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Effect of different levels of irrigation and integrated weed management practices on weeds and yield of aerobic rice

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ABSTRACT

The experiment was conducted on irrigation levels and integrated weed management practices during 2013 and 2014 at College of Agriculture, Hyderabad. Results revealed that higher grain yield was recorded with scheduling of irrigations at IW/CPE ratio of 2.0 (2.55 and 2.42 t/ha) due to accumulation of higher chlorophyll content and dry matter production of crop. Net returns (` 20656 and 18347/ha) and benefit cost ratio (1.7 and 1.6) was also higher with the same irrigation level. Scheduling of irrigations at IW/CPE ratio of 1.5 was the next best treatment in aerobic rice. Out of weed management practices tested, application of pendimethalin/butachlor as pre-emergence *fb* chlorimuron-ethyl + metsulfuron-methyl post-emergence *fb* MW + HW at 45 DAS recorded lower weed population, weed dry matter and higher in weed control efficiency, which resulted higher chlorophyll and dry matter accumulation in crop and finally produced higher grain yield in pendimethalin 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (2.15 and 2.05 t/ha) and butachlor 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (2.08 and 1.98 t/ha). The same treatments recorded higher net returns and benefit cost ratio in pendimethalin 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (1.6 and 1.5) and butachlor 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (1.6 and 1.5). Over the pooled years, significant interaction effect of irrigation scheduling at IW/CPE ratio of 2.0 along with application of pendimethalin/butachlor as pre emergence *fb* chlorimuron-ethyl + metsulfuron-methyl as post-emergence *fb* MW + HW at 45 DAS recorded lower weed dry matter (35.1/36.4) and higher grain yield (2.85/2.80 t/ha).

Key words: Aerobic rice, Irrigation regimes, Weed management practices, Weed control efficiency, Weed index, Yield

India is the second largest producer of rice (103.5 mt) after China (145.7 mt) (USDA, 2015). In Telangana, rice is cultivated in 13.67 lakh ha with production of 43.2 lakh tones and productivity of 3.16 kg/ha (Department of Agriculture 2015). Rice consumes fresh water about 90% and it requires 3,000-5,000 litres of water to produce 1.0 kg of grain (IRRI 2001). High water requirement encourages in shifting from traditional transplanting to aerobic rice cultivation.

Unpuddled and aerated tillage is highly vulnerable to weeds which emerge early than the crop when adequate moisture and nutrients available by frequent irrigations scheduled, hence the later stage of crop growth was slow down and finally decreased the yields by 50-91%. Manual, mechanical and chemical control measures were effective against weeds but shortage of labour during peak period and escalating of labour wages are making delayed and expensive weed control practices. So, the integration of herbicides like application as pre- and post-emergence and also including of mechanical and manual weeding practices results in timely weed control and more productive (Hussain *et al.* 2008). Therefore, experiment was done to see the effect of irrigation levels and integrated weed management practices on weed and crop growth and yield of aerobic rice.

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MATERIALS AND METHODS

The field experiment was conducted during *Kharif*, 2013 and 2014 at College of Agriculture, Rajendranagar (latitude 17.2, longitude 78.4), Hyderabad, India. The soil was clay loam, neutral in reaction, low soil organic carbon (0.45%), low in available N 150.5 kg/ha, P_2O_5 18.7 kg/ha and medium in K_2O 227.2 kg/ha, respectively. The Moisture retention at field capacity (-0.03 M Pa) and at permanent wilting point (-1.5 M Pa) was estimated by using pressure membrane apparatus. At the soil depth of 45 to 60 cm, the bulk density was 1.39 g/cc (Dastane 1972). The total available soil moisture amounted to 124.1 mm. Irrigation water was neutral in pH 7.89 and safe to use.

During the crop growth period, weekly mean maximum temperature was 26.3 °C to 31.8 °C and 27.2 °C to 36.2 °C; mean minimum temperatures were 11.4 °C to 22.2 °C and 22.1 °C to 24.9 °C during 2013 and 2014, respectively. The pan evaporation was 403.1 mm in 2013 and 423 mm in 2014. The total rainfall was 468 mm in 24 rainy days in 2013 and 358.2 mm in 23 rainy days in 2014. The experiment was replicated thrice with 24 treatment combinations comprising four irrigation levels (IW/CPE ratios of 0.5, 1.0, 1.5 and 2.0) and six weed management practices *i.e.*, pendimethalin 1.0 kg/ha as pre-emergence (PE) followed by (*fb*) fenoxaprop-p-ethyl 60 g/ha at 15 DAS *fb* mechanical weeding (MW) *fb* hand weeding (HW) at 45 DAS, pendimethalin 1.0 kg/ha as PE *fb* metsulfuron-methyl (MSM) + chlorimuron-ethyl (CME) 4.0 g/ha at 25 DAS *fb* MW *fb* HW at 45 DAS, butachlor 1.0 kg/ha as PE *fb* fenoxaprop-p-ethyl 60 g/ha at 15 DAS *fb* MW *fb* HW at 45 DAS, butachlor 1.0 kg/ha as PE *fb* metsulfuron-methyl + chlorimuron-ethyl 4.0 g/ha at 25 DAS *fb* MW *fb* HW at 45 DAS, weed free check (HW at 25 DAS and MW *fb* HW at 45 DAS) and unweeded control as sub-plots in split plot design.

Rice '*JGL-17004*' was sown in 25 cm x solid rows spacing using seed rate 40 kg/ha and fertilized with 140 N, 60 P_2O_5 and 50 K_2O kg/ha. Nitrogen was applied in four equal splits at basal, tillering, panicle initiation and heading stages. The entire dose of phosphorus, 2/3rd of potassium at basal and 1/3rd potassium applied at panicle initiation stage. Later, foliar spray of 2% $FeSO_4$ was given at tillering and panicle initiation stages as the crop showed iron deficiency symptom. For every irrigation, 40 mm depth of irrigation water (IW) was given when the cumulative pan evaporation (CPE) readings reached the level of 80, 40, 26.6 and 20 mm in order to get IW/CPE ratio of 0.5, 1.0, 1.5 and 2.0, respectively. Soil samples were drawn before irrigation and moisture content was estimated gravimetrically. Volume of water measured through water meter. Observations on weed growth, crop growth and yield were recorded and presented.

RESULTS AND DISCUSSION

Effect on weeds

In aerobic rice at 40 DAS and harvest during two years of study (**Table 1**), high frequency of irrigations at IW/CPE ratio of 2.0 recorded higher weed density (7.4 and 8.1) and (4.7 and 5.6) followed by IW/CPE ratio of 1.5 (7.2 and 7.9) and (4.4 and 5.3) during 2013 and 2014, respectively. Early emergence of weeds due to higher availability of moisture and nutrients might be reason for higher weed population (Banerjee *et al.* 2008).

Integrated weed management practices, recorded lower density of weeds in weed free check (3.9 and 4.3 in 2013) and (2.9 4.0 no./m^2 in 2014) followed by pendimethalin/butachlor 1.0 kg/ha *fb* metsulfuron-methyl + chlorimuron-ethyl 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS in pendimethalin 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (5.2 and 4.1no./m^2 in 2013)

Table 1. Influence of irrigation levels and integrated weed management practices on weed population, weed dry matter at 40 DAS and harvest in aerobic rice

Treatment	Weed population (no./m^2)				Weed dry matter (g/m^2)			
	45 DAS		At harvest		45 DAS		At harvest	
	2013	2014	2013	2014	2013	2014	2013	2014
Irrigation levels (IW/CPE ratios)								
IW/CPE =0.5	6.3 (44.9)	6.9 (52.7)	3.8 (24.0)	4.9 (32.8)	53.8	60.5	34.4	33.7
IW/CPE =1.0	6.5 (47.5)	7.2 (56.4)	4.1 (25.4)	5.0 (34.2)	57.2	63.7	37.7	37.0
IW/CPE =1.5	7.2 (57.6)	7.9 (66.4)	4.4 (28.8)	5.3 (37.7)	67.3	74.1	41.3	39.5
IW/CPE =2.0	7.4 (60.5)	8.1 (69.8)	4.7 (31.0)	5.6 (39.9)	71.5	78.5	43.7	41.5
LSD (p=0.05)	0.1	0.2	0.2	0.2	1.8	2.0	1.3	NS
Integrated weed management								
T_1- Pendimethalin 1.0 kg/ha as PE *fb* fenoxaprop-p-ethyl 60 g/ha at 15 DAS + MW *fb* HW at 45 DAS	7.5 (56.3)	7.9 (64.1)	3.0 (8.5)	3.9 (14.7)	71.3	75.2	7.2	11.1
T_2- Pendimethalin 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS	5.2 (26.6)	4.1 (36.3)	2.7 (7.1)	3.7 (13.2)	26.9	32.0	6.1	9.4
T_3- Butachlor 1.0 kg/ha as PE *fb* fenoxaprop-p-ethyl 60 g/ha at 15 DAS + MW *fb* HW at 45 DAS	7.7 (58.7)	8.0 (66.0)	3.1 (9.1)	3.8 (14.4)	73.8	78.2	8.4	11.7
T_4- Butachlor 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS	5.4 (28.8)	4.3 (39.3)	2.8 (7.4)	3.9 (14.8)	27.7	33.8	6.8	10.0
T5- Weed free check (HW at 25 DAS and MW *fb* HW at 45 DAS	3.9 (15.4)	4.3 (22.2)	2.9 (8.3)	4.0 (15.3)	11.8	18.9	6.7	9.8
T_6- Weedy check (unweeded control)	11.4 (130)	11.1 (140)	11.1 (123)	12.0 (144)	163.2	177.2	200.4	175.7
LSD (p=0.05)	0.2	0.2	0.3	0.3	2.3	4.5	4.3	4.7

Original data in parentheses was subjected to squar root transformation

Table 2. Interaction effect of irrigation levels and integrated weed management practices on weed dry matter (g/m^2) in aerobic rice at 40 DAS (pooled)

Treatment	T_1	T_2	T_3	T_4	T_5	T_6	Mean
IW/CPE =0.5	59.2	24.3	62.1	25.2	13.3	158.6	57.1
IW/CPE =1.0	64.3	26.2	66.8	27.2	14.0	164.3	60.5
IW/CPE =1.5	80.9	32.2	84.0	34.0	16.6	176.6	70.7
IW/CPE =2.0	88.6	35.1	91.0	36.4	17.4	181.3	75.0
Mean	73.2	29.5	76.0	30.7	15.4	170.2	
Interaction		I x T	T x I				
LSD (p=0.05)		6.4	6.2				

and (2.7 and 3.7 no./m^2 in 2014) and butachlor 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (5.4 and 4.3no./m^2 in 2013) and (2.8 and 3.9no./m^2 in 2014), which were at par with each other (Sunil *et al.* 2010 and Jayadeva *et al.* 2011).

Higher weed dry matter production (**Table 1**) recorded in irrigation scheduled at IW/CPE ratio of 2.0 (71.5 and 78.5 g/m^2 in 2013) and (43.7 and 41.5 g/m^2 in 2014) followed by IW/CPE ratio of 1.5 (67.3 and 74.1) and (41.3 and 39.5) at 40 DAS and harvest, but it was not significant at harvest in 2014. Application of metsulfuron-methyl + chlorimuron-ethyl 4.0 g/ha applied at 25 DAS recorded the lower weed dry matter production in pendimethalin 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (26.9 and 32.0 g/m^2 in 2013) and (6.1 and 9.4 g/m^2 in 2014) and butachlor 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (27.7 and 33.8) and (6.8 and 10.0) and they were followed with weed free check (11.8 and 18.9) and (6.7 and 9.8) at 45 DAS and harvest during both the years (Narolia *et al.* 2014).

There was significant interaction effect (**Table 2**) of on drymatter production of weeds pooled over both the years. It was higher with irrigation regime at IW/CPE ratio of 2.0 along with application of pendimethalin/butachlor 1.0 kg/ha as PE *fb* metsulfuron-methyl + chlorimuron-ethyl 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS in IW/CPE =2.0 pendimethalin 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (35.1 g/m^2) and IW/CPE =2.0 butachlor 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (36.4 g/m^2) and which followed by same weed treatments within the IW/CPE ratio of 1.5 as IW/CPE =1.5 pendimethalin 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (32.2 g/m^2) and IW/CPE =1.5 butachlor 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (34.0 g/m^2). This might be due to effective control of sedges and broad-leaved weeds (BLW).

Significantly lower weed control efficiency (**Table 3**) was recorded with irrigation scheduled at IW/CPE ratio of 2.0 at 40 DAS (59.0 and 58.3%) and harvest (79.3 and 77.7) during both the years except in 2014 when it was non-significant. This might be due to adequate availability of moisture, early emergence of weeds and accumulation of drymatter which caused lower weed control efficiency (Saha *et al*. 2005). Among the weed management practices, higher weed control efficiency was recorded with application of metsulfuron methyl + chlorimuron-ethyl 4.0 g/ha at 25 DAS in pendimethalin 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS and butachlor 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (83.6 and 82.0%) and (83.2 and 81.0%) and at harvest (97.0 and 95.0%) and (96.7 and 94.6%) during both the years respectively. Application of fenoxaprop-p-ethyl 60 g/ha at 15 DAS was effective only on grasses and resulted in lower weed control efficiency (**Table 2**).

Table 3. Influence of irrigation levels and integrated weed management practices on weed control efficiency (%) at 40 DAS and harvest and weed index (%) in aerobic rice

Treatment	Weed control efficiency (%)				Weed index (%)	
	45 DAS		At harvest			
	2013	2014	2013	2014	2013	2014
Irrigation levels (IW/CPE ratios)						
IW/CPE =0.5	64.5	63.4	81.4	79.0	28.4	27.5
IW/CPE =1.0	63.6	62.7	81.0	78.7	20.4	21.8
IW/CPE =1.5	60.3	59.6	80.1	78.2	18.8	19.7
IW/CPE =2.0	59.0	58.3	79.3	77.7	18.3	19.0
LSD (p=0.05)	1.1	1.2	0.8	NS	-	-
Integrated weed management						
Pendimethalin 1.0 kg/ha as PE *fb* fenoxaprop-p-ethyl 60 g/ha at 15 DAS + MW *fb* HW at 45 DAS	56.5	57.7	96.5	94.1	20.8	21.8
Pendimethalin 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS	83.6	82.0	97.0	95.0	6.9	6.6
Butachlor 1.0 kg/ha as PE *fb* fenoxaprop-p-ethyl 60 g/ha at 15 DAS + MW *fb* HW at 45 DAS	55.1	56.0	95.9	93.7	23.8	24.7
Butachlor 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS	83.2	81.0	96.7	94.6	9.7	9.7
Weed free check (HW at 25 DAS and MW *fb* HW at 45 DAS	92.8	89.2	96.7	94.7	0.0	0.0
Weedy check (unweeded control)	0.0	0.0	0.0	0.0	67.5	69.2
LSD (p=0.05)	1.1	1.5	0.6	0.9	-	-

Effect on crop

In aerobic rice (**Table 4**), irrigation regime at IW/CPE ratio of 2.0 recorded higher SPAD chlorophyll reading (SCMR) values at 40 DAS (35.11 and 34.72%) and harvest (32.93 and 32.44%) and it followed by IW/CPE ratio of 1.5 during both years, respectively. These findings were supported by Geethalakshmi *et al.* (2008). Control of broad spectrum weeds resulted higher SCMR values were with application of pendimethalin/butachlor as PE *fb* post-emergence application of metsulfuron-methyl + chlorimuron-ethyl *fb* MW + HW at 45 DAS. At harvest, SCMR value was recorded at par with all other treatments ranged from 31.23 to 32.04 except unweeded control recorded lower during both years (**Table 4**).

Dry matter production of crop (**Table 4**) at 40 DAS was higher with IW/CPE 2.0 (142.1 and 138.1 g/m^2) followed by IW/CPE ratio of 1.5 (133.9 and 129.8 g/m^2) whereas at harvest IW/CPE ratios of 2.0 (995.0 and 921.8 g/m^2) and 1.5 (924.6 and 832.0 g/m^2) both were at par each other during both the years. This was supported by Narolia *et al.* (2014). Over the weed management practices, weed free check (135.4 and 131.0 g/m^2) and application of pendimethalin 1.0 kg/ha as PE *fb* metsulfuron-methyl + chlorimuron-ethyl 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (133.5 and 130.1 g/m^2) recorded at par higher drymatter production and it followed by butachlor 1.0 kg/ha as PE *fb* metsulfuron-methyl + chlorimuron-ethyl 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (128.8 and 125.5). Weed free check (1044.8 and 920.1 g/m^2) recorded higher dry matter production followed by application of pendimethalin 1.0 kg/ha as PE *fb* metsulfuron-methyl + chlorimuron-ethyl 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (1009.5 and 883.4 g/m^2) and butachlor 1.0 kg/ha as PE *fb* metsulfuron-methyl + chlorimuron-ethyl 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (948.4 and 868.7 g/m^2) at harvest during 2013 and 2014, respectively. This might be caused by reduction in crop weed competition for resources at critical stage of the crop (Jadhav *et al.* 2014).

Slightly higher grain yield was recorded (**Table 5**) in 2013 and 2014 with irrigations given at IW/CPE ratio of 2.0 (2.55 and 2.42 t/ha) followed by 1.5 (2.16 and 2.04 t/ha) over other irrigation levels. This might be due to increased number of irrigations which favoured in more availability of resources and efficient translocation of photosynthates from source to sink in turn recorded better crop growth and yields (Pandey *et al.* 2010). Higher grain yields recorded with weed free check (2.29 and 2.19 t/ha) followed by application of pendimethalin/butachlor 1.0 kg/ha as PE *fb* metsulfuron-methyl + chlorimuron-ethyl 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS in pendimethalin 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (2.15 and 2.05 t/ha) and butachlor 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (2.08 and 1.98 t/ha) both were statistically at par with each other. Similar findings were made by Singh *et al.* (2008) and Walia *et al.* (2012). Comparatively lower yields were recorded with fenoxaprop-p-ethyl 60 g/

Table 4. Influence of irrigation levels and integrated weed management practices on SPAD chlorophyll content and dry matter production of crop (g/m^2) at 40 DAS and harvest in aerobic rice

Treatment	SPAD chlorophyll content				Dry matter production of crop (g/m^2)			
	45 DAS		At harvest		45 DAS		At harvest	
	2013	2014	2013	2014	2013	2014	2013	2014
Irrigation levels (IW/CPE ratios)								
IW/CPE =0.5	31.23	30.57	30.80	30.04	108.3	104.3	641.2	588.6
IW/CPE =1.0	32.95	32.27	31.52	30.76	111.0	107.0	763.4	689.8
IW/CPE =1.5	34.28	33.77	31.89	31.29	133.9	129.8	924.6	832.0
IW/CPE =2.0	35.11	34.72	32.93	32.44	142.1	138.1	995.0	921.8
LSD (p=0.05)	0.50	0.04	0.49	0.11	7.0	8.0	172.3	94.1
Integrated weed management								
Pendimethalin 1.0 kg/ha as PE *fb* fenoxaprop-p-ethyl 60 g/ha at 15 DAS + MW *fb* HW at 45 DAS	33.66	32.49	32.02	30.80	121.9	116.9	880.5	806.2
Pendimethalin 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS	34.13	33.61	32.03	31.41	133.5	130.1	1009.5	883.4
Butachlor 1.0 kg/ha as PE *fb* fenoxaprop-p-ethyl 60 g/ha at 15 DAS + MW *fb* HW at 45 DAS	33.64	32.56	32.01	31.23	121.7	116.7	855.4	810.1
Butachlor 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS	34.02	33.74	31.71	31.35	128.8	125.5	948.4	868.7
Weed free check (HW at 25 DAS and MW *fb* HW at 45 DAS	33.56	32.99	32.04	31.45	135.4	131.0	1044.8	920.1
Weedy check (unweeded control)	31.75	31.20	30.83	30.22	101.7	98.4	247.9	260.0
LSD (p=0.05)	0.33	0.66	0.34	0.66	3.4	3.8	33.4	27.4

Table 5. Influence of irrigation levels and integrated weed management practices on grain and straw yield and harvest index (%) in aerobic rice

Treatment	Grain yield (t/ha)		Straw yield (t/ha)		Harvest index (%)	
	2013	2014	2013	2014	2013	2014
Irrigation levels (IW/CPE ratios)						
IW/CPE =0.5	1.05	1.03	2.53	2.40	28.3	29.2
IW/CPE =1.0	1.52	1.40	2.84	2.70	34.6	33.5
IW/CPE =1.5	2.16	2.04	3.89	3.74	35.5	35.0
IW/CPE =2.0	2.55	2.42	4.60	4.41	35.9	35.7
LSD (p=0.05)	0.22	0.24	0.33	0.28	1.4	2.3
Integrated weed management						
Pendimethalin 1.0 kg/ha as PE *fb* fenoxaprop-p-ethyl 60 g/ha at 15 DAS + MW *fb* HW at 45 DAS	1.85	1.74	3.29	3.15	35.4	34.7
Pendimethalin 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS	2.15	2.05	4.24	4.00	33.1	33.7
Butachlor 1.0 kg/ha as PE *fb* fenoxaprop-p-ethyl 60 g/ha at 15 DAS + MW *fb* HW at 45 DAS	1.77	1.67	3.17	3.01	35.1	35.2
Butachlor 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS	2.08	1.98	3.92	3.83	34.4	33.9
Weed free check (HW at 25 DAS and MW *fb* HW at 45 DAS	2.29	2.19	4.44	4.32	33.7	33.3
Weedy check (unweeded control)	0.79	0.71	1.71	1.59	29.8	29.4
LSD (p=0.05)	0.09	0.10	0.13	0.15	1.1	1.4

ha applied treatments. This might be due to fenoxaprop-p-ethyl controlled only grassy weeds (Kumar *et al.* 2010**)**.

The interaction effect was significant when irrigation applied at IW/CPE ratio of 2.0 along with it weed free check (3.06 t/ha) and followed by application of pendimethalin/butachlor 1.0 kg/ha applied as PE *fb* metsulfuron-methyl + chlorimuron-ethyl 4.0 g/ha at 25 DAS (**Table 6**).

Higher straw yield (**Table 5**) was recorded with irrigations given at IW/CPE ratio of 2.0 (4.60 and 4.41 t/ha) followed by 1.5 (3.89 and 3.74 t/ha). Weed free check (4.44 and 4.32 t/ha) resulted higher straw yield and followed by pendimethalin/butachlor 1.0 kg/ha applied as PE *fb* metsulfuron methyl + chlorimuron-ethyl 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS in pendimethalin 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (4.24 and 4.0 t/ha) and butachlor 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (3.92 and 3.83 t/ha) during two years. Similar results were obtained by Prameela *et al.* (2014). Harvest index (**Table 5**) was higher with IW/CPE ratio of 2.0 (35.9 and 35.7%) and 1.5 (35.5 and 35.0% in 2013 and 2014, respectively) both were at par with ach other.

Table 6. Interaction effect of irrigation levels and integrated weed management practices on grain yield (t/ha) of aerobic rice (pooled)

Treatment	T_1	T_2	T_3	T_4	T_5	T_6	Mean
I_1 (IW/CPE =0.5)	1.01	1.29	0.93	1.24	1.45	0.31	1.04
I_2 (IW/CPE =1.0)	1.45	1.75	1.44	1.67	1.86	0.60	1.46
I_3 (IW/CPE =1.5)	2.12	2.49	2.09	2.42	2.60	0.89	2.10
I_4 (IW/CPE =2.0)	2.60	2.85	2.42	2.80	3.06	1.19	2.49
Mean	1.79	2.10	1.72	2.03	2.24	0.75	
Interaction		I x T	T x I				
LSD (p=0.05)		0.18	0.28				

*I x T: IWM practices within the irrigation levels (at 5% level of significance); T x I: Irrigation levels across the IWM practices (at 5% level of significance)

Economics

During two years of study (**Table 7**), net returns of aerobic rice was higher with IW/CPE ratio of 2.0 (` 20656 and 18347) and was followed by 1.5 (` 15098 and 12908). Similar findings were observed with Murthy and Reddy (2013) and Narolia *et al.* (2014). Among the integrated weed management practices, higher net returns were observed with weed free check (` 19562 and 17726 in 2013 and 2014, respectively) and was followed by pre-emergence application of pendimethalin/butachlor 1.0 kg/ha *fb* (metsulfuron-methyl + chlorimuron ethyl) 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS as in pendimethalin 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (` 16683 and 14590) and butachlor 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS (` 15270 and 13541 in 2013 and 2014, respectively) both these treatments were on par each other. Higher net returns might be attributed to higher grain and straw yield. Prameela *et al.* (2014) also found similar results. Heavy weed infestation resulted lower yields and in turn lower net returns by unweeded control in aerobic rice.

Significantly higher benefit cost ratio was noticed with IW/CPE ratio of 2.0 (1.7 and 1.6) and was at par with IW/CPE ratio of 1.5 (1.5 and 1.5). It may be due to higher yields and returns. These findings were in accordance with the results of Murthy and Reddy (2013) and Narolia *et al.* (2014). Wherein integrated weed management practices the benefit cost ratio was higher in weed free check (` 1.7 and 1.7) and was at par with application of pendimethalin/butachlor 1.0 kg/ha as PE *fb* (metsulfuron-methyl + chlorimuron-ethyl) 4.0 g/ha at

Table 7. Net returns and benefit cost ratio of aerobic rice as influenced by irrigation levels and integrated weed management practices

Treatment	Net returns (x10^3 `/ha)		Benefit cost ratio	
	2013	2014	2013	2014
Irrigation levels (IW/CPE ratios)				
IW/CPE =0.5	4.22	3.82	1.3	1.2
IW/CPE =1.0	8.68	6.33	1.5	1.3
IW/CPE =1.5	15.10	12.91	1.5	1.5
IW/CPE =2.0	20.66	18.35	1.7	1.6
LSD (p=0.05)	4.60	4.29	0.2	0.2
Integrated weed management				
Pendimethalin 1.0 kg/ha as PE *fb* fenoxaprop-p-ethyl 60 g/ha at 15 DAS + MW *fb* HW at 45 DAS	9.74	7.63	1.4	1.3
Pendimethalin 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS	16.68	14.59	1.6	1.5
Butachlor 1.0 kg/ha as PE *fb* fenoxaprop-p-ethyl 60 g/ha at 15 DAS + MW *fb* HW at 45 DAS	8.66	7.08	1.3	1.2
Butachlor 1.0 kg/ha as PE *fb* MSM + CME 4.0 g/ha at 25 DAS + MW *fb* HW at 45 DAS	15.27	13.54	1.6	1.5
Weed free check (HW at 25 DAS and MW *fb* HW at 45 DAS	19.56	17.73	1.7	1.7
Weedy check (unweeded control)	3.07	1.54	1.3	1.2
LSD (p=0.05)	1.78	1.78	0.1	0.1

25 DAS + MW *fb* HW at 45 DAS. These findings were supported by Prameela *et al.* (2014) (**Table 7**).

The study revealed that successful growing of aerobic rice in Telangana with scheduling of irrigations at IW/CPE ratio of 2.0 and 1.5 and pendimethalin/butachlor 1.0 kg/ha applied as PE *fb* chlorimuron-ethyl + metsulfuron-methyl 4.0 g/ha applied as POE *fb* MW + HW at 45 DAS provided higher yields.

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