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Weed Control Efficiency as Influenced by Nutrient Levels and Weed Management in Aerobic Rice

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A B S T R A C T

A field experiment was conducted during *kharif* 2023 and 2024 to study the influence of nutrient levels and weed management practices on weed control efficiency in aerobic rice. The experiment consisted of three nutrient levels *viz.,* 75:37.5:37.5 kg $N:P_2O_5:K_2O$ ha^{-1}, 100:50:50 kg $N:P_2O_5:K_2O$ ha^{-1} and 125:62.5:62.5 kg $N:P_2O_5:K_2O$ ha^{-1} along with four weed management practices *viz.,* hand weeding + intercultivation at 20 and 40 DAS, pyrazosulfuron ethyl 10% WP @ 100 g ha^{-1} (PE) + sunhemp, pyrazosulfuron ethyl 10% WP @ 100 g ha^{-1} (PE) + bispyribac sodium 10 SL @ 0.4 ml L^{-1} (POE) and weedy check. The experiment was laid out in factorial randomized block design with three replications. Among nutrient levels, higher weed control efficiency was recorded under application of 125:62.5:62.5 kg $N:P_2O_5:K_2O$ ha^{-1} with pooled values of 59.5 per cent at 45 DAS and 59.3 per cent at 60 DAS. Among weed management practices, hand weeding + intercultivation at 20 and 40 DAS recorded the highest pooled weed control efficiency of 89.3 per cent at 45 DAS and 82.7 per cent at 60 DAS.

Introduction

Rice is one of the most important cereal crops in the world and serves as the staple food for more than half of the global population. In India, rice occupies a major share in total food grain production and plays a vital role in ensuring food security. However, conventional transplanted rice cultivation requires large quantities of water, labour and energy. In recent years, increasing water scarcity, erratic rainfall, rising labour wages and shortage of farm labour have created serious challenges for sustaining conventional rice production (Kang and

Cho, 2022). Under such situations, aerobic rice has emerged as a promising alternative production system. Aerobic rice is cultivated under non-puddled and non-flooded conditions with irrigation applied as and when required. This method reduces water requirement considerably compared to transplanted rice. Aerobic rice is especially suitable for areas facing water scarcity and labour shortage.

Despite its advantages, weed infestation is considered one of the major constraints in aerobic rice cultivation. In conventional flooded rice fields, standing water suppresses the emergence of many weed species. However, in aerobic rice, the absence of standing water favours germination and rapid growth of a wide range of grasses, sedges and broad-leaved weeds. Weeds compete aggressively with the crop for moisture, nutrients, sunlight and space, particularly during the early growth stages (Kumar *et al.,* 2020).

Uncontrolled weed growth can cause substantial reduction in crop growth and yield in aerobic rice. Yield losses due to weeds in aerobic rice may range from 30 to 80 per cent depending upon weed flora, severity of infestation and duration of weed competition (Surendran *et al.,* 2021). Therefore, timely and effective weed management is essential for successful cultivation of aerobic rice.

Different weed management practices are available for controlling weeds in aerobic rice. Manual weeding through hand weeding and intercultivation is considered effective, but it is often difficult because of labour shortage and higher labour cost. Herbicides are widely used because they reduce labour requirement and provide timely weed control. Integration of herbicides with cultural methods such as cover crops and intercultivation can further improve weed suppression. Nutrient management also plays an important role in influencing weed growth and crop competition. Application of higher fertilizer levels may enhance crop vigour and canopy development, which can help in suppressing weeds. However, weeds also respond positively to nutrient application and may grow vigorously if not controlled properly. Therefore, it is necessary to understand the combined effect of nutrient levels and weed management practices on weed control (Pan *et al.,* 2017).

Weed control efficiency is an important parameter used to evaluate the effectiveness of weed management treatments. It indicates the degree of weed suppression achieved under different treatments compared to the untreated control. Estimation of weed control efficiency helps in identifying suitable nutrient and weed management practices for aerobic rice (Yadav *et al.,* 2017).

Keeping these facts in view, the present investigation was undertaken to study the influence of nutrient levels and weed management practices on weed control efficiency in aerobic rice.

Materials and Methods

The field experiment was conducted during the *kharif* seasons of 2023 and 2024 at the Zonal Agricultural and Horticultural Research Station (ZAHRS), Navile, Shivamogga, Karnataka, India, to study the influence of nutrient levels and weed management practices on weed control efficiency in aerobic rice. The soil of the experimental site was red sandy loam, low in nitrogen, high in phosphorus and medium in potassium, with a pH of 5.89. The experimental site was suitable for aerobic rice cultivation. The experiment was laid out in factorial randomized block design with three replications.

Treatment details

The experiment consisted of three nutrient levels and four weed management practices

Nutrient levels

- N_1: 75:37.5:37.5 $N:P_2O_5:K_2O$ ha^{-1}
- N_2: 100:50:50 kg $N:P_2O_5:K_2O$ ha^{-1}
- N_3: 125:62.5:62.5 kg $N:P_2O_5:K_2O$ ha^{-1}

Weed management practices

- W_1: Hand weeding + intercultivation at 20 and 40 DAS
- W_2: Pyrazosulfuron ethyl 10% WP @ 100 g ha^{-1} (PE) + sunhemp
- W_3: Pyrazosulfuron ethyl 10% WP @ 100 g ha^{-1} (PE) + bispyribac sodium 10 SL @ 0.4 ml L^{-1} (POE)
- W_4: Weedy check

The recommended dose of fertilizers was applied according to treatment details. Full dose of phosphorus and potassium and half dose of nitrogen were applied as basal dose at the time of sowing. The remaining nitrogen was applied in two equal splits at active tillering and panicle initiation stages.

Rice was sown under aerobic conditions by maintaining optimum soil moisture. All the recommended agronomic practices were followed uniformly for all the treatments except nutrient and weed management treatments.

In W_1 treatment, hand weeding and intercultivation were carried out manually at 20 and 40 DAS. In W_2 treatment, pyrazosulfuron ethyl 10% WP was applied as pre-emergence herbicide at 100 g ha^{-1} immediately after sowing, followed by growing of sunhemp as intercrop for weed suppression. In W_3 treatment, pyrazosulfuron ethyl 10% WP was applied as pre-emergence herbicide at 100 g ha^{-1} followed by application of bispyribac sodium 10 SL at 0.4 ml L^{-1} as post-emergence herbicide. W_4 was maintained as untreated weedy check throughout the crop growth period.

Observations on weed dry weight were recorded at 45 and 60 DAS by collecting weeds from randomly selected quadrats in each plot. The collected weeds were dried under sunlight followed by oven drying until constant weight was obtained.

Weed control efficiency was calculated by using the following formula:

Weed Control Efficiency (WCE) = [(Weed dry weight in weedy check – Weed dry weight in treated plot) / Weed dry weight in weedy check] × 100

The recorded data were statistically analyzed using analysis of variance appropriate for factorial randomized block design. Significance of treatment differences was tested at 5 per cent level of significance.

Results and Discussion

Effect of nutrient levels on weed control efficiency

Different nutrient levels significantly influenced weed control efficiency at both 45 and 60 DAS. At 45 DAS, higher weed control efficiency was recorded under N_3 with pooled value of 59.5 per cent, followed by N_2 (56.0%) and N_1 (54.4%). Similar trend was observed at 60 DAS where N_3 recorded pooled weed control efficiency of 59.3 per cent.

The higher weed control efficiency recorded under N_3 might be due to better crop growth, increased tillering, higher leaf area and rapid canopy development under higher nutrient availability. Adequate supply of nitrogen, phosphorus and potassium may have helped the crop to establish quickly during the early stages, resulting in better ground coverage and reduced space for weed emergence. A vigorous crop canopy intercepts more sunlight and reduces light penetration to the soil surface, thereby suppressing weed germination and growth (Pavithra and Poonguzhalan, 2018).

Application of higher nutrient levels may also improve root growth and nutrient absorption by the crop, enabling it to compete more effectively with weeds for moisture, nutrients and sunlight. Under aerobic conditions, where weeds emerge rapidly because of absence of standing water, crop competitiveness becomes an important factor in reducing weed growth. Hence, plots receiving higher fertilizer dose showed relatively better weed control efficiency.

In contrast, lower weed control efficiency under N_1 could be attributed to poor crop vigour, reduced canopy spread and weaker competitive ability of the crop. Lower fertilizer availability may have restricted crop growth and left more open space for weeds to proliferate (Yadav *et al.,* 2018). Weeds present under low nutrient conditions may have utilized the available moisture and nutrients more effectively than the crop, resulting in relatively lower weed control efficiency.

Effect of weed management practices on weed control efficiency

Among weed management practices, hand weeding + intercultivation at 20 and 40 DAS (W_1) recorded significantly higher weed control efficiency with pooled values of 89.3 per cent at 45 DAS and 82.7 per cent at 60 DAS.

The superior performance of W_1 might be due to effective removal of weeds at the critical stages of crop growth. Hand weeding at 20 DAS removed the initial flush of weeds, while intercultivation and second hand weeding at 40 DAS helped in controlling later emerging weeds.

This sequential removal of weeds reduced weed competition throughout the crop growth period and maintained the crop in a relatively weed-free condition (Paramesh *et al.,* 2014).

Mechanical removal of weeds through hand weeding and intercultivation uprooted weeds completely and prevented them from competing with the crop for moisture, nutrients, light and space (Gong *et al.,* 2024). Intercultivation also loosened the soil surface, improved soil aeration and helped in conserving soil moisture, which might have contributed to better crop growth.

Interaction effect of nutrient levels and weed management practices on weed control efficiency

Higher weed control efficiency under N_3W_1 and N_2W_1 interaction treatments might be due to the combined effect of optimum nutrient supply and effective weed removal through hand weeding and intercultivation. Adequate fertilizer availability helped the crop to produce more tillers, greater leaf area and rapid canopy development, which enhanced crop competitiveness against weeds. Simultaneously, manual weeding operations at 20 and 40 DAS removed the weeds completely during the critical crop-weed competition period (Kalaimathi *et al.,* 2023). The interaction effect clearly indicated that nutrient application alone was not sufficient to improve weed control efficiency unless weeds were effectively managed. Under higher nutrient levels, weeds also tend to grow vigorously because of better nutrient availability. Therefore, if proper weed control measures are not adopted, the added nutrients may be utilized by weeds rather than the crop.

Among the herbicidal treatments, higher weed control efficiency under N_3W_2 might be due to better crop vigour under higher fertilizer application combined with effective early weed suppression by pyrazosulfuron ethyl and later weed smothering effect of sunhemp.

The cover crop might have reduced weed emergence by shading the soil surface and competing with weeds for nutrients, moisture and space (Kumar *et al.,* 2023).

The lower weed control efficiency observed under interaction treatments involving weedy check could be due to unrestricted weed growth throughout the crop growth period. Under higher nutrient levels, weeds in weedy check plots might have utilized the available nutrients more effectively and produced greater biomass, which reduced weed control efficiency substantially (Pratap *et al.,* 2017).

Fig.1 Interaction Effect of Nutrient Levels and Weed Management Practices on Weed Control Efficiency at 45 and 60 DAS in Aerobic Rice

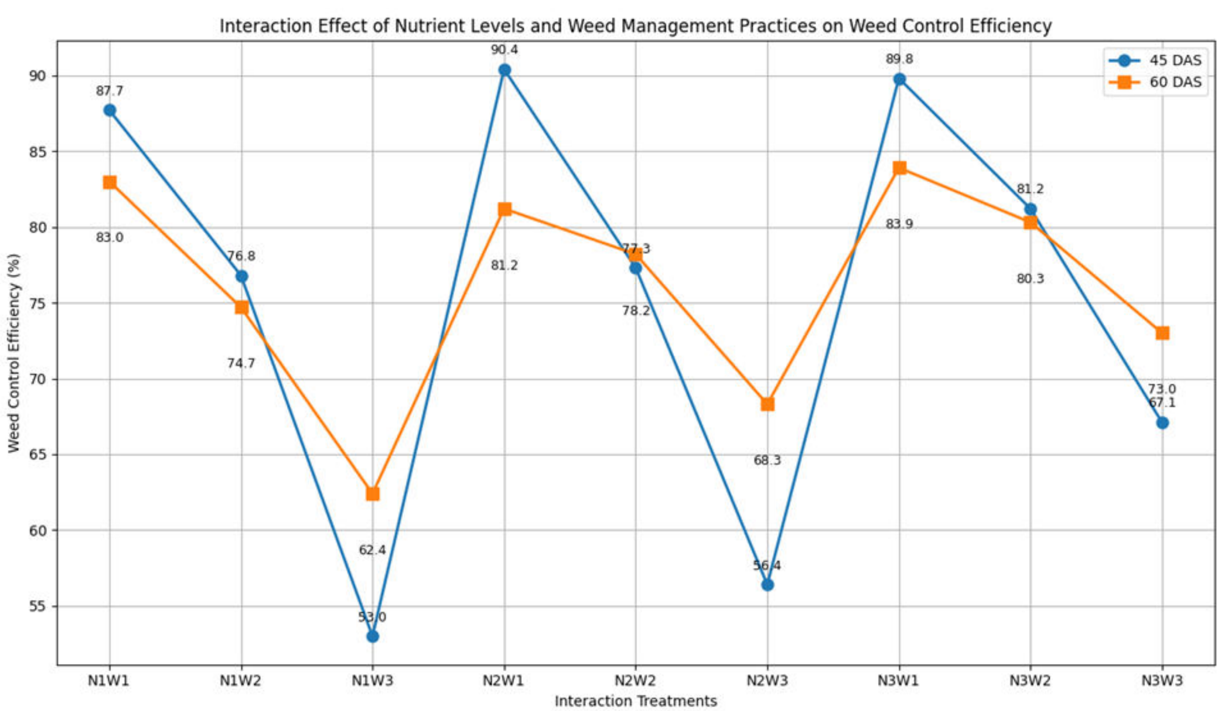

Table.1 Weed control efficiency as influenced by different nutrient levels and weed management practices in aerobic rice

Treatments	45 DAS			60 DAS		
	2023	2024	Pooled	2023	2024	Pooled
Nutrient levels (N)						
N_1	55.5	53.3	54.4	56.9	53.2	55.0
N_2	55.6	56.4	56.0	59.3	54.5	56.9
N_3	58.6	60.5	59.5	60.2	58.4	59.3
S.Em±	0.7	0.7	0.7	0.5	0.7	0.6
C.D. at 5%	2.0	2.1	2.0	1.6	1.9	1.8
Weed management practices (w)						
W_1	89.3	89.3	89.3	83.6	81.8	82.7
W_2	78.0	78.9	78.4	80.3	75.1	77.7
W_3	58.9	58.8	58.9	71.3	64.5	67.9
W_4	-	-	-	-	-	-
S.Em±	0.8	0.8	0.8	0.6	0.8	0.7
C.D. at 5%	2.3	2.4	2.3	1.9	2.2	2.0
Nutrient levels X Weed management practices (N X W)						
N_1W_1	88.2	87.2	87.7	83.7	82.3	83.0
N_1W_2	77.3	76.3	76.8	77.3	72.0	74.7
N_1W_3	56.3	49.7	53.0	66.5	58.3	62.4
N_1W_4	-	-	-	-	-	-
N_2W_1	90.3	90.6	90.4	82.9	79.4	81.2
N_2W_2	77.1	77.5	77.3	81.8	74.5	78.2
N_2W_3	55.2	57.7	56.4	72.5	64.1	68.3
N_2W_4	-	-	-	-	-	-
N_3W_1	89.4	90.2	89.8	84.1	83.7	83.9
N_3W_2	79.7	82.7	81.2	81.9	78.8	80.3
N_3W_3	65.2	69.1	67.1	74.9	71.2	73.0
N_3W_4	-	-	-	-	-	-
S.Em±	1.4	1.4	1.4	1.1	1.3	1.2
C.D. at 5%	4.0	4.1	4.1	3.2	3.9	3.5

N): Nutrient levels	**(W): Weed management practices**
N_1: 75:37.5:37.5 NPK kg ha^{-1}	W_1: Hand weeding + Intercultivation (20 and 40 DAS)
N_2: 100:50:50 NPK kg ha^{-1}	W_2: Pyrazosulfuron ethyl 10% WP @ 100gm/ha (PE) + sunhemp
N_3: 125:62.5:62.5 NPK kg ha^{-1}	W_3: Pyrazosulfuron ethyl 10% WP @ 100gm/ha (PE) + Bispyribac sodium 10 SL 0.4 ml\ltr (POE)
	W_4: Weedy check

These findings suggest that higher nutrient levels should always be combined with efficient weed management practices to achieve better weed suppression and improved crop growth in aerobic rice.

In conclusion, the results of the study revealed that weed control efficiency in aerobic rice was significantly influenced by nutrient levels and weed management practices. Among the nutrient levels, application of 125:62.5:62.5 kg N:P_2O_5:K_2O ha^{-1} recorded higher weed control efficiency at both 45 and 60 DAS owing to better crop vigour and competitive ability against weeds.

Among weed management practices, hand weeding combined with intercultivation at 20 and 40 DAS recorded the highest weed control efficiency throughout the crop growth period. This treatment effectively controlled weeds during the critical stages of crop growth and maintained the crop under relatively weed-free conditions.

Among the herbicidal treatments, application of pyrazosulfuron ethyl 10% WP @ 100 g ha^{-1} as pre-emergence followed by sunhemp proved superior over sequential application of pyrazosulfuron ethyl followed by bispyribac sodium. The combined effect of herbicide and smother crop helped in achieving better weed suppression.

Interaction effects indicated that higher nutrient levels should be combined with efficient weed management practices to achieve maximum weed control efficiency. Application of higher nutrients without proper weed control may favour weed growth and reduce the benefits of fertilizer application.

Therefore, for effective weed management in aerobic rice, application of 125:62.5:62.5 kg $N:P_2O_5:K_2O$ ha^{-1} along with hand weeding and intercultivation at 20 and 40 DAS may be recommended. Under labour shortage conditions, pyrazosulfuron ethyl 10% WP @ 100 g ha^{-1} as pre-emergence followed by sunhemp can be considered as an effective alternative weed management practice.

Author Contributions

Dr. M. Raghuveer: Conceived the original idea and designed the model and wrote the manuscript. Dr. C. J. Sridhara: Designed the model and the computational framework and analysed the data. Dr. Shankarappa sridhara: Contributed to review and editing of the manuscript and supervised the research work. Dr. M. S. Nandish: Assisted in field experimentation, data collection, interpretation of results and manuscript review. Dr. G. K. Girijesh: Contributed to data compilation, statistical interpretation and editing of the manuscript. Dr. K. T. Gurumurthy: Provided overall supervision, technical guidance and final approval of the manuscript.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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