**Weed management in aerobic rice cultivation in South Gujarat, India**

**ABSTRACT**

An experiment on weed management in aerobic rice cultivation in South Gujarat India was conducted during the *kharif* seasons of 2020-2022 at the Main Rice Research Centre, Navsari Agricultural University, Navsari, Gujarat, India. The experiment was carried out in a Randomized Block Design with three replications. The results revealed that total weed population-grasses, sedges, and broad-leaved weeds and dry weed biomass was affected by different weed management practices as compared to unweeded practices. Total weed population and dry weed biomass were significantly lower with weed-free practices, but they remained at par with mechanical weed management practices. The weed index was found to be lower with weed-free practices followed by mechanical weeding. Weed control efficiency was recorded as higher under weed-free treatment, followed by mechanical weeding, as compared to the rest of the weed management treatments. Yield attributes like panicle/m2, panicle weight, grain and straw yield of rice were recorded significantly higher with weed-free treatment, but it was at par with mechanical weeding.

***Keywords****: Aerobic rice, weed management, mechanical weeding, yield, sustainable practice*

**1. INTRODUCTION**

Rice is an important staple food crop in India. It is mainly grown by manual transplanting of seedlings into puddled soil. Aerobic rice system is the growing of rice in non-puddled and non-flooded soil, which adds to water productivity by reducing the seepage, percolation, and evaporation. Hence, aerobic rice is one of the options to minimize the irrigation requirement of the rice crop. However, it is subject to much higher weed pressure with a broader weed spectrum than flood-irrigated rice. Moreover, land area under the aerobic rice system is expected to increase in the future because of labour and water shortage. Rice and groundnut are very sensitive to weed competition in the early stage of growth, and failure to control weeds in the first three weeks after seeding reduces the yield by 50 per cent [15]. The most common methods of weed control are mechanical, chemical, biological, and cultural methods. Chemical weed control is more prominent than manual and mechanical practices. However, its adverse effects on the environment are causing farmers to consider and accept mechanical methods. Further, herbicides are an economic tool to fight against weeds, but continuous use of one herbicide for a long time may result in the development of herbicide-resistant weed biotypes, causing a shift in weed flora. Manual weeding alone is time consuming and costly. Mechanical weeding has always been an environment-friendly, sustainable weeding substitute in agricultural history, and it is also the most important alternative to chemical weed control [6]. The substitution of manual weeding with mechanical tools is considered an important intervention in both upland rice and organic production systems [11]. Further, a single weed control approach may not be able to keep weeds below the economic threshold level and result in an environmental hazard. Therefore, integrated approaches are suggested for weed control since they may be found most practical and cost-effective for reducing weed competition and the sustainability of direct-seeded rice. Considering the above weed management approach, a field experiment was conducted to evaluate the feasibility of various weed management options during the cropping period and to develop appropriate, economic, and eco-friendly weed management method in aerobic rice cultivation.

**2. MATERIAL AND METHODS**

A field experiment was conducted during *Kharif* season of 2020 to 2022 at Main Rice Research Centre Farm, Navsari Agricultural University, Navsari, Gujarat, india. The soil of the experiment field was clayey in texture, alkaline in nature, low in available nitrogen, medium in available phosphorus and high in available potassium. Experiment consisting 10 treatments as below:

T1- Mulching with paddy straw @ 5 t/ha at the time of sowing

T2- Mulching (paddy straw @ 5 t/ha) at the time of sowing + Bispyribac sodium 10 % SC, 10 ml/10 lit water at 20 DAS

T3- Mechanical weeding (thrice) using weeder

T4- Chemical weed control (Pre-pedimethalin @ 1.5 kg a.i./ha at 2-3 DAS and post- bispyribac sodium 10 % SC, at 20 DAS)

T5- Mechanical weeding + Bispyribac sodium 10 % SC, 10 ml/10 lit water at 20 DAS

T6- Pre emergence herbicide (pendimethalin @ 1.5 kg a.i./ha) followed by one mechanical weeding at maximum tillering stage of crop

T7- Intercropping in rice with sesbania (incorporation after 1 to 1.5 month of sowing)

T8- Raised bed system of cultivation with application of bispyribac-sodium @200-250 ml/ha at 2-3 leaf stage of weeds at 20-25 DAS

T9-Weed-free

T10- Weedy check

The treatments were replicated thrice in randomized block design. In *kharif* season, ‘GNR-3’ rice variety was sown with seed rate of 50 kg/ha at spacing of 30 cm between rows. The recommended dose of fertilizer is 100-30-0 kg NPK/ ha and nitrogen was applied in three splits viz., 40 % as basal, 40 % at tillering stage, and 20 % at panicle initiation stage. Full dose of P was applied as basal to the crop. The data on weed population (grasses, sedges, and broad-leaved weed (BLW)) and dried weeds were collected at 15-20 days after sowing, maximum tillering stage (60-65 days after sowing), and panicle initiation stage (80-85 days after sowing) of rice crop. For measurement of weed count and dried weeds, 1m × 1 m quadrant was used and samples at three spots were taken at all observation. Weed population (density) data was transformed using square root transformation to normalize their distribution before analysis. Yield attributes were measured from a sample of five panicles drawn at random from each plot at harvesting. The net plot was harvested and sun dried for followed by weighing the biological yield. Threshing was done manually and weighing of grain was done at about 14% moisture content. The other cultural operation and irrigations were given as common practices as per the recommendation for the rice followed in the region. The statistical significance among applied treatments was studied by using analysis of variance (ANOVA) following the standard procedure [12]. Weed index and weed control efficiency were calculated as per the standard formulae given below:

|  |  |  |  |
| --- | --- | --- | --- |
| Weed control efficiency | = | Dry weed biomass in unweeded plot -Dry weed biomass in treated plot | x 100 |
| Dry weed biomass in unweeded plot |

|  |  |  |  |
| --- | --- | --- | --- |
| Weed  control index | = | Yield from weed-free plot-Yield from treatment plot | x 100 |
| Yield from weed-free plot |

**3. RESULTS AND DISCUSSION**

**3.1 Weed flora**

The major weeds infesting aerobic rice during the experimental period were grasses, *viz., Echinochloa colona* L.*, Echinochloa crusgalli* L.*, Dactyloctenium aegyptium* L.*, Setaria glauca* L.; sedges *viz., Cyperus iria* L.*, Cyperus difformis* L.*, Fimbristylis littoralis* L., and broad-leaf weeds *viz., Eclipta alba* L.*, Marsilea quadrifolia* L., *Rotala densiflora, Bergia carpensis* L.*, Celosia argentea* L., etc. Almost similar composition of weed flora in direct-seeded rice [5,14].

**3.2 Effect on weeds**

The results of total weed population (grasses, sedge, and BLW), weed biomass, and weed control efficiency are presented in Table 1. The highest weed density and biomass were found in the weedy check plots, which were significantly higher than other treatments [9,10]. This also indicates the abundance of weed seed bank [13].In three years, pooled results showed significantly lower weed population and dry weed biomass of grasses, sedges, and broad-leaved weeds were counted with weed-free (T9) treatment, followed by mechanical weeding (T3), than the rest of the treatments. Weed control efficiency (WCE) refers to the magnitude of effective reduction of weeds by different weed management treatments over unweeded control. This was highly influenced by various weed management methods in the experiment conducted. It was observed that among all weed control methods, higher weed control efficiency was counted under the weed-free plot (61.49%), followed by thrice weeding using a mechanical weeder (43.97%). This might be due to a greater reduction of weeds through timely control of weeds. Previous studies have also reported the highest weed control efficiency with mechanical weeding as compared to control treatment [2,11,17]. The result of the weed index shows that the weed index was also lower under the weed-free receiving plot, followed by mechanical weed management practice (T3), and it was found to be lower in the weedy check plots. This was mainly due to better control of weed growth, resulting in lower dry weed biomass. The weed index in the weed-free plot was zero because the weeds were completely removed. Weedy check plot produced a higher weed index as compared to other weed management treatments due to the presence of invasive weeds, which were never removed from the plot.

**Table 1: Effect of weed management treatments(T) on total weed population and weed control efficiency (Pooled data of three years)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments\*** | | **Total weed population (No./m2)** | | | **Weed control efficiency (%)** |
| **Grasses** | **Sedges** | **BLW\*\*** |
| **T1** |  | 2.38  (5.19) | 2.35  (5.04) | 2.72  (7.22) | 41.87 |
| **T2** |  | 2.51  (5.81) | 2.49  (5.70) | 2.76  (7.41) | 34.33 |
| **T3** |  | 2.33  (4.92) | 2.32  (4.90) | 2.64  (6.74) | 43.97 |
| **T4** |  | 2.48  (5.67) | 2.48  (5.63) | 2.75  (7.37) | 37.11 |
| **T5** |  | 2.51  (5.78) | 2.44  (5.45) | 2.75  (7.37) | 36.20 |
| **T6** |  | 2.50  (5.74) | 2.51  (5.78) | 2.68  (7.00) | 32.42 |
| **T7** |  | 2.46  (5.55) | 2.37  (5.11) | 2.66  (6.85) | 36.90 |
| **T8** |  | 2.44  (5.45) | 2.37  (5.11) | 2.73  (7.26) | 33.14 |
| **T9** |  | 1.98  (3.41) | 2.00  (3.48) | 1.94  (3.56) | 61.49 |
| **T10** |  | 3.18  (9.63) | 3.08  (8.96) | 3.62  (12.89) | - |
| SEm ± | | 0.04 | 0.05 | 0.04 | - |
| CD (p=0.05) | | 0.11 | 0.13 | 0.13 | - |
| CV % | | 4.88 | 5.32 | 5.04 | - |

\*as per methods

\*\* Broad leaved weeds

***Note***: *Figure out side parenthesis indicates √x+0.5 transformed values.*

**Table 2: Effect of weed management treatments on total dry weed biomass and weed index (Pooled data of three years)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | | **Total dry weed biomass (g/m2)** | | | **Weed Index** |
| **Grasses** | **Sedges** | **BLW** |
| **T1** |  | 7.64 | 7.18 | 11.80 | 15.87 |
| **T2** |  | 8.52 | 8.37 | 13.05 | 13.49 |
| **T3** |  | 7.10 | 7.14 | 11.39 | 7.88 |
| **T4** |  | 8.17 | 8.01 | 12.49 | 15.51 |
| **T5** |  | 8.43 | 8.07 | 12.55 | 14.26 |
| **T6** |  | 8.80 | 8.71 | 13.21 | 17.94 |
| **T7** |  | 8.76 | 8.09 | 11.59 | 15.05 |
| **T8** |  | 9.37 | 8.23 | 12.74 | 16.76 |
| **T9** |  | 5.79 | 5.11 | 6.10 | 0.00 |
| **T10** |  | 13.60 | 11.82 | 20.53 | 37.30 |
| SEm ± | | 0.24 | 0.23 | 0.36 | - |
| CD (p=0.05) | | 0.68 | 0.66 | 1.02 | - |
| CV % | | 8.61 | 8.76 | 8.95 | - |

**3.3 Effect on crop yield and its attributes**

Weed management practices had a significant effect on rice yield and yield parameters (Table 3). The number of panicle/m2 and panicle weight was recorded significantly higher under weed-free conditions and at par with weeding with mechanical weeder (T3) compared to the weedy check. It may be due to the minimal crop-weed competition, which ensured sufficient nutrients and other growth resources, thereby enhancing higher panicle production. Weed-free treatment produced the highest test weight, but it was statistically similar to the results of the treatments T1, T3, T5, T6, and T7 but was found significantly different from the weedy check. The weedy check had the lowest test weight (1000 grain weight) because of the unfavourable environment created by weeds throughout the crop period. Grain yield was significantly influenced by different weed management practices; weed-free treatment (T9) and mechanical weeding using weeder treatment (T3) were found equally effective and at par with each other in increasing grain yield of rice (5040 and 4731 kg/ha, respectively) over the rest of the weed management treatments. The variation in rice yield due to different weed management practices in transplanted rice [16]. The grain yield was recorded as higher with mechanical weeding as compared to chemical weed management [2]. Mechanical weeder helped in increasing rice yield [4]. The increased yield in mechanical weeding practices could be due to higher productive panicles and grain-filling percentage [1,11]. Further, three times mechanical weeding in both directions was capable of producing higher yields in rice [14,17]. Mechanical method of controlling weeds not only kills the weed between rows, but also loosens the soil surface, ensuring better soil aeration, and water intake capacity. This technique may be effectively buried and incorporates the weeds into the soil and minimizes the weed competition. Further, it improves the soil aeration, root development, nutrient absorption, and the number of tillers, which favoured the crop growth; yield attributes, and results in higher grain yield [17]. Significantly higher straw yield was recorded with the treatment T9 (weed-free), which was at par with treatments T2, T3, T4, and T5. Mechanical weeding technique avoids the use of herbicides and increased grain yield, promotes rice growth, and provided an efficient and non-chemical weeding method for rice production [7,8]. The lower yield in the weedy check treatment might be due to competition from weeds, which reduced leaf area index (LAI) and allowed less light transmission, producing less biosynthate and ultimately low dry matter production.

**Table 3: Effect of weed management treatments on yield and yield parameters of aerobic rice (Pooled data of three years)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatment\*** | **Panicle/m2** | **Panicle weight**  **(g)** | **Test weight**  **(g)** | **Grain yield (kg/ha)** | **Straw Yield (kg/ha)** |
| T1 | 206 | 4.74 | 30.98 | 4227 | 7122 |
| T2 | 201 | 4.49 | 29.95 | 4349 | 6545 |
| T3 | 211 | 5.31 | 31.75 | 4731 | 7556 |
| T4 | 207 | 4.74 | 30.00 | 4242 | 7089 |
| T5 | 206 | 4.94 | 31.07 | 4322 | 6925 |
| T6 | 192 | 4.83 | 30.59 | 4115 | 6449 |
| T7 | 200 | 4.41 | 31.16 | 4270 | 6674 |
| T8 | 191 | 4.88 | 29.46 | 4171 | 6808 |
| T9 | 228 | 5.50 | 32.49 | 5040 | 7828 |
| T10 | 168 | 3.45 | 27.99 | 3166 | 5516 |
| SEm ± | 6 | 0.13 | 0.87 | 112 | 203 |
| CD (p=0.05) | 17 | 0.37 | 2.47 | 318 | 574 |
| CV % | 8.70 | 8.24 | 8.55 | 7.88 | 8.87 |

\* as per methods

**4. Conclusion**

Based on the results of the experiment, mechanical weeding with a weeder – conducted three times at 20 days after sowing, and twice more at 15-20 days interval –proved effective in controlling weed growth. Both the grain yield and yield attributing characters of rice were found to be better with mechanical weeding practices than chemical and cultural practices. Therefore, mechanical weed management not only promoted rice growth, but also avoided the use of chemicals for weed control, making it sustainable and eco-friendly option for aerobic rice cultivation in south Gujarat, India.

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**REFERENCES**

1. Akbar, N., Jabran, K., & Ali, M.A. (2011). Weed management improves yield and quality of direct seeded rice. *Australian Journal of Crop Science*, 5, 688-694.
2. Anantachar, M., Mareppa, N. B., Sushilendra and Sunil Shirwal (2018). Development, testing and performance evaluation of push type conoweeder for wet land paddy crop. *Journal of Pharmacognosyand Phytochemistry* 7(2): 2394-2397.
3. Gangawar, S. K. and Reyaz, A. (2019). Evaluation of mechanical and chemical weed management in rice. *International Journal of Advanced Biological Research*, 9 (4): 318-322.
4. Kathia, M.K., Mati, B., Ndiiri, J. and Wanjogu, R. (2019). Integrating mechanical weeding and planting for reduced labour input in paddy rice under system of rice intensification. *Agricultural Sciences*, 10:121-130.
5. Kashyap, S., Singh, V.P., Guru, S.K., Pratap, T., Singh, S.P. and Praharaj, S. (2019). Integrated weed control option for dry direct seeded rice under irrigated ecosystem. *International Journal of Current Microbiology and Applied Science*, 8(2): 315-323.

6. Kunz, C., Weber, J., Gerhards, R., (2015). Benefits of precision farming technologies for mechanical weed control in soybean and sugar beet-comparison of precision hoeing with conventional mechanical weed control.*Agronomy,* 5, 130-142.

7. Kumar, Mahender. R., Singh, Vidhan, T., Sreedevi, B., Surekha, K., Padmavathi, Ch., Prasad, M.S., Gangaiah, B., Sudhaker, T., Srinivas, D., Subbarao, L.V. Muthuraman, P., Tuti, Mangaldeep and Ravindra Babu, V. (2016). Mechanized weed management to enhance productivity in System of rice Intensification. *Indian Journal of Weed Science*, 48 (3): 256-261.

8. Liu, C., Yang, K., Chen, Y., Gong, H., Feng, X., Tang, Z., Dengbin, Fu., & Long, Qi. (2023). Benefits of mechanical weeding for weed control, rice growth characteristics and yield in paddy fields. *Field Crop Research*, 293:108852.

9. Mandal, M.K., Duary, B.,&De, G.C. (2013). Effect of crop establishment and weed management practices on weed growth and productivity of Basmati rice. *Indian Journal of Weed Science*, 45(3): 166–170.

10. Mitra, B.K., Karim, A.J.M.S., Haque, M.M., Ahmed, G.J.U.,&Bari, M.N. (2005). Effect of weed management practices on transplanted Aman rice. *Journal of Agronomy,*4(3): 238– 241.

11. Mohanty, D.K. and Bhuyan, J. (2020). Evaluation of different mechanical weed controls methods in rice field, *Journal of Krishi Vigyan*, 8 (2): 115-119.

12. Panse, V.G., & Sukhatme, P.V. (1957). Publication and information division Statistical Indian methods for agricultural workers. Council of Agricultural Research.New Delhi. pp. 87-89.

13. Sharma, P., Singh, M.K., Verma, K. and Prasad, S.K.(2020). Changes in the weed seed bank in long-term establishment methods trials under rice-wheat cropping system. *Agronomy,*10(2): 292; doi:10.3390/agronomy10020292.

14. Singh, S.K., Kumar, A., Sarkar, B. and Mishra, P. K. (2019). Mechanized weed management to enhance productivity and profitability in system of rice intensification. *Indian Journal of Weed Science*, 51 (3): 232-235.

15. Sridhar, H. S. (2013). Development of single wheel multi use manually operated weed remover. *Int J Modern Engg Res*, (IJMER) 6(3): 3836-3840.

16. Rathod, B.G.S. and Somasundaram, E. (2019). Eco-friendly weed management in organic rice (*Oryza sativa* L.) production. *Journal of Pharmacognosy and Phytochemistry*, 8(6): 2544 2549.

17. Roy, S. (2012). Effect of age of seedling and weed management practices on the productivity of rice under system of rice intensification (SRI),*KrishKosh.eagranth.ac.in*.