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

**ABSTRACT**

The experimententitled Weed management in aerobic rice cultivation in South Gujarat, India was conducted during *kharif* seasons of 2020-2022 at the Main Rice Research Centre, Navsari Agricultural University, Navsari, Gujarat. The experiment was carried out in Randomized Block Design with three replications. The results revealed that total weed population-grasses, sedges and broad leaved weed 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 recorded lower with weed free practices but it was remained at par with mechanical weed management practices. Weed index was found lower with weed free practices followed by mechanical weeding. Weed control efficiency was recorded higher under weed free treatment followed by mechanical weeding as compared to 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.Thus, among different weed management practices, mechanical weeding method found sustainable, efficient and eco-friendly in aerobic system for rice production.

***Keywords****: Aerobic cultivation,rice, mechanical weeding, yield, sustainable practice*

**1. INTRODUCTION**

Rice is an important staple food crop in India. It is mainly grown by manual transplanting of seedling 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 irrigation requirement of rice crop. However, it is subject to much higher weed pressure with a broader weed spectrum than flood-irrigated rice and land area under these systems 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 reduce the yield by 50 per cent (Sridhar,2013).The most common methods of weed control are mechanical, chemical, biological, and cultural methods. Chemical method of weed control is more prominent than manual and mechanical practice. However, its adverse effects on the environment are making farmers to consider and accept mechanical methods. Further, herbicide is the economic tool to fight against weeds butcontinuous use of one herbicide for a long time may result in development of herbicide resistant weed biotypes and 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 (Kunz et al., 2015). The substitution of manual weeding with mechanical tools is considered as an important intervention in both upland rice and organic production system (Mohanty and Bhuyan, 2020). Further, single weed control approach may not be able to keep weeds below the economic threshold level and result in environmental hazard (Fishkis et al., 2024).Therefore, integrated approaches are suggested for weed control since it may find most practical and cost effective for reducing weed competition and sustainability of direct seeded rice (Pervaiz et al., 2024). Considering the above weed management approach, a field experiment was conducted to evaluate the feasibility of various weed management options during cropping period and developing 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 Navsari Agricultural University campus is geographically located at 20° 57’ N latitude and 72° 54’ E longitude at an altitude of 10 m above the mean sea level. The soil of the experiment field come under great group of Vertic chromustert or Typic chromustert. Soils are deep, clayey in texture, with good water holding capacity, medium to poor drainage with flat topography. Clay content ranges from 42 to 50 per cent with dominance of montmorillonite clay mineral.It is slightly alkaline in nature (pH 7.88, 7.88 and 7.86), low in available nitrogen (282, 266 and 226 kg/ha), medium in available phosphorus (22, 32 and 36 kg/ha) and high in available potassium (851, 596 and 789 kg/ha). The plot size was 2.4 m x 4.8 m while for treatment T8 it was1.2 m x 4.8 m. 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 Days after Sowing (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 as it was suitable for aerobic system and 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 N (nitrogen) P (phosphorus) K (potash)/ ha and N 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, sedge and broad-leaved weed (BLW)] and dry weed biomass was 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 dry weed biomass, 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 were 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 in aerobic rice during experimental period were grasses *viz., Echinochloa colona* L.*, Echinochloa crusgalli* L.*, Dactyloctenium aegyptium* L.*, Setaria glauca* L.; sedges *viz.,Cyperu siria* L.*, Cyperus difformis* L.*, Fimbristylis littoralis* L., and broad-leaf weeds *viz., Eclipta alba* L.*, Marsilea quadrifolia* L.*, Rotala densiflora* (Roth ex Roem. & Schult.) Koehne*, Bergia carpensis* L.*, Celosia argentea* L., *Ludwigi aparviflora* Roxb., *Eichhornia crassipes* (Mart.) Solms. Almost similar composition of weed flora found in direct seeded rice [5, 14].

**3.2 Effect on weeds**

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

**Table 1. Effect of weed management treatments on weed population and weed control efficiency (Pooled of three years)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Total weed population (no./m2)** | | | **Weed control efficiency (%)** |
| **Grasses** | **Sedges** | **Broad Leaved Weed** |
| **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 | - |

***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 of three years)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Total dry weed biomass (g/m2)** | | | **Weed Index (%)** |
| **Grasses** | **Sedges** | **Broad Leaved Weed** |
| 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). Number of panicle/m2 and panicle weight was recorded significantly higher under weed free condition and at par with weeding with mechanical weeder (T3) as compared to weedy check. It might be due to the least crop-weed competition that ensured sufficient nutrients and other growth resources, that enhanced higher panicle production. Weed free treatment produced highest test weight but it was statistically similar with the result of the treatments T1, T3, T5, T6, and T7 but was found significantly different with weedy check. The weedy check had lowest test weight (1000 grain weight) because of the unfavourable environment created by weeds throughout the crop period. Grain yield was significantly influenced due to different weed management practices; weed free treatment (T9) and mechanical weeding using weeder treatment (T3) found equally effective and at par with each other in increasing grain yield of rice (5040 and 4731 kg/ha, respectively) over rest of the weed management treatments. The variation in rice yields due to different weed management practices in transplanted rice [16]. The grain yield was recorded 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 resulted in higher rice yields [14,17]. Mechanical method of controlling weed not only kills the weed between rows, but also loosen soil surface, ensuring better soil aeration, stimulate root growth which helped to access nutrient more efficiently and water intake capacity. This technique may be effectively buried and incorporates the weeds into soil and minimizes the weed competition. Further, it improves the soil aeration, root development, nutrient absorption, and more number of tillers, which favoured the crop growth, yield attributes and resulted 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 use of herbicides and increased grain yield, promoted rice growth, provided an efficient and non chemical weeding method for rice production [7,8]. The lower yield in weedy check treatment might be due to competition from weeds 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 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 |

**4. Conclusion**

Based on results of the experiment, mechanical weeding using weeder (weeding thrice- at 20 days after sowing and remaining two weeding at 15-20 days interval) was effective in reducing 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. Thus, mechanical weed management practice promoted rice growth, non chemical method for controlling weed, sustainable and eco-friendly in aerobic rice cultivationin south Gujarat, India.

**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 Pharmacognosy and 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*.

18. Fishkis, O., Weller, J., Lehmhus, J., Pöllinger, F., Strassemeyer, J., & Koch, H. J. (2024). Ecological and economic evaluation of conventional and new weed control techniques in row crops. Agriculture, Ecosystems & Environment, 360, 108786.

19. Pervaiz, R., Baloch, R., Arshad, M. A., Abbas, R. N., Shahzad, N., Hamid, M., ... & Akbar, M. M. (2024). Herbicide strategies for weed control in rice cultivation: Current practices and future directions. Haya: Saudi Journal of Life Sciences, 9(4), 114-129.