Original Research Article

# Evaluation of new generation herbicide-based weed management strategies on direct sown rice production in Cauvery deltaic zone


## Abstract

Field assay was conducted during "*Navarai*" season, 2019 at Chidambaram region of cauvery delta to find out the influenceof new generation herbicidebased weed management in direct sown rice production. The Experiment was laid out in randomized block design with three replications using rice cultivar CO-51. The treatments includes $T_1$- Un-weeded check, $T_2$- Twice hand weeding at 15 and 30 DAS $T_3$- Pre-emergence application of pyrazosulfuron-ethyl 10% WP at 200g $ha^{-1}$ at 7 DAS + one Hand weeding at 30 DAS $T_4$- Pre-emergence application of metsulfuran-methyl 10% + chlorimuron-methyl 10% WP at 20g $ha^{-1}$ at 7 DAS + one Hand weeding at 30 DAS $T_5$-Pre-emergence application of Pretilachlor 50% EC at 1250 ml $ha^{-1}$ at 7 DAS + one Hand weeding at 30 DAS $T_6$- Early post-emergence application of pretilachlor 6% + pyrazosulfuran-ethyl 0.15% G at 615g $ha^{-1}$ at 15 DAS. $T_7$- Early post-emergence application of bispyribac-sodium 10% SC at 300 ml $ha^{-1}$ 15 DAS $T_8$- Early post-emergence application of pretilachlor 6% + pyrazosulfuran-ethyl 0.15% G at 615g $ha^{-1}$ at 15 DAS + one Hand weeding at 30 DAS $T_9$- Early post-emergence application of bispyribac-sodium 10% SC at 300 ml $ha^{-1}$ at 15 DAS+ one Hand weeding at 30 DAS. On analysing the experimental results, it is revealed that all the imputed treatments has affected weed flora,crop growth, yield attributes and economics of direct sown rice cultivation. Furthermore, application of bispyribac-sodium 10% SC at 300 ml $ha^{-1}$ at 15 DAS + one hand weeding at 30 DAS provided superior results amid all the treatments.The absence of weed management practices (i.e) $T_1$- Un-weeded check has negatively affected the crop production to a greater extent by registering poor crop growth and yield parameters.



**Key words:** Crop yield,Direct Sown Rice,New-generation herbicides and Integrated Weed management


## Introduction

Cauvery delta zone is a highly fertile rice growing area lies in the eastern part of Tamil Nadu in which the cropping systems are majorly based on rice[1]. The farmers in this zone are specialized in wetland rice cultivation since time immemorial. Globally, weeds are the main biotic factor limiting rice productivity. Approximately 60% of the weeds in transplanted rice appear one week to one month after transplanting. At the effective tillering stage, these emerging weeds are competing with rice, and a decrease in panicle quantity results in a lower grain yield[33]. One of the most common weeds cyperusrotundus, makes it difficult to prepare land for rice farming. Additionally, during the early stages of rice growth, weed infestation and cyperus rhizome regeneration occur due to improper land levelling and an alternating wet and dry irrigation patter[17].As transplanted paddy is most common practice among this area, due to resource constraint situations direct sown rice cultivation is opted by rice farmers among this agro-ecological zone[35].While undergoing conversion from transplanted rice production to directly sown rice results in more weed flora competition, requiring revised weed management approaches to effectively control the complex weed biota[21].Farmers frequently use hand weeding as a method of controlling weeds, but it takes a lot of time, is labor-intensive, and is waged highly. The most practical, affordable, and efficient method of controlling weeds is through the use of herbicides[37]. Butold generation herbicides requires bulk application and formation of toxic residues in environment, modern new generation low dose herbicides offers a feasible management practice in crop production without affecting the environment[4,40,41,42]. Although butachlor, a renowned rice herbicide, when applied in field conditions may cause ecological consequences like alteration of the metamorphosis cum growth of the alpine cricket frog (*Fejervaryalimnocharis*)[14], causing DNA damage on the erythrocytes of freshwater catfish (*Clariasbatrachus*)[2], and has been affirmed as a B2, L2, and C class of carcinogen by various environmental agencies[19]Recently, pendimethalin has been banned by the government of Kerala because of its harmful side effects on humans and aquatic animals. New generation herbicides like bispyribac sodium and pyrazosulfuron-ethyl are relatively much safer when applied appropriately (i.e., bispyribac sodium improved the AMF colonisation, sporulation, and other microbial properties in an aerobic rice system[24], andapplication of pyrazosulfuron ethyl at 25 g $ha^{-1}$ to manage annual and perennial weeds in rice field, did not cause any environmental hazard[31]. Considering the above information in view, a field investigation has been carried out to study the efficacy of new generation herbicide-based weed management strategies on weed population dynamics, crop growth and development, crop yield, and economics in direct-sown rice and to find a suitable weed management strategy for this locality.

**Materials and methods**

Field assessment was conducted during Navarai rice growing season,2019 at Agronomy Department Experimental Farm, Annamalai University to observe theinfluence of certain new generation herbicide-based weed management practises in direct-sown rice production.The soil of the experimental field was clay loam in texture and the physico-chemical properties of the experimental field soil is presented in Table 1. The treatments assigned in this field assessment weretabulated in Supplementary Table1. Before sowing, the test crop CO51 rice variety seeds aretreated with *Pseudomonas fluorescens* for preventing fungal infection at early growth stages and sown at a spacing of 15 x 10 cm in the main field. The experiment was carried out in a randomized block design (RBD) with three replications.The statistical method used for the data analysis is two-way anova with the software name is Statistical Package for Social Sciences (SPSS).All the pre-emergence herbicides (pyrazosulfuron-ethyl 10%, pretilachlor 50% EC, metsulfuron-methyl 10%, and cholrimuron-ethyl 10% @ 20 g ha$^{-1}$) were sprayed on 7 DAS, and early post-emergence herbicides (pretilachlor 6%, pyrazosulfuron-ethyl 0.15% G, and bispyribac-sodium 10%) were applied on 15 DAS with a flat fan nozzle attachment of knapsack sprayer. As per the recommendations issued by Tamil Nadu Agriculture University, the blanket fertiliser recommendationof 120:40:40 kg NPK ha$^{-1}$ was followed by applying entire quantity of phosphorus as basal dose whereasNitrogen cum potassium fertilisers were given in 3 splits during basal, tillering, and panicle initiation stages of the crop.Observations, *viz.*, weed parameters (weed population, weed Dry Matter Production (DMP)), crop growth parameters (plant height, Leaf area Index (LAI), number of tillers clump$^{-1}$, and Dry Matter Production (DMP)), yield parameters (number of panicles m$^{-2}$, number of filled grains in panicle$^{-1}$, 1000 grain weight, grain yield, and straw yield), and economics (cost of cultivation, gross income, net income, and benefit cost ratio (BCR)) were recorded and furnished in tables 2, 3, 4, 5and 6. The experimental data were statistically analysed and significance of the difference between the means of the treatments, the critical difference (CD) was calculated at the 5% probability level.



## Result

### Effect of weed control measures on weed attributes

The most important weed flora detected in the experimental field are *Echinochloacolonum*, *Echinochloa crus-galli*, *Leptochloachinensis*,*Cyperusrotundus*, *Cyperusdifformis*, *Marsileaquadrifolia*, and *Eclipta alba*. Sedges are the dominant weed biota in rice production, our experimental setup has also shown a severe infestation of sedges. All the given treatments have a substantial influence on the weed population, DMP and Weed Control Index (WCI). Among them, $T_7$- early post-emergence application of bispyribac-sodium 10% SC at 15 DAS + one Hand weeding at 30 DAS produced superior results by recording the lowest weed population of 6.77 and 8.83 on 30 and 60 DAS, the lowest DMP of 17.23 and 24.87 on 30 and 60 DAS, and the highest WCI of 92.40% on 60 DAS.

**Effect of weed control measures on Crop growth attributes**

All the imposed weed control treatments has shown momentous effects on the crop growth. Among them, $T_7$- early post-emergence application of bispyribac-sodium 10% SC at 15 DAS + one Hand weeding at 30 DAS gives superior results, *viz*., plant height (75.56 cm on 60 DAS), number of tillers clump$^{-1}$ (26.21 on 60 DAS), LAI (6.74), and DMP (10.43 t ha$^{-1}$on 60 DAS).

**Effect of weed control measures on Yield parameters**

The results showed that the assigned treatments impactedyield parameters *viz.*,number of panicles, number of filled grains, grain yield and straw yield. The rice yield is mainly governed by the efficiency of the weed control practices involved in cultivation[1]. 415.42 number of panicles m$^{-2}$, 113.56 number of filled grains panicle$^{-1}$, 5675 kg ha$^{-1}$ grain yield and 7865 kg ha$^{-1}$straw yield arerecorded in our trial with application of bispyribac-sodium 10% SC on 15 DAS + one Hand weeding at 30 DAS which is the best among given treatments.

**Effect of weed control measures on economics**

Higher crop productivity with lesser cost of cultivation could result in better economic parameters like higher net returns and B:C ratio. The treatment, Bispyribac-sodium 10% SC @ 15 DAS + one hand weeding on 30 DAS ($T_9$) registered the highestnet income of Rs.49260.89 ha$^{-1}$ and return rupee$^{-1}$ invested of rupee 2.07. Unweeded control ($T_1$) recorded the least net income of Rs.-1264.13 ha$^{-1}$and return rupee$^{-1}$ invested of 0.96.

## Discussion

**Effect of weed control measures on weed attributes**

Bispyribac sodium + hand weeding recorded lowest weed density and highest weed control index. This result is attributed to the weed-control potential of systemic herbicide bispyribac-sodium (2,6-bis [(4,6 dimethoxypyrimidin-2-yl) oxy] benzoate), which moves inside plant tissues and interferes with the production of acetolactate synthase (ALS), which plays a pivotal role in the branched chain amino acids (i.e.) leucine, isoleucine, and valine production[7]. Except for BCAA starvation, other hypotheses about the secondary effects of ALS inhibition, such as accumulation of pyruvate and 2-aminobutyrate, inhibition of DNA synthesis, disruption of photo-assimilate translocation, and anaerobic respiration, have also been implicated in the mechanism of plant death caused by ALS-inhibiting herbicides[15,39]. The affected weeds show stunted growth, reddening at plant tips, and further end up in plant death. As this treatment is given along with hand weeding at 30 DAS, which removes the new weeds, it provides a weed-free environment in the crop vicinity, favouring crop growth to its maximum potential without any competition from weeds in the critical period of crop weed competition. The major advantage of following Integrated Weed Management (IWM) is that it prevents the formation of herbicidal resistance among weed flora and the accumulation of toxic herbicidal residues in the ecosystem. These findings agree with[9,13,32].

**Effect of weed control measures on growth attributes**

Researchers[36], reported the growth improvementby bispyribac-sodium 10% SC+ hand weeding[3,29] stimulated growth attributes by herbicide cum hand weeding practise in direct sown rice. In this line, the selection of bispyribac-sodium 10% SC at 15 DAS + one hand weeding at 30 DAS for weed control in direct-sown rice has modified the agro-ecosystem for rice crop production by eliminating the competitive heterogeneous allelopathic weed flora present in the crop land during the active crop growth stages and making sure that the crop plant receives maximum light, space, nutrient, and moisture[12]. As weed plants harbours harmful pests and diseases, its removal ensures safer and competition free environment to the crop plants and resulted in improved growth of rice plants[17].

**Effect of weed control measures on Yield parameters**

Yield parameters also bispyribac-sodium 10% SC+ hand weedingcombination was best this is because of the right selection and adoption of integrated weed management strategy rather than using chemical methods of weed management alone, it was similar with the findings of[26]. This new generation herbicide based integrated weed management practise improved availability of natural resources and critical inputs for establishment of rice crop and endangering the survival of weed biota in the field[27]. As direct sown rice is highly succumbed to weed competition, the effectiveness of this treatment removes the weed competition and facilitated higher yield in rice. This report is synchronous with the reports of [10,25]. Yield reduction in rice cultivation is attributed to the increased weed infestation and weed interference throughout the crop period[6]. Due to heavy competition offered by weeds in unweeded control plot, poor crop performance was obtained[5].

**Effect of weed control measures on economics**

The efficacy of any production system is ultimately evaluated on the basis of its economics. Effective weed control without increasing the cost of cultivation is highly preferable among the farming community[16,30]. As traditional weed management needs high labour charges, this integrated approach produced good results with lesser expenses[20]. This hypothesis is supported by the highest B:C ratio (2.07) in the given treatment bispyribac sodium 10% SC & 15 DAS followed by one hand weeding on 30 DAS. This finding is congruent with the results of [11,28].

**Conclusion**

Our experimental results revealed that the use of this integrated approach to weed management in direct-sown rice production has controlled the weed biota, enhanced crop growth, and produced a higher yield at a lower expense. As this method requires less labour and provides good control over heterogeneous weeds without building up toxic residues in the environment, it can be easily adapted in resource-constrained situations. Hence, the recommendation of bispyribac sodium 10% SC @15 DAS followed by one hand weeding on 30 DAS is advisable among the direct sown rice farming community for effective weed management in this Cauvery Deltaic Zone. As our studies are conducted from an agronomical perspective, much research is needed to find out about the various factors hindering the adoption of this practise in this region for achieving sustained rice production and food security.

**Conflict of Interest**

The author has no conflict of interest with the other authors and academic institution

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1.

2.

3.

**Table 1 Soil Physico-chemical properties of the experimental field**

| Parameters | Values | Remark | Methods adopted |
|---|---|---|---|
| pH | 7.5 | Neutral | Jackson, 1973 |
| Organic carbon (%) | 0.70 | Medium | Walkley and Black, 1934 |
| Available N (kg $ha^{-1}$) | 232.5 | Low | Subbiah and Asija, 1956 |
| Available P (kg $ha^{-1}$) | 19.2 | Medium | Olsen *et al.*, 1954 |
| Available K (kg $ha^{-1}$) | 324.6 | High | Jackson, 1973 |

**Supplementary Table 1- Treatment details**

| | |
|---|---|
| **$T_1$** | Un-weeded check |
| **$T_2$** | Twice hand weeding @ 15 and 30 DAS |
| **$T_3$** | Pre-emergence application of Pyrazosulfuron-ethyl 10% WP @ 200g $ha^{-1}$ @ 7 DAS + one Hand weeding @ 30 DAS |
| **$T_4$** | Pre-emergence application of Metsulfuran-methyl 10% + Chlorimuron-methyl 10% WP @ 20g $ha^{-1}$ @ 7 DAS + one Hand weeding @ 30 DAS |
| **$T_5$** | Pre-emergence application of Pretilachlor 50% EC @ 1250 ml $ha^{-1}$ @ 7 DAS + one Hand weeding @ 30 DAS |
| **$T_6$** | Early post-emergence application of Pretilachlor 6% + Pyrazosulfuran-ethyl 0.15% G @ 15 DAS. |
| **$T_7$** | Early post-emergence application of Bispyribac-sodium 10% SC @ 300 ml $ha^{-1}$ 15 DAS |
| **$T_8$** | Early post-emergence application of Pretilachlor 6% + Pyrazosulfuran-ethyl 0.15% G @ 15 DAS + one Hand weeding @ 30 DAS |
| **$T_9$** | Early post-emergence application of Bispyribac-sodium 10% SC @ 300 ml $ha^{-1}$@ 15 DAS+ one Hand weeding @ 30 DAS |

**Table.2. Effect of weed control treatments on individual weed population (m$^{-2}$) on 30 DAS**

| **Treatments** | ***Echinochloacolonum*** | ***Echinochloa crus-galli*** | ***Leptochloachinensis*** | ***Cyperusrotundus*** | ***Cyperusdifformis*** | ***Marsileaquadrifolia*** | ***Eclipta alba*** |
|---|---|---|---|---|---|---|---|
| $T_1$ | 12.5 (3.60) | 10.2 (3.27) | 11.3 (3.43) | 41.02 (6.44) | 19.26 (4.44) | 8.6 (3.01) | 3.2 (1.92) |
| $T_2$ | 1.84 (1.52) | 3.6 (2.02) | - | 4.3 (2.19) | 3.25 (1.93) | - | - |
| $T_3$ | 6.03 (2.55) | 7.2 (2.77) | 4.2 (2.16) | 12.1 (3.54) | 8.14 (2.93) | 5.1 (2.36) | 1.9 (1.54) |
| $T_4$ | 5.1 (2.36) | 6.2 (2.58) | 3.4 (1.97) | 11.2 (3.42) | 7.4 (2.81) | 4.5 (2.23) | 1.3 (1.34) |
| $T_5$ | 5.9 (2.52) | 6.8 (2.70) | 3.9 (2.09) | 11.8 (3.50) | 7.8 (2.88) | 4.8 (2.30) | 1.7 (1.48) |
| $T_6$ | 8.58 (3.01) | 8.1 (2.93) | 5.3 (2.40) | 16.4 (4.11) | 12.83 (3.65) | 6.4 (2.62) | 2.21 (1.64) |
| $T_7$ | 9.57 (3.17) | 8.8 (3.04) | 6.40 (2.62) | 25.2 (5.01) | 14.75 (3.90) | 7.3 (2.79) | 2.8 (1.81) |
| $T_8$ | 3.8 (2.07) | 4.9 (2.32) | 2.38 (1.69) | 7.6 (2.84) | 5.41 (2.43) | - | - |
| $T_9$ | 1.04 (1.24) | 1.73 (1.49) | - | 2.16 (1.63) | 1.84 (1.52) | - | - |
| S.Ed | 0.11 | 0.09 | NS | 0.26 | 0.15 | NS | NS |
| | | | | 0.54 | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CD (p=0.05) | 0.23 | 0.2 | | | 0.31 | | |

Figures in paranthesis are original values, values are square root transformed (√x + 0.5)

**Table.3. Effect of weed control treatments on individual weed population ($m^{-2}$) on 60 DAS**

| Treatments | *Echinochloa colonum* | *Echinochloa crus-galli* | *Leptochloac hinensis* | *Cyperusrotu ndus* | *Cyperusdiffo rmis* | *Marsileaqua drifolia* | *Eclipta alba* |
|---|---|---|---|---|---|---|---|
| $T_1$ | 23.36 (4.88) | 16.91 (4.17) | 11.6 (3.47) | 47.34 (6.91) | 27.91 (5.33) | 12.41 (3.59) | 3.96 (2.11) |
| $T_2$ | 5.36 (2.42) | 2.05 (1.59) | - | 6.65 (2.67) | 3.68 (2.04) | - | - |
| $T_3$ | 12.86 (3.65) | 7.42 (2.81) | 4.21 (2.17) | 17.67 (4.26) | 12.73 (3.63) | 3.13 (1.90) | 1.43 (1.38) |
| $T_4$ | 11.74 (3.49) | 6.21 (2.59) | 3.16 (1.91) | 16.63 (4.13) | 11.92 (3.52) | 2.24 (1.65) | 1.13 (1.26) |
| $T_5$ | 12.15 (3.55) | 6.84 (2.70) | 3.81 (2.07) | 17.12 (4.19) | 12.17 (3.55) | 2.72 (1.79) | 1.20 (1.30) |
| $T_6$ | 17.72 (4.26) | 13.11 (3.68) | 7.45 (2.81) | 22.91 (4.83) | 17.82 (4.28) | 6.21 (2.59) | 3.14 (1.90) |
| $T_7$ | 18.53 (4.36) | 13.54 (3.74) | 8.34 (2.97) | 23.82 (4.93) | 18.51 (4.36) | 7.35 (2.80) | 3.61 (2.02) |
| $T_8$ | 8.25 (2.95) | 3.81 (2.07) | - | 10.37 (3.29) | 7.86 (2.89) | - | - |
| $T_9$ | 2.79 (1.81) | 1.01 (1.22) | - | 3.61 (2.02) | 1.42 (1.38) | - | - |
| | 0.21 | 0.20 | | 0.28 | 0.31 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.Ed | | | NS | | | NS | NS |

| **Treatments** | **Weed population on 30 DAS** | **Weed population on 60 DAS** | **Weed DMP 30 DAS** | **Weed DMP 60 DAS** | **Weed Control Index (WCI)** |
|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CD (p=0.05) | 0.42 | 0.41 | | 0.56 | 0.62 | | |

Figures in paranthesis are original values, values are square root transformed ($\sqrt{x} + 0.5$)

| Treatments | Plant height (cm) on 60 DAS | LAI 60 DAS | No. of tillers clump$^{-1}$ 60 DAS | DMP 60 DAS | Number of panicles (m$^{-2}$) | Number of filled grains panicle$^{-1}$ | 1000 grain weight | Grain yield (kg ha$^{-1}$) | Straw yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| $T_1$ | 106.08 (10.29) | 143.29 (11.99) | 210.84 | 327.38 | --- |
| $T_2$ | 12.99 (3.60) | 17.74 (4.27) | 28.30 | 37.53 | 88.53 |
| $T_3$ | 44.67 (6.68) | 59.45 (7.74) | 63.89 | 114.26 | 65.09 |
| $T_4$ | 39.10 (6.25) | 53.03 (7.31) | 59.31 | 109.43 | 66.57 |
| $T_5$ | 42.70 (6.53) | 56.01 (7.51) | 61.46 | 112.11 | 65.75 |
| $T_6$ | 59.81 (7.73) | 88.36 (9.42) | 144.68 | 157.54 | 52.53 |
| $T_7$ | 74.82 (8.64) | 93.67 (9.70) | 148.52 | 155.39 | 51.87 |
| $T_8$ | 24.09 (4.91) | 30.29 (5.54) | 37.74 | 46.72 | 85.72 |
| $T_9$ | 6.77 (2.60) | 8.83 (3.05) | 17.23 | 24.87 | 92.40 |
| **S.Ed** | 0.47 | 0.59 | 2.67 | 3.27 | |
| **CD (p=0.05)** | 0.97 | 1.21 | 5.43 | 6.65 | |

**Table.4. Effect ofweed control treatments on total weed population, weed dry matter production (kg ha$^{-1}$) and WCI**

Figures in paranthesis are original values, values are square root transformed ($\sqrt{x} + 0.5$)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | 55.06 | 2.43 | 13.16 | 5.36 | 216.90 | 48.93 | 16.41 | 2290 | 4721 |
| $T_2$ | 72.06 | 5.72 | 23.36 | 9.26 | 403.79 | 104.70 | 16.69 | 5287 | 7546 |
| $T_3$ | 63.90 | 3.94 | 18.34 | 7.26 | 385.64 | 88.76 | 16.51 | 4655 | 6795 |
| $T_4$ | 65.33 | 4.16 | 19.27 | 7.60 | 352.38 | 90.79 | 16.58 | 4784 | 6986 |
| $T_5$ | 64.73 | 4.07 | 18.81 | 7.43 | 346.09 | 89.06 | 16.53 | 4701 | 6832 |
| $T_6$ | 60.10 | 3.37 | 16.53 | 6.46 | 318.53 | 80.32 | 16.48 | 3805 | 6437 |
| $T_7$ | 59.33 | 3.23 | 15.82 | 6.33 | 312.34 | 79.33 | 16.46 | 3634 | 6211 |
| $T_8$ | 68.83 | 4.88 | 21.15 | 8.46 | 385.64 | 98.25 | 16.60 | 5046 | 7307 |
| $T_9$ | 75.56 | 6.74 | 26.21 | 10.43 | 415.42 | 113.56 | 16.72 | 5675 | 7865 |
| **S.Ed** | 1.09 | 0.13 | 0.61 | 0.21 | 6.64 | 1.55 | NS | 91 | 112 |
| **CD (p=0.05)** | 2.23 | 0.27 | 1.24 | 0.43 | 13.49 | 3.16 | | 184 | 227 |

**Table.5. Effect ofweed control treatments on Crop growth and yield attributes**

**Table.**

| Treatments | Cost of cultivation (Rs.) | Grossincome (Rs.) | Netincome (Rs.) | BCR |
|---|---|---|---|---|
| $T_1$ | 41500.38 | 40236.25 | -1264.13 | 0.96 |
| $T_2$ | 46745.54 | 88737.5 | 41991.96 | 1.89 |
| $T_3$ | 46019.27 | 77165 | 31145.73 | 1.67 |
| $T_4$ | 45563.78 | 79055 | 33491.22 | 1.73 |
| $T_5$ | 45745.43 | 78168.75 | 32423.32 | 1.70 |
| $T_6$ | 43575.62 | 65121.27 | 21545.65 | 1.49 |
| $T_7$ | 43695.38 | 62273.75 | 18578.37 | 1.42 |
| $T_8$ | 46975.15 | 84823 | 37847.85 | 1.80 |
| $T_9$ | 45695.36 | 94956.25 | 49260.89 | 2.07 |

**6.Economic analysis ofweed control treatments on direct sown rice**

## Reference


1. Arivelarasan T., ManivasagamV.S., Geethalakshmi, V., Bhuvaneswari K., Natarajan, K., Balasubramanian, M. and Muthurajan R., How Far Will Climate Change Affect Future Food Security? An Inquiry into the Irrigated Rice System of Peninsular India, *Agriculture*, **13**(3), 551**(2023)**
2. Ateeq B., Farah M.A. and Ahmad W., Detection of DNA damage by alkaline single cell gel electrophoresis in 2, 4-dichlorophenoxyacetic-acid- and butachlor exposed erythrocytes of Clariasbatrachus, *Ecotoxicol. Environ. Saf.*,**62**, 348-354**(2015)**
3. Chakraborti M., Duary B. and Datta M., Effect of Weed Management Practices on Nutrient Uptake by Direct Seeded Upland Rice under Tripura Condition, *Int.J.Curr.Microbiol.App.Sci.*,**6**(12), 66-72**(2017)**
4. Cheng F. and Cheng Z., Research progress on the use of plant allelopathy in agriculture and the physiological and ecological mechanisms of allelopathy, *Frontiers in plant sci.*, **6**, 1020**(2015)**
5. Das R., Bera S., Pathak A. and Mandal M.K., Weed management in transplanted rice through bispyribac-sodium 10% SC and its effect on soil microflora and succeeding crop-Blackgram. *Int. J. Cur. Micro App. Sci.*, **4**(6), 681-688**(2015)**
6. Dass A., Shekhawat K., Choudhary A.K., Sepat S., Rathore S.S., Mahajan G. and Chauhan B.S., Weed management in rice using crop competition-a review. *Crop protection*, **95**, 45-52**(2017)**
7. Gu T., Wang Y., Cao J., Zhang Z., Li G., Shen W. and Wang H., Hydrogen-Rich Water Pre-treatment Alleviates the Phytotoxicity of Bispyribac-Sodium to Rice by Increasing the Activity of Antioxidant Enzymes and Enhancing Herbicide Degradation, *Agronomy*, **12**(11), 2821**(2022)**
8. Jackson M.L., Soil chemical analysis, Prentice Hall of India Pvt. Ltd., New Delhi. II$^{nd}$ Indian Reprint, 1-498 **(1973)**
9. Kaur S. and Singh S., Bio-efficacy of different herbicides for weed control in direct-seeded rice, *I. J. Weed. Sci.*, **47**(2),106-109**(2015)**
10. KhaliqA., Matloob A.,Ihsan M.Z., Abbas R.N., Aslam Z. and Rasool F. Supplementing herbicides with manual weeding improves weed control efficiency, growth and yield of direct seeded rice,*Int. J. Agric. Biol.*,**15**: 191-199**(2013)**
11. Kumar S., Rana S.S.,Chander N. and Ramesh, Mixed weed flora management by Bispyribac-sodium in transplanted rice, *I. J. Weed. Sci.*, **45**(3), 151-155**(2013)**

12. Kumaran S.T., Kathiresan G., Arthanari P.M., Chinnusamy C. and Sanjivkumar V., Efficacy of new herbicide (bispyribac sodium 10% SC) against different weed flora, nutrient uptake in rice and their residual effects on succeeding crop of green gram under zero tillage, *J. Appli. Nat. Sci.*, **7**(1), 279-285**(2015)**
13. LamichhaneJ.R., Devos Y.,Beckie H.J., OwenM.D., TillieP., Messéan A. and Kudsk P., Integrated weed management systems with herbicide-tolerant crops in the European Union: lessons learnt from home and abroad, *Critical reviews in biotechnology*, **37**(4), 459-475**(2017)**
14. Liu W.Y., Wang C.Y., Wang T.S., Fellers G.M., Lai B.C. and Kam Y.C., Impacts of the herbicide butachlor on the larvae of a paddy field breeding frog (*Fejervaryalimnocharis*) in subtropical Taiwan,*Eco***., 20,** 377-384**(2011)**
15. Liu X.Q., Yu C.Y., Dong J.G., Hu S.W. and Xu A.X.,Acetolactate synthase-inhibiting gametocide amidosulfuron causes chloroplast destruction, tissue autophagy, and elevation of ethylene release in rapeseed. *Frontiers in Plant Science,* **8**, 1625**(2017)**
16. MacLaren, C., Storkey J., Menegat A., MetcalfeH. and Dehnen-SchmutzK., An ecological future for weed science to sustain crop production and the environment. A review. *Agronomy for Sustainable Development*, **40**, 1-29 **(2020)**
17. Manisankar G., Ramesh T., and Rathika S., Weed management in Transplanted Rice through pre plant application of herbicide: A Review, *International Journal of Current Microbiology and Applied Science.*, **9**(5), 684-692 **(2020)**
18. ManisankarG., Ghosh P., Malik G.C. and Banerjee M., Recent trends in chemical weed management: A review, *The Pharma Innovation*, **11**(4), 745-753**(2022)**
19. Mohanty S.S. and Jena H.M.,A systemic assessment of the environmental impacts and remediation strategies for chloroacetanilide herbicides,*J. Water Process Engi.*, **31,** 100860**(2019)**
20. MonteiroA. and Santos S., Sustainable approach to weed management: The role of precision weed management, *Agronomy*, **12**(1), 118 (2022)
21. Nazir A., Bhat M.A., Bhat T.A., Fayaz S., Mir M.S., Basu U. and El Sabagh A., Comparative analysis of rice and weeds and their nutrient partitioning under various establishment methods and weed management practices in temperate environment, *Agronomy*, **12**(4), 816**(2022)**
22. Olsen S.R., Cole C.V., Watanable F.S. and Dean D.A., Estimation of available phosphorus in soil by the extraction with sodium bicarbonate, USDA (1954)

23. Pandey D., Singh G., Kumar R., Rao A., Kumar M. and Kumar A., Effect of weed management practices on growth and yield of Indian mustard. *J. Pharm. Phyto-chem.*, **8**(4), 3379-3383**(2019)**
24. Panneerselvam, PeriyasamyS.,Saha A.,Senapati A.K.,Nayak U., Kumar and Mitra, D., New generation post-emergence herbicides and their impact on arbuscular mycorrhizae fungal association in rice, *Cur. Res. Micro. Sci.*, **2**: 100067**(2021)**
25. ParthipanT., RaviV., Subramanian E. and Ramesh T., Integrated weed management on growth and yield of transplanted rice and its residual effect on succeeding black gram, J. Agron., **12**(2), 99-103**(2013)**
26. Pawar S.B., Mahadkar U.V., Jagtap D.N. and Jadhav M.S., Effect of different planting techniques and inputs on yield attributes and yield of rice (*Oryzasativa* L.) during kharif season, Fmg. &Mngmt, **2** (1),16-21 **(2017)**
27. Peerzada A.M., BukhariS.A.H., Dawood M., Nawaz A., Ahmad S. and Adkins S., Weed management for healthy crop production, *Agronomic Crops: Volume 2: Management Practices*, 225-256**(2019)**
28. Priya R.S., Chinnusamy C.,Arthanari P.M. and Janaki P., Bio-efficacy of new herbicide combination (Bispyribac sodium 4% + Metamifop 10% SE) on weeded control, economics and profitability of direct seeded rice,*Intl. J. Chem Stud.*, **5**(4): 2349-8528**(2017)**
29. SatapathyB.S., Duary B., Saha S., Pun K.B. and Singh T. Effect of weed management practices on yield and yield attributes of wet direct seeded rice under lowland ecosystem of Assam, *ORYZA-An Intl. J. Rice*, **54**(1), 29-36**(2017)**
30. ScavoA. and MauromicaleG., Integrated weed management in herbaceous field crops, *Agronomy*, **10**(4), 466**(2020)**
31. ShobhaS. and Waseem U., Residue dynamics and degradation behaviour of pyrazosulfuron-ethyl in the rice field environment,*I. J. Weed Sci.*, **52**(4): 362-365**(2020)**
32. Singh R.S., Singh R.P., Singh R.K., Pathak M., Kumar and Pandey D., Effect of weed management practices on weed flora, growth attributes and yield of direct seeded rice (*Oryzasativa*L.), *I. J. Agron.*, **1**(1),27-34**(2014)**
33. Soethura., 2010. Evaluation of Weed Management practices in the System of RiceIntensification (SRI). M.Sc. (Ag.) Thesis, Department of Agronomy, Yezin Agricultural University, Yezin, Nay Pyi Taw

34. Subbiah B.V. and Asija G.L., A rapid procedure for the estimation of available nitrogen in soils, *Curr. Sci.*,**25**, 259-260 **(1956)**
35. Surendran U., Raja P., Jayakumar M. andSubramoniam S.R., Use of efficient water saving techniques for production of rice in India under climate change scenario: A critical review, *Journal of Cleaner Production*, **309**, 127272**(2021)**
36. Toppo O. and Kewat M.L., Impact of sowing time and weed management practices on yield of direct-seeded rice, *The Pharma Innovation Journal*, **12**(2): 3475-3478 **(2023)**
37. Verma B., Bhan M., Jha, A.K., Khatoon S., Raghuwanshi, M., Bhayal L., Sahu M.P., Patel R. and Singh V., Weeds of direct seeded rice influenced by herbicide mixture, *The Pharma Innovation Journal*, **11**(2), 1080-1082 **(2021)**
38. Walkley A. and Black C.A., An examination of digestion method for determining soil organic matter and proposed modification of the chromic acid titration method, Soil Sci., 37, 28-29 (1934)
39. Zhou Q., Liu W., Zhang Y. and Liu K.K., Pesticide Biochemistry and Physiology,**89**, 89-96**(2007)**
40. Kalyani, M. S. R., Ameena, M., Srinivas, Y., Shanavas , S., Susha, V. S., &Sethulakshmi, V. S. (2024). Bio-Efficacy of New Herbicide Molecules for Weed Management in Grain Legumes. Journal of Advances in Biology & Biotechnology, 27(1), 191–204. https://doi.org/10.9734/jabb/2024/v27i1691
41. Bhadoria, P. B. S. (2010). Allelopathy: A Natural Way towards Weed Management. Journal of Experimental Agriculture International, 1(1), 7–20. https://doi.org/10.9734/AJEA/2011/002
42. Lodovichi MV, Blanco AM, Chantre GR, Bandoni JA, Sabbatini MR, Vigna M, López R, Gigón R. Operational planning of herbicide-based weed management. Agricultural Systems. 2013 Oct 1;121:117-29.