	21.0
SEm±	**1.19**	**1.79**	**1.02**	**1.59**
CD (p=0.05)	**3.4**	**5.1**	**2.9**	**4.6**
CV%	**13.1**	**19.6**	**10.5**	**30.2**
Interaction (I×W)	**NS**	**S**	**NS**	**NS**

The data are arc sine transformed. The figures in parenthesis are original values

Table.4 Yield parameters in dry sown rice influenced by irrigation schedules and weed management options

Treatments	Filled grains	Grain yield (kg ha^{-1})
Irrigation schedules		
I_1 -1.5 IW /CPE ratio	111.6	5431
I_2 - 2.0 IW /CPE ratio	113.0	5632
I_3 -3.0 IW /CPE ratio	116.9	6142
I_4 -Continuous submergence	122.5	6307
SEm±	**2.06**	**113.01**
CD (p=0.05)	**7.1**	**391**
CV %	**6.8**	**7**
Weed management options		
W_1- Control	105.8	5298
W_2 -2 HW at 20 & 35 DAS	128.3	6555
W_3 -PM + HW at 25 DAS	120.6	6061
W_4 -PM + Bis. Sodium	111.3	5648
W_5 -PM + Bis. sodium + Metsulfuron &Chlorimuron	114.0	5827
SEm±	**3.22**	**95.89**
CD (p=0.05)	**9.2**	**275**
CV%	**9.6**	**5**
Interaction (I×W)	**NS**	**NS**

On the other hand, scheduling of irrigation through IW/CPE ratios 3.0, 2.0 and 1.5 were found at par in recording number of filled grains per panicle. This might be due to the fact that increased frequency of irrigation led to effective uptake of water and nutrients by the rice plants. Ramamoorthy *et al*. (1998) and Shekara *et al*. (2010) reported similar increase in filled grains per panicle with higher frequency of irrigations to upland direct-seeded rice. The highest number of grains and filled grains per

panicle recorded with hand weeding twice at 20 and 35 DAS (W_2) (138.2 and 128.3 respectively) was found to be on a par with application of pendimethalin + one HW at 25 DAS (W_3) (132.8). Continuous submergence (I_4) recorded significantly the highest grain yield, (6307 kg ha^{-1}) though on a par with irrigation scheduled at 3.0 IW/CPE ratio (I_3) (6142 kg ha^{-1}) over other two irrigation levels. Difference between irrigation levels scheduled at IW/CPE ratio 1.5 (I_1) and 2.0 (I_2) was not significant in increasing the grain yield. Among the weed control treatments, the highest grain yield (6555 kg ha^{-1}) and straw yield (9470 kg ha^{-1}) recorded with two hand weedings (W_2) were found to be significantly higher over all other treatments. It was followed by the treatment W_3 (pendimethalin + hand weeding) which recorded significantly higher grain yield over W_4 and W_5.

In conclusion overall, alternate irrigations based on 3.0 IW/CPE ratio found to be more beneficial, pre emergence herbicide application along with manual weeding (W_3) or sequential application of herbicides (W_4 and W_5) found to better comparatively with less weed growth in dry sown rice. .

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