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K Keerthana
PG Scholar, Department of Agronomy, Agricultural College and Research Institute, TNAU, Killikulam, Tamil Nadu, India

E Subramanian
Assistant Professor, Department of Agronomy, Agricultural College and Research Institute, TNAU, Killikulam, Tamil Nadu, India

D Rajakumar
Assistant Professor, Department of Agronomy, Agricultural College and Research Institute, TNAU, Killikulam, Tamil Nadu, India

B Jeberlin Prabina
Associate Professor, Department of Agriculture and Microbiology, SS&AC, Agricultural College and Research Institute, TNAU, Killikulam, Tamil Nadu, India

Corresponding Author:
K Keerthana
PG Scholar, Department of Agronomy, Agricultural College and Research Institute, TNAU, Killikulam, Tamil Nadu, India

Weed and Nitrogen management in aerobic rice intercropping system

K Keerthana, E Subramanian, D Rajakumar and B Jeberlin Prabina

Abstract
An experiment trial was conducted at the Agricultural College and Research Institute in Killikulam during the summer crop of 2021-2022. treatments using a different range of weed control methods. According to this experimental, minimum weed density and weed dry weight, maximum weed control efficiency was achieved in rice + Dhaincha 1:1 ratio *fb* 2, 4-D at 25 DAS (Brown manuring) and mechanical weeding (MW) at 45DAS. Dhaincha intercropping, when combined with brown manuring, reduces weed growth while increasing rice crop growth and yield. Nitrogen has the greatest impact on rice production. Different levels of nitrogen application are followed to find the difference in crop growth reported by (Subramanian *et al.*, 2021). RDF Nitrogen at 4 splits 20% at 15 DAS, 30% at AT, 30% at PI, and 20% at Flowering increases the growth and yield in aerobic rice. Therefore, two crucial management parameters that affect aerobic rice yield are nitrogen and weed management.

Keywords: Dhaincha, intercropping, weed control, nitrogen, growth, yield of aerobic rice

1. Introduction
Aerobic rice is grown in non-puddled, non-flooded, and unsaturated fields to reduce water requirements by 44-45% when compared to flooded rice. To overcome this, the International Rice Research Institute (IRRI) developed a new technique called Aerobic rice system. The aerobic method of rice growing is a revolutionary concept, in contrast to nursery rearing, puddling, transplanting, and submerging techniques. This production method mostly utilises direct sowing and surface irrigation as like grown maize and wheat (Subramanian *et al*., 2020) [7]. It is regarded as one of the most promising methods for conserving water. Aerobic rice used approximately 51% less water overall and produced 32-88 percent more grains per kilogramme of water than flooded rice by using less water for soil preparation, seepage, percolation, and evaporation, according to (Priyanka *et al.*, 2012). When compared to flooded rice, aerobic rice uses around 60% less water while producing 1.6 to 1.9 times more water overall. Water crisis in the present situation, pay a way to aerobic rice cultivation. Upland and aerobic rice are most susceptible to weed pressure and competition, whereas transplanted irrigated rice is least susceptible. Conversely, aerobic soil dry-tillage and alternating soaking and drying conditions are favourable for weed germination and development, resulting in a 50-91% reduction in grain production. Since weeds are the main barrier to the production of aerobic rice, the success of this technique largely rests on adequate weed control. The majority of Asian upland and aerobic rice farmers hand-weed their fields up to 190 person per ha^{-1} were crops mechanically weeded two or three times per season (Juraimi *et al.*, 2013) [1]. Concluding, rice yield has been shown to increase by 27-30% under aerobic circumstances when appropriate weed management strategies are used (Juraimi *et al.*, 2013) [1]. Weed management is necessary during the crop life cycle, (CPWC) critical period weed competition in order to avoid unacceptably high or significant yield losses. The presence of weeds before or after CPWC shouldn't pose a concern or significantly reduce yields. Consequently, crop production gained with CPWC weeding is substantially identical to that produced under full-season weed-free circumstances. Subramanian *et al.* (2005) [8] reported that intercropping offers the chance to use crops as biological weed control techniques since it suppresses weeds more effectively than solitary cropping. In this trail Intercropping with Dhanicha is grown in between rice (1:1 ratio) for better smothering effect. The seeds are soaked and treated with carbendazim at a seed rate of 40 kg ha^{-1}. The spacing of the main crop as well as intercrop was 25 cm. The soil type of the experimental field was sandy clay loam soil. Intercropping is done to reduce the weed density and to increase the nutrient level in the soil. Hand weeding, mechanical weeding, brown manuring and green manuring are used in this experiment to control the weed density.

2. Materials and Method

2.1 Location of the experimental site

A field experiment was conducted at Agricultural College and Research Institute, Killikulam, during the summer 2021-2022. The field trial was carried out on plot 9a" of the B block of the Agricultural College and Research Institute, Killikulam, which is located at 8°46' N latitude, 77°42'E longitude, and 40 MSL height and has a semi-arid climate.

2.2 Experimental design and layout

The field experiment was carried out in a factorial randomised block design with three replications. It consists of two factors: weed management and nitrogen management. The weed management factor has four levels, and nitrogen management also has four levels. The layout is formed based on treatment combinations of 16 and on plant spacing and dimensions for irrigation channels. The treatment consists (W1) Rice+ Dhaincha 1:1 ratio *fb* 2,4-D at 25 DAS (Brown manuring) *fb* mechanical weeding (MW) at 45 DAS, (W2) Rice+ Dhaincha 1:1 ratio *fb* 2 MW at 25 and 45 DAS (Green manuring), (W3) Rice alone with 2 mechanical weeding at 25 and 45DAS, (W4) Rice alone with 2 hand weeding at 25 and 45DAS, (N1) STCR-IPNS 100% at 4 varied split doses 20% at 15 DAS, 30% at active tillering (AT), 30% at Panicle initiation (PI) and 20% at Flowering, (N2) STCR-IPNS 75% at 4 varied split doses 20% at 15 DAS, 30% at AT, 30% at PI and 20% at Flowering, (N3) STCR-IPNS 75% with 5 split applications at 10 days interval from 15DAS (1/7+2/7+2/7+1/7+1/7), (N4) RDF Nitrogen at 4 split 20% at 15 DAS, 30% at AT, 30% at PI and 20% at Flowering.

2.3 Data collection

2.3.1 Weed density

The density of grasses, sedges, and broad-leaved weeds, was identified in the total weed population. At 20, 40 and 60 DAS, the total weed density and the individual group-wise densities were recorded using quadrats of 0.25 m^2 placed at four random locations and expressed as numbers m^{-2} (Van Heemst, 1985) [10].

2.3.2 Weed dry weight

The dry weight of the weeds was accounted and expressed in kg ha^{-1}. Weeds that were present within a one m^{-2} area in each individual plot were removed, shade dried, and then oven dried at 70 °C for 72 hours.

2.3.3 Weed Control Efficiency (WCE)

It was developed by (Yadav *et al.*, 2019) [11] and given as a percentage to measure the effectiveness of weed management (percent). Were, WDC-Dry weight of weeds in weedy check plot (kg ha^{-1}), WDT-Dry weight of weeds in treated plot (kg ha^{-1}).

$$WCE = \frac{WDC - WDT}{WDC} \times 100$$

2.3.2 Yield attributes

2.3.2a Panicle length

From the point of collar to the tip of the panicle, the length of 10 primary, secondary and tertiary panicles $hill^{-1}$ was measured and the mean length was given in cm.

2.3.2b Number of productive tillers m^{-2}

Each net plot, number of productive tillers in an area of 0.25 m^2 four random places was counted and expressed as numbers m^{-2}

3.1 Weed flora of the experimental field

The weed flora of the experimental field contains grass, sedges and broad-leaved weeds. Dominating grassy weeds are *Echinochloa Colona, Panicum repens* and sedges are *Cyperus rotundus,* which affects the plant's growth. The broad-leaved weeds which are grown in fields are *Digera arvensis, Celosia argentea, Corchorus aestuans, Trianthema portulacastrum, Phyllanthus maderaspatensis* and *Aerva lanata. These* are the dominating weeds which affect the rice growth. To control the weeds, different treatments are followed, such as dhaincha intercropping, hand weeding, mechanical weeding. All the treatments considerably reduce the weed density, weed dry matter over the control plot. Rice + Dhaincha 1:1 ratio *fb* 2,4-D at 25 DAS (Brown manuring) and mechanical weeding (MW) at 45DAS recorded low weed density and weed dry matter on the 20th and 60th days. On the 40th day, it remains on par with rice alone, with two hand weeding at 25 and 45DAS. The weed control efficiency and weed control index were more in (W1) Rice + Dhaincha 1:1 ratio *fb* 2,4-D at 25 DAS (Brown manuring) *fb* mechanical weeding (MW) on par with Rice alone with 2 hand weeding at 25 and 45 DAS on the 60th day. These findings were in accord with Parthipan *et al.* (2013) [4]. Weedy conditions harmed the rice crop's growth and yield-contributing characteristics, resulting in a 90% reduction in rice grain output.

4.1 Result

4.1a Weed dry weight

The effect of treatments on controlling the weed density and weed dry weight at different time intervals were given in Table 1. Minimal weed density and weed dry weight were on the 20 DAS in (W2) Rice+ Dhaincha 1:1 ratio *fb* 2 MW at 25 and 45 DAS (Green manuring) were 26.5 kg ha^{-1}. In 60 DAS (W1) Rice+ Dhaincha 1:1 ratio *fb* 2,4-D at 25 DAS (Brown manuring) and *fb* mechanical weeding (MW) at 45 DAS (Green manuring) reported low weed density and dry weight. The findings are in accordance with Radhakrishnan *et al.* (2010) [6]. The weed density and weed dry weight were low because the 75% nitrogen was applied in five varied split doses. The treatment is (N3) STCR-IPNS 75% with 5 split applications at 10-day intervals from 15 DAS (1/7+2/7+2/7+1/7+1/7). On the 60 DAS, the best interaction treatment was (W1N1) Rice+ Dhaincha 1:1 ratio fb 2,4-D at 25 DAS (Brown manuring) fb mechanical weeding (MW) at 45 DAS with STCR-IPNS 100% at four different split doses 20% at 15 DAS, 30% at active tillering (AT), 30% at panicle initiation (PI), and 20% at flowering. Subramanian *et al.* (2021) [9] reported this result in their research work. The weed density and weed dry weight are reduced at 60 DAS in intercropping of dhaincha followed by brown manuring compared to a sole crop of rice. This is due to the smothering impact of dhaincha, which may have decreased weed density and dry weight. Similar findings were reported by (Subramanian *et al.*, 2020) [7], who noted a 40-50% reduction in weed density when rice was intercropped with a brown manuring crop.

Table 1: Effect of weed management practices on total Dry weight of weeds (kg ha^{-1}) in aerobic rice

Treatment	20 DAS					40 DAS					60 DAS				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	26.5	26.1	27.6	27.4	26.9	262	325	291	321	300	168	225	220	222	209
W2	26.8	25.9	27.0	26.2	26.5	339	359	335	374	352	280	271	238	319	277
W3	56.6	52.9	57.3	50.0	54.2	407	379	362	299	362	347	364	287	312	327
W4	52.2	52.7	52.7	56.4	53.5	271	278	265	310	281	205	216	211	241	219
Mean	40.5	39.4	41.1	40.0		319	335	313	325		250	269	239	274	
	W		N		WxN	W		N		WxN	W		N		WxN
S.Ed.	0.32		0.32		0.64	2.09		2.09		4.18	4.67		4.67		9.34
CD	0.65		0.65		1.31	4.27		4.27		8.55	9.54		9.54		19.0

4.1b Weed control efficiency

The weed control efficiency varied according to the treatments used in the field trial at different time intervals, as shown in Table 2. The best treatment was (W1) Rice + Dhaincha 1:1 ratio *fb* 2,4-D at 25 DAS (Brown manuring) *fb* mechanical weeding (MW) at 45DAS at 60th day has 88.5% on par with (W4) rice alone with 2 hand weeding at 25 and 45DAS and weed control efficiency was 87.5%. The minimum weed control efficiency was recorded in (W3) rice alone with 2 mechanical weeding at 25 and 45DAS has 82.4%. Due to the smothering effect of dhaincha, the weed growth was controlled in the intercropping plot compared to the rice alone plot. On the 60th day, the best interaction treatment is (W1N1) Rice + Dhaincha 1:1 ratio *fb* 2,4-D at 25 DAS (Brown manuring) *fb* mechanical weeding (MW) at 45 DAS with STCR-IPNS 100% at four different split doses 20% at 15 DAS, 30% at active tillering (AT), 30% at panicle initiation (PI) and 20% at flowering. The higher weed control efficiency was recorded in Rice + Dhaincha 1:1 ratio *fb* 2,4-D at 25 DAS (Brown manuring) and *fb* mechanical weeding (MW) at 45DAS at 60th day reported these results in their research findings. The result of the incorporation of dhaincha, which was shown to be more successful in suppressing weed growth and reducing weed density and dry weight, was also impressive. Similar research results were found by Maity *et al.* (2009) [2].

Table 2: Effect of weed management practices on weed control efficiency (%) in aerobic rice

Treatment	20 Day					40 Day					60 Day				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	29.3	29.0	31.0	30.3	29.9	76.6	70.3	72.0	71.8	72.7	90.7	87.3	87.6	88.2	88.5
W2	29.7	28.7	30.0	29.3	29.4	69.8	67.6	68.6	67.2	68.3	84.7	83.7	87.2	83.6	84.8
W3	62.7	58.7	63.3	55.7	60.1	63.7	65.5	65.2	73.7	67.0	81.1	80.4	84.4	83.8	82.4
W4	57.7	58.3	58.7	62.3	59.3	75.9	74.9	75.2	72.7	74.7	88.6	87.0	88.0	86.5	87.5
Mean	44.8	43.7	45.8	44.4		71.5	69.6	70.3	71.4		86.3	84.6	86.8	85.5	
S.Ed	W		N		WxN	W		N		WxN	W		N		WxN
CD	0.41		0.41		0.82	0.55		0.55		1.11	0.70		0.70		1.41
	0.84		0.84		1.68	1.14		1.14		2.28	1.44		1.44		2.89

4.1c Panicle length and number of productive tillers m^{-2}

The effect of weed control treatments resulted in increasing the panicle length and the number of productive tillers m^{-2}. The maximum panicle length and number of tillers m^{-2} were recorded in rice alone with 2 hand weeding at 25 and 45DAS. In the treatment plot, the values are 22.7 and 295 respectively. The next best treatment (W1) Rice + Dhaincha 1:1 ratio *fb* 2,4-D at 25 DAS (Brown manuring) *fb* mechanical weeding (MW) at 45DAS. The findings were reported in Parthipan *et al.* (2013) [4]. The panicle length and number of productive tillers are more in (N4) RDF Nitrogen at 4 splits 20% at 15 DAS, 30%at AT, 30% at PI and 20% at flowering as compared to other treatments. (W1N4) rice+ Dhaincha 1:1 ratio fb 2,4-D at 25 DAS (Brown manuring) fb mechanical weeding (MW) at 45 DAS, with RDF Nitrogen at 4 splits 20% at 15 DAS, 30% at AT, 30% at PI and 20% at Flowering these results were recorded in Ogutu *et al.* (2012) [3]. The panicle length and number of productive tillers are recorded in RDF Nitrogen at 4 splits (20% at 15 DAS, 30% at AT, 30% at PI and 20% at flowering with dhaincha intercropping followed by brown manuring. This was most likely caused by the intercropping of dhaincha and its *in-situ* conservation, which released enough nutrients at crucial points in crop growth to fulfil crop needs during the growth period. The findings were accorded with the report of Subramanian, Sathish Kumar *et al*., (2021) [9].

Table 3: Effect of weed management practices on panicle length (cm) and No of tillers m^{-2} of aerobic rice

Treatment	Panicle length (cm)					No of tillers (m^{-2})				
	N1	N2	N3	N4	Mean	N1	N2	N3	N4	Mean
W1	22.7	21.6	20	23.2	21.8	301	289	257	334	295
W2	19.7	19.1	17.8	20.5	19.2	276	244	211	308	259
W3	18.6	18.1	17	19	18.1	253	228	206	289	244
W4	21.6	19.4	18.7	22.7	20.6	286	251	224	313	268
Mean	20.6	19.5	18.3	21.3		279	253	224	311	
	W		N		WxN	W		N		WxN
S.Ed	0.17		0.17		0.34	2.85		2.85		5.70
CD	0.35		0.35		0.70	5.82		5.82		11.6

Conclusion

From this study, it clearly indicated that, aerobic rice cultivation reduced the water input in 45-50%. Weed management is a greater problem in aerobic rice cultivation. In this experiment an ideal weed management practice was (W1) rice + Dhaincha 1:1 ratio *fb* 2,4-D at 25 DAS (Brown manuring) *and* mechanical weeding (MW) at 45DAS reduced the weed density and dry weight. This treatment produced higher yield attributing character. Among the nutrient management (N4) RDF at four splits 20% at 15 DAS, 30% at

AT, 30% at PI and 20% at flowering produced higher growth character and yield attributes. Hence, a treatment combination of (W1) rice + Dhaincha 1:1 ratio *fb* 2,4-D at 25 DAS (Brown manuring) and mechanical weeding (MW) at 45DAS with (N4) RDF at four splits 20% at 15 DAS, 30% at AT, 30% at PI and 20% at flowering are ideal for obtaining yield in aerobic rice cultivation.

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