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Short communication

Water - weed interactions in aerobic rice

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Abstract

A field study was undertaken at Agronomic Research Station, Chalakudy, Kerala for developing suitable water and weed management strategies for aerobic rice. The trial was laid out with three levels of irrigation in the main plot [irrigation at 10, 20 and 30 mm CPE (cumulative pan evaporation)] and five weed management treatments in the subplot (pre emergent herbicide oxadiargyl followed by hand weeding, 2,4- D sodium salt or bispyribac sodium at 20 days after sowing (DAS), hand weeding at 20 and 40 DAS and unweeded control). Irrigation at 10 mm CPE increased crop growth, but reduced weed growth. Less irrigation (30 mm CPE) favoured the growth and density of grasses and broad leaf weeds and produced the highest weed dry matter. Sedge population was more in frequently irrigated plot (10 mm CPE). Moisture stress in 30 mm CPE resulted in 44 per cent yield loss. Weed competition caused 64 per cent yield reduction. Both water and weeds together accounted for 85 per cent yield reduction. Irrigation at 10 mm CPE recorded the highest grain yield and weed control efficiency, but lowest water productivity. Among weed management practices, hand weeding at 20 and 40 DAS recorded the highest grain yield, weed control efficiency and water productivity. However, application of oxadiargyl followed by bispyribac sodium resulted in better water productivity and recorded highest B:C ratio.

Keywords: Aerobic rice, Water productivity, Weed control efficiency

In India, rice is the staple food crop for more than 65 per cent of the population. Unfortunately, declining quantity and quality of land, depletion of water resources, and reduced income generated from the crop are prompting the farmers to shift to other crops/practices. The scenario is further aggravated by the impact of climate change on hydrological cycle. With increasing water scarcity, the productivity and sustainability of rice production systems are threatened on account of its large water requirements and poor water productivity. There is a need to adopt and popularise water saving technologies in rice to have an edge in economising water use.

Aerobic rice cultivation is expected to have a higher water productivity, but is often associated with yield loss, the extent of which is dependent on the water applied in the field and its frequency. The major focus should be to maintain higher water productivity with less reduction in yield. Besides, weed problems are quite high as the fields are never with standing water. Therefore weed management in aerobic rice is as important as water management. However, the technology has to be standardized for specific soil and climatic conditions. In this context, a field study was conducted to understand the weed-water interactions in aerobic conditions and to develop water and weed management strategies for aerobic rice in loamy sand soils of Kerala.

The experiment was conducted in loamy sand soil of Agronomic Research Station, Chalakudy during *rabi* 2016-17. Three levels of irrigation (irrigation

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at 10, 20 and 30 mm cumulative pan evaporation) and five weed management treatments (pre emergent herbicide oxadiargyl followed by hand weeding at 20 days after sowing (DAS), oxadiargyl followed by 2,4- D sodium salt at 20 DAS, oxadiargyl followed by bispyribac sodium at 20 DAS, hand weeding at 20 and 40 DAS and an unweeded control) were selected and combinations of these treatments were tested for the study.

The field was ploughed twice in dry condition, pulverized and brought to a fine tilth and then levelled. Farmyard manure @ 5.0 t ha^{-1} and nitrogen, phosphorus and potassium as per the Package of Practices recommendations of Kerala Agricultural University (90:45:45 kg ha^{-1}) were applied. The rice variety Aiswarya was line sown at a spacing of 20 x 10 cm. Uniform irrigation was given to each plot till a uniform plant stand was observed in the field. Thereafter, irrigation was scheduled as per the treatments, based on daily evaporation data collected from a USWB Class B Open pan evaporimeter maintained at ARS, Chalakudy. Based on physical properties of soil and depth of root zone, depth of irrigation was fixed as 3 cm and measured volume of water was applied to each plot. Herbicides were sprayed at 3 DAS and 20 DAS as per treatments at the recommended doses. Hand weeding was followed as per the technical programme at 20 DAS and 40 DAS.

Effective rainfall was calculated based on water balance accounting method (Thomas, 2010) and the total water applied in the field was calculated as the sum of effective rainfall and irrigation water applied. Observations on growth and yield parameters, weed density and weed dry matter production were recorded and were statistically analysed. Based on the weed dry matter in different treatments, weed control efficiency was estimated. Water productivity was also assessed as the biological yield produced per unit of water applied in the field.

Crop growth and development was highly influenced by varying levels of irrigation. Irrigation at 10 mm CPE was found positively affecting the overall growth performance of the crop and produced taller plants with more number of tillers and leaf area index (Table 1). Moisture stress in rice led to inhibition of leaf production and decline in leaf area and resultant reduction in canopy photosynthesis. Number of panicles, filled grains per panicle and thousand grain weight were found higher under irrigation at 10 mm CPE. Better growth and yield attributes found under frequently irrigated plots finally resulted in higher grain yield (2131 kg ha^{-1}) and straw yield (3856 kg ha^{-1}). As yield reduction in aerobic rice occurs as soon as the moisture content falls below the field capacity (Bouman and Tuong, 2001), a better moisture regime favoured increase in yield. Moisture stress

Table 1. Effect of varying irrigation levels and weed management practices on the growth and yield of aerobic rice

Levels of irrigation	Plant height (cm)	Tillers per m^2	LAI	Number of panicles per m^2	Grain yield (kg ha^{-1})
Irrigation at 10 mm CPE	101.00	361	4.09	306	2131
Irrigation at 20 mm CPE	92.66	311	3.77	284	1612
Irrigation at 30 mm CPE	89.66	286	3.66	251	1194
SE (m)	0.54	2.90	0.07	4.25	62
CD (0.05)	2.19	11.69	0.29	17.13	249
Weed management					
Oxadiargyl + Hand weeding	97.67	377	4.40	333	1816
Oxadiargyl + 2, 4- D	93.89	313	3.79	274	1577
Oxadiargyl + bispyribac sodium	95.78	380	4.08	334	1883
Hand weeding twice	100.44	404	4.22	354	2168
Unweeded control	84.44	123	2.71	105	782
SE (m)	0.62	3.09	0.76	5.43	64
CD (0.05)	1.84	9.09	0.22	15.96	189

in 30 mm CPE resulted in 44 per cent yield loss over 10 mm CPE.

Weed management treatments were influential enough to produce significant changes in grain and straw yield. Hand weeding twice at 20 and 40 DAS recorded the highest grain yield and straw yield. Lowest grain and straw yield was recorded from unweeded control. In comparison with two hand weedings, unweeded check recorded 64 per cent yield reduction. Higher yield reduction in aerobic rice was caused by weeds (64 per cent) than due to water stress (43 per cent). Among treatment combinations, irrigation at 10 mm CPE in association with hand weeding twice recorded the highest grain yield. Lesser weed competition and ample moisture conditions might have created better growing conditions in plots provided with irrigation at 10 mm CPE and two hand weedings. This in turn resulted in better yield parameters. A combination of stress produced by water and weed interaction resulted in 85 per cent reduction in grain yield.

Most dominant group of weeds identified was grasses and they included *Leptochloa chinensis, Echinochloa colona, Eleusine indica, Digitaria ciliaris, Eragrostis uniloides* and *Dactyloctenium aegyptium*. Only two sedges viz., *Cyperus iria* and *Fimbrystylis miliacea* were observed in the field, of which *Fimbrystylis miliacea* dominated. Broad leaf weeds included *Portulaca oleracea, Phyllanthus amara, Melochia corchorifolia, Heliotropium indicum, Cleome burmanii, Mollugo pentaphylla, Ludwigia parviflora, Scoparia dulcis,*

Table 2. Effect of varying irrigation levels and weed management practices on the weed growth at 90 DAS in aerobic rice

Levels of irrigation	Grass weed density (no. m^{-2})	Sedge weed density (no m^{-2})	Broad leaf weed density (no. m^{-2})	Total weed density (no m^{-2})	Weed dry weight (g m^{-2})
Irrigation at 10 mm CPE	6.66*	3.97*	5.64*	9.55	9.06
	(45.20)	(15.60)	(33.66)	(94.46)	(94.40)
Irrigation at 20 mm CPE	7.00	3.29	6.58	10.09	10.95
	(49.60)	(10.13)	(44.33)	(104.06)	(132.78)
Irrigation at 30 mm CPE	7.14	2.76	7.03	10.33	11.99
	(51.00)	(07.33)	(50.33)	(108.86)	(161.53)
SE (m)	0.08	0.15	0.10	0.06	0.05
	(1.12)	(0.89)	(1.56)	(1.21)	(01.31)
CD (0.05)	0.32	0.60	0.43	0.25	0.21
	(4.54)	(3.60)	(6.30)	(4.90)	(05.29)
Weed management					
Oxadiargyl + Hand weeding	6.27	3.18	6.11	9.26	8.37
	(38.66)	(09.66)	(36.88)	(85.22)	(69.47)
Oxadiargyl + 2, 4- D	7.12	2.52	5.29	9.17	10.92
	(49.88)	(05.88)	(27.55)	(83.33)	(121.77)
Oxadiargyl + bispyribac sodium	6.31	3.37	5.71	9.10	8.68
	(39.11)	(11.00)	(32.00)	(82.11)	(74.90)
Hand weeding twice	6.00	3.22	5.71	8.81	7.52
	(35.44)	(09.55)	(32.11)	(77.11)	(57.84)
Unweeded control	8.97	4.42	9.29	13.60	17.92
	(79.88)	(19.00)	(85.66)	(184.55)	(323.87)
SE (m)	0.15	0.13	0.11	0.17	0.08
CD (0.05)	0.45	0.406	0.34	0.51	0.23

* √ x +0.5 transformed values, original values in the parenthesis

Mimosa pudica, Cyanotis axillaris and *Cleome viscosa.*

Higher weed dry matter was recorded from 30 mm CPE (I_3) (Table 2). Irrigation at 30 mm CPE, being more aerobic, was favourable for germination and growth of weeds and faced less competition from rice. A better crop stand in 10 mm CPE might have competed effectively with weeds and suppressed them even from early growth stages resulting in lower weed dry matter. Grasses, sedges and broad leaf weed densities were found influenced by irrigation schedule (Table 2). Densities of grasses and broad leaf weeds were found highest in irrigation at 30 mm CPE. Grass weed density in 30 mm CPE irrigation was on par with 20 mm CPE irrigation. Sedges at all stages were found significantly higher in 10 mm CPE followed by 20 mm CPE, and the least in 30 mm CPE. Both *Cyperus iria* and *Fimbrystylis miliacea* preferred water rich conditions (Thomas and Abraham, 1998), which might be the reason for their dominance in frequently irrigated plots. Sedges were nil or was found negligible in least irrigated plots (I_3). The conditions in I_3 resembled upland conditions and the dominant broad leaf weeds observed included *Portulaca oleracea, Scoparia dulcis* and *Mimosa pudica,* which are not common in the lowlands. Dry matter production of weeds in 30 mm CPE was high because of the presence of more broad leaf weeds.

The effect of irrigation on growth of weeds was reflected in the weed control efficiency (Table 3). At 90 DAS, 10 mm CPE irrigation, recorded 20 per cent higher weed control efficiency than 30 mm CPE irrigation indicating the importance of frequent irrigation in controlling the weeds. Weed management practices were found essential for aerobic rice at the early stages for better establishment and crop growth. Oxadiargyl was successful in controlling the weeds as a pre-emergent herbicide. Data obtained at 20 DAS recorded very low weed dry matter and better weed control efficiency in herbicide applied plots (6.96 g m^{-2} and 72.7 per cent) than in the unweeded control (21.28 g m^{-2} and 15.82 per cent). At 40 DAS, oxadiargyl followed by hand weeding recorded a higher weed control efficiency (96.43 per cent), followed by oxadiargyl+bispyribac sodium (86.78 per cent) and two hand weedings (86.38 per cent). At 90 DAS, hand weeding twice which had received additional weeding at 40 DAS recorded a higher weed control efficiency. This proved that the period of crop weed competition is longer for aerobic rice and weed management up to 40 DAS resulted in better growth and yield. Sunil et al. (2010) also

Table 3. Effect of varying irrigation levels and weed management practices on the weed control efficiency and water productivity in aerobic rice

Levels of irrigation	Weed control efficiency (%)			Water productivity
	20 DAS	40 DAS	90 DAS	(kg m^{-3})
Irrigation at 10 mm CPE	64.36	82.02	77.84	0.64
Irrigation at 20 mm CPE	47.94	77.07	68.82	0.87
Irrigation at 30 mm CPE	44.58	67.74	61.86	0.96
SE (m)	0.88	0.40	0.27	0.01
CD (0.05)	3.55	1.62	1.09	0.069
Weed management				
Oxadiargyl + Hand weeding	73.23	96.43	83.69	0.77
Oxadiargyl + 2, 4- D	73.30	82.59	71.41	0.78
Oxadiargyl + bispyribac sodium	71.77	86.78	82.41	1.06
Hand weeding twice	27.36	86.38	86.42	1.13
Unweeded control	15.82	25.87	23.09	0.37
SE (m)	0.88	0.59	0.43	0.01
CD (0.05)	3.55	1.74	1.28	0.052

recommended an intercultural operation at 40 DAS in aerobic rice for better weed control and plant growth. Lowest weed control efficiency at all stages were recorded from unweeded and least irrigated plot (I_3W_5). Irrigation at 10 mm CPE in combination with hand weeding twice (I_1W_4) at 90 DAS recorded the highest weed control efficiency.

Water productivity of aerobic rice is higher than the flooded rice. In the experiment, it varied from 0.64 - 0.96 kg m^{-3} which was much higher than that of conventional flooded rice (0.44 kg m^{-3}). For irrigation at 30 mm CPE only 403 mm of water was applied in total, but for irrigation at 20 mm CPE and 10 mm CPE, water applied was 574 mm and 933 mm respectively. More water applied by irrigation at 10 mm CPE resulted in higher yield, but low water productivity (Table 3). Irrigation at 20 mm CPE with a water saving of 38.4 per cent recorded a yield reduction of 24.4 per cent over 10 mm CPE irrigation. Irrigation at 30 mm CPE with a water saving of 56.8 per cent recorded a yield reduction of 44 per cent.

Weed management treatments were also found influencing the water productivity. Unweeded control recorded the lowest water productivity. Hand weeding twice registered the highest water productivity (1.3 kg m^{-3}) followed by oxadiargyl + bispyribac sodium (1.06 kg m^{-3}), due to higher yield obtained from these plots. Hand weeding twice resulted in three times higher water productivity than unweeded control. Interaction between water and weed management treatments also affected the water productivity. When combined with hand weeding twice, the water productivity of irrigation at 20 mm CPE was enhanced (1.29 kg m^{-3}) became comparable with irrigation at 30 mm CPE (1.21 kg m^{-3}), and recorded significantly higher water productivity among treatments. On the contrary, combination with no weeding reduced the positive effect of 30 mm CPE irrigation and the lowest water productivity was obtained from I_3W_5 (0.35 kg m^{-3}).

Irrigation at 10 mm CPE combination with two hand weedings resulted in the highest return. However, it increased the cost of cultivation (Rs.71331ha^{-1}), and hence net return (Rs.37625 ha^{-1}) and B: C ratio (1.53) reduced drastically. Irrigation at 10 mm CPE in combination with oxadiargyl followed by bispyribac sodium at 20 DAS (I_1W_3), and irrigation at 20 mm CPE in combination with oxadiargyl followed by bispyribac sodium at 20 DAS (I_2W_3) recorded higher B: C ratios (2.31 and 2.38 respectively). The reduced cost of cultivation in both the treatments (Rs. 39170 ha^{-1} and Rs.34620 ha^{-1}) resulted in a higher B: C ratio. Net return was higher under I_1W_3 (Rs. 51478 ha^{-1}). Higher grain yield along with lower cost of cultivation under this treatment resulted in higher income.

Aerobic rice, with high water productivity is a promising water saving technology. Moisture stress resulted in 44 per cent yield loss while weed competition caused 64 per cent yield reduction in aerobic rice. Both water and weeds together accounted for 85 per cent yield reduction. Irrigation at 10 mm CPE combination with two hand weeding resulted in the highest returns. However, irrigation at 10 mm CPE in combination with oxadiargyl followed by bispyribac sodium recorded the highest net return and B:C ratio of 2.31.

References

Bouman, B.A.M. and Tuong, T.P. 2001. Field water management to save water and increase its productivity in irrigated lowland rice. Agric. Water Manage., 49(1): 11-30.

Sunil, C.M., Shekara, B.G., Anilkumar, S.N., Murthy, K.K. and Vijay, M. 2011. Economics and uptake of nutrients by crops and weeds as influenced by weed control practices in aerobic rice. Adv. Res. J. Crop Improv., 1(2):183-186.

Thomas, C.G. 2010. Land Husbandary and Water Shed Management. Kalyani Publishers, Ludhiana, 693p.

Thomas, C.G. and Abraham, C.T. 1998. Common Weeds in Rice Ecosystems of Kerala and their Management. Kerala Agricultural University, Thrissur, 80p.