**Effect of different post emergence herbicides on productivity and weed dynamics of rice (*Oryza sativa* L.) under transplanted condition**

**ABSTRACT**

An experiment was conducted during the *Kharif* 2022 at Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh to assess the effect of herbicides on growth and yield of transplanted rice. The experiment was laid out in randomized block design with three replication and nine distinct treatments. Among all the treatments, highest values of yield attributing characters *viz*., effective tillers m-2, number of grains panicle-1, number of filled grains panicle-1, panicle length, panicle weight and grain yield (57.44 q ha-1) were found under hand weeding at 20 and 40 DAT closely followed by penoxsulam 1.02% + cyhalofop butyl 5.1% OD (RM) @ 135 g a.i. ha-1 among the chemical weed control. Lowest values of above characters were obtained under unweeded control. The experimental field was dominated with *Echinochloa colona, Alternanthera sessilis, Cyperus iria, Cyperus difformis, Cynodon dactylon* and *Eclipta prostrata* throughout the crop growth period. Minimum total weed density (0.88 - 3.53 m-2) and total weed dry weight (0.94 - 4.66 g m-2) were registered under hand weeding at 20 and 40 DAT followed by application of penoxsulam 1.02% + cyhalofop butyl 5.1% OD (RM) @ 135 g a.i. ha-1 at different time intervals. Weed control efficiency was found highest in hand weeding at 20 and 40 DAT and lowest in unweeded control.

**Keywords –** Post- emergence herbicides, yield, weed density, weed dry weight, weed control efficiency.

**INTRODUCTION**

 “The productivity of rice in India is declining due to an array of biotic and abiotic factors. Among different biotic stresses, weed infestation is responsible for 40-60% yield loss” (Dass *et al.*, 2017). The major weed species compete with rice are *Echinochloa colona, Echinochloa crusgallii, Cyprus difformis, Cyperus iria, Cynodon dactylon, Alternanthera sessilis and Eclipta prostrata* for moisture, nutrient, light, temperature and space. Losses due to weeds are the foremost importance to be concentrated in rice production systems as they interfere with all the activities involved in the field throughout crop growing period. In addition to competing with other plants for nutrients, light, and water, weeds also serve as a heaven for pests like nematodes, insects, and diseases that lower rice yields and quality (Raghuwanshi et al., 2023).

 In order to manage weeds at different growth stages during the crop season, magnitude of chemical weed control has increased significantly over the last decade (Prajapat, 2024). “Among different weed management methods, chemical method is easy, economical, efficient and effective way to suppress weeds” (Bhurer *et al.,* 2013, Mahapatra *at el.*, 2023). “Use of herbicides has been found promising for managing weeds in rice crops. Bispyribac sodium in rice field, have the potentiality to keep the weed below the economic threshold level. Application of bispyribac sodium at 30 a.i. g ha-1 resulted in the weed control of more than 74 percent of weeds” (Das *at el.*, 2015). **“**But the continuous use of same herbicide with same mode of action leads to weed flora shift and development of herbicide resistance in weeds. Therefore, herbicide mixtures with different spectrum of weed control are found to be more effective to manage weeds” (Mahapatra *at el.*, 2023). **“**Most of currently recommended herbicides for transplanted rice are applied as pre-emergence (PE) of which, many a time do not perform well particularly, when crop is subjected to water scarce conditions immediately after transplanting” (Das at el., 2015). Hence, there is need for post-emergence herbicides for control of complex weed flora in transplanted rice.

**MATERIALS AND METHODS**

 Field experiment was conducted at Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, during *kharif* season of 2022 to find out the suitable post emergence herbicide or herbicide mixture in transplanted rice. The soil of the experimental field was clay in texture and locally named as *Kanhar* and neutral (pH 6.93) having 0.41 % soil organic carbon, low nitrogen (201.5 kg ha-1), medium phosphorous (15.4 kg ha-1) and high potassium (323.8 kg ha-1) content. Rice variety IGKV R1 (*Indira Rajeshwari*) grown as test crop was released by Central Variety Release Committee in 2009-10.

 The experiment was laid out in randomized block design with three replication and nine distinct treatments viz. T1- bispyribac sodium 10% SC @ 25 g a.i. ha-1, T2 - penoxsulam 21.7% SC @ 22.5 g a.i. ha-1, T3 - 2,4-D ethyl ester 38% EC @ 950 g a.i. ha-1, T4 - penoxsulam 1.02% + cyhalofop butyl 5.1% OD (RM) @ 135 g a.i. ha-1, T5 - triafamone 20% + ethoxysulfuron 10% WG (RM) @ 67.5 g a.i. ha-1, T6 - bentazone 48 % SL @ 960 g a.i. ha-1, T7 - metsulfuron methyl + chlorimuron ethyl 20 % (RM) @ 4 g a.i. ha-1, T8 - hand weeding at 20 and 40 DAT and T9 - unweeded control.

 Twenty-one days old seedlings were transplanted at a spacing of 20 cm × 10 cm on July, 2022. Recommended dose of N, P2O5 and K2O *i.e*. 100: 60: 40 kg ha-1 was applied through urea, single super phosphate and muriate of potash, respectively. The whole amount of P and K were applied as basal during final land preparation. The nitrogen fertilizer was applied in three splits, 50% as basal, 25% at tillering stage (30 DAT) and 25% at panicle initiation (60 DAT). Hand weeding was carried out twice at 20 and 40 DAT. All herbicides were applied as post-emergence at 2-4 leaf stage of weeds i.e. 23 days after transplanting. Herbicides were sprayed by using a knapsack sprayer fitted with flat fan nozzle.

 Data on growth parameters, yield attributing characters, total and species wise density and weed biomass were recorded at 25, 50, 75 days after application (DAA). Weed count was made randomly from four spots by quadrate of 50 cm x 50 cm (0.25 m2) in each plot. The number of weeds were counted and the data were computed per m-2. Then the weeds were oven dried at 60°C for 36 to 48 hours. Weed density and weed dry weight were subjected to square root of transformation *i.e.*√𝑥 + 0.5.

**RESULT AND DISCUSSION**

**Effect on crop**

 Higher values of yield attributes *viz.* effective tillers m-2 (432 m-2), filled grains panicle-1 (151) and panicle weight (5.54 g) were recorded with hand weeding at 20 and 40 DAT which was found at par with application of penoxsulam 1.02% + cyhalofop butyl 5.1% OD (RM) @ 135 g ha-1 which ultimately resulted in higher grain yield (Table 1). Significantly highest grain yield (57.44 q ha-1) was obtained under hand weeding at 20 and 40 DAT due to reduced crop-weed competition which resulted in improved uptake of nutrients, utilizing more sunlight, moisture and space by the crop. Similar results have been reported by Yadav *et al.* (2018). Among herbicide treatments, maximum grain yield (56.22 q ha-1) was obtained under application of penoxsulam 1.02% + cyhalofop butyl 5.1% OD (RM) @ 135 g ha-1 which was superior to grain yield obtained from single application of penoxsulam 21.7% SC @ 22.5 g ha-1 (47.36 q ha-1) as well as all other weed management treatments.

All weed-control treatments showed significantly higher values of yield components compared to unweeded control (T9) (Table 1) mainly due to effective suppression of weeds that resulted in improved uptake of inputs like nutrients, light, moisture and other resources by crop. Grain yield reduction in rice is directly related to increasing weed density, dry weight and intensity of weed interference throughout the crop period.

 All the weed control treatments increased the rice grain yield by 33.33 % to 61.7% as compared to unweeded control (T9). The highest yield increment (61.7 %) was noted in hand weeding at 20 and 40 DAT (T8) followed by penoxsulam 1.02 % + cyhalofop butyl 5.1 % OD (RM) @ 135 g ha-1 (T4) (58.27 %), bispyribac sodium 10% SC @ 25 g ha-1 (T1) (48.73%) and bentazone 48 % SL @ 960 g ha-1 (T6) (44.59 %). Weed competition in unweeded control (T9) resulted in 38.16 % reduction in grain yield.

**Table 1 : Yield attributing characters, grain yield and economics as influenced by different post emergence herbicides in transplanted rice**.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Dose** | **Yield attributing characters** |  | **Cost of cultivation** | **Net return** | **B:C Ratio** |
| **a.i.****(gha-1)** | **No. of effective tillers m-2** | **No. of grains panicle-1** | **No. of filled grains panicle-1** | **Sterility percentage****(%)** | **Panicle length (cm)** | **Panicle weight (g)** | **Grain yield****(q ha-1)** | **(Rs. ha-1)** | **(Rs.ha-1)** |  |
| **T1****T2****T3****T4****T5****T6****T7****T8****T9** | Bispyribac sodium 10% SCPenoxsulam 21.7% SC2,4-D Ethyl ester 38% ECPenoxsulam 1.02% + cyhalofop butyl 5.1% OD (RM)Triafamone 20% + ethoxysulfuron 10% WG (RM)Bentazone 48 % SL Metsulfuron methyl + chlorimuron ethyl 20 % (RM) Hand weeding twice Unweeded control**SEm±** **C.D. (P=0.05)** | 2522.595013567.59604-- | 386361373414339386365432266**20****59** | 134120128146120135125151108**6****17** | 12110411413410512111014190**6****18** | 9.513.110.88.112.610.311.86.916.2**1.5****4.4** | 21.1920.420.6721.3820.2521.1720.9421.5520.16**0.493****NS** | 4.893.873.945.034.24.724.145.542.8**0.248****0.745** | 74.4465.6967.3677.3671.4172.5068.6977.8950.67**1.96****5.88** | 324493246531486313173461133501308643666129661 | 902137728182285988438195085773837329609452940 | 2.82.42.63.22.42.62.72.61.8 |

**Effect on weeds**

**Weed density :** The low weed densities of *Echinochloa colona, Alternanthera sessilis, Cyperus iria, Cyperus difformis, Cynodon dactylon, and Eclipta prostrata* were found under hand weeding at 20 and 40 DAT (T8). Application of penoxsulam 1.02% + cyhalofop butyl 5.1% OD (RM) @ 135 g ha-1 followed by bispyribac sodium 10% SC @ 25 g ha-1 and bentazone 48 % SL @ 960 g ha-1 controlled the narrow leaved weeds as well as broad leaved weeds effectively as compared to others. Lower weed density and dry weight observed under herbicide mixtures compared to single herbicide might be due to effective control of complex weed flora by two different modes of actions (Mohapatra *et al*, 2017). Highest weed density of *Alternanthera sessilis* (7, 13.67 and 17.67 m-2) and lowest weed density of *Cynodon dactylon* (3.67, 5.67 and 7.33 m-2) was recorded under unweeded control at 25, 50 and 75 DAA respectively. The highest total weed density (26.67, 51.67, and 69.67 m-2) was recorded under unweeded control at 25, 50 and 75 DAA respectively as compared to lowest weed density (0.33, 7.33 and 12 m-2) under hand weeding at 20 and 40 DAT at 25, 50 and 75 DAA respectively (Table 2).

**Weed dry weight :** The highest total weed dry weight (66.88, 95.78, and 118.51 g m-2) was recorded under unweeded control at 25, 50 and 75 DAA respectively as compared to lowest total weed dry weight (0.50, 15.78 and 21.25 g m-2) under hand weeding at 20 and 40 DAT at 25, 50 and 75 DAA respectively. Among weed management treatments, application of penoxsulam 1.02% + cyhalofop butyl 5.1% OD (RM) @ 135 g ha-1 (T4) recorded significantly lower dry weight including *Echinochloa colona,* *Alternanthera sessilis,* *Cyperus iria,* *Cyperus difformis,* *Cynodon dactylon, and Eclipta prostrata* followed by bispyribac sodium 10% SC @ 25 g ha-1, bentazone 48 % SL @ 960 g ha-1 and triafamone 20% + ethoxysulfuron 10% WG (RM) @ 67.5 g ha-1 at different time interval. “Penoxsulam and bispyribac sodium applied as PoE have already been reported very effective against *E. crusgalli* and *E. colona*, few broad-leaf weeds and sedges, but not against other grasses such as *Leptochloa, Eragrostis, Dactyloctenium* etc” (Yadav *et al*, 2008). “Application of cyhalofop 80 g/ha alone proved less effective in reducing density and dry weight of complex weed flora, than combined application of penoxsulam + cyhalofop 135 g/ha in transplanted rice” (Singh *et al*, 2016). Kailkhura *et al*. (2015) and Hossain and Malik (2017) also found effective control of complex weed flora in transplanted rice with premix application of penoxsulam + cyhalofop 135 g/ ha (Table 2).

**Table 2 : Total weed density, total weed dry weight, weed control efficiency and weed index as influenced by different post emergence**

 **herbicides in transplanted rice.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatment** | **Dose**  | **Weed Density (no. m-2)**  | **Weed dry weight (g m-2)** | **Weed control efficiency** **(%)** | **Weed index** |
|  | **ai****(g ha-1)** | **25 DAA** | **50 DAA** | **75 DAA** | **25 DAA** | **50 DAA** | **75** **DAA** | **25 DAA** | **50 DAA** | **75 DAA** | **(%)** |
| Bispyribac sodium 10% SC | 25 | **2.97**(8.33) | **4.04**(16.00) | **4.83**(23.00) | **4.13**(16.79) | **5.68**(32.11) | **6.23**(38.31) | 74.60 | 66.64 | 67.71 | 8.01 |
| Penoxsulum 21.7% SC | 22.5 | **4.37**(18.67) | **5.58**(30.67) | **6.52**(42.00) | **6.23**(38.50) | **7.38**(54.10) | **8.05**(64.36) | 41.83 | 43.32 | 45.70 | 17.54 |
| 2,4-D Ethyl ester 38% EC | 950 | **4.14**(16.67) | **5.35**(28.33) | **6.18**(37.67) | **5.91**(34.44) | **7.12**(50.40) | **7.76**(59.80) | 48.12 | 47.43 | 49.42 | 14.39 |
| Penoxsulum 1.02% + cyhalofop butyl 5.1% OD | 135 | **2.06**(4.00) | **3.53**(12.00) | **4.30**(18.00) | **2.95**(9.48) | **4.80**(22.60) | **5.55**(30.36) | 86.29 | 76.33 | 74.32 | 2.13 |
| Triafamone 20% + ethoxysulfuron 10% WG | 67.5 | **3.67**(13.00) | **4.84**(23.00) | **5.61**(31.00) | **5.26**(27.17) | **6.54**(42.41) | **7.08**(49.74) | 59.22 | 55.73 | 58.05 | 12.72 |
| Bentazone 48 % SL | 960 | **3.33**(10.67) | **4.49**(19.67) | **5.27**(27.33) | **4.80**(22.77) | **6.05**(36.09) | **6.78**(45.46) | 65.15 | 62.34 | 61.60 | 10.54 |
| Metsulfuron methyl + chlorimuron ethyl 20 % (RM) | 4 | **3.98**(15.33) | **5.15**(26.00) | **5.95**(35.00) | **5.71**(32.14) | **6.88**(46.79) | **7.44**(54.90) | 51.73 | 51.12 | 53.72 | 13.87 |
| Hand weeding at 20 and 40 DAT | - | **0.88**(0.33) | **2.80**(7.33) | **3.53**(12.00) | **0.94**(0.50) | **4.03**(15.78) | **4.66**(21.25) | 99.17 | 83.50 | 82.05 | 0.00 |
| Unweeded control | **-** | **5.64**(31.33) | **7.22**(51.67) | **8.37**(69.67) | **8.20**(66.88) | **9.81**(95.78) | **10.91**(118.51) | 0.00 | 0.00 | 0.00 | 38.13 |
| **Sem±** **C.D. (P=0.05)** |  | **0.164****0.491** | **0.171****0.511** | **0.133****0.400** | **0.316****0.946** | **0.217****0.649** | **0.122****0.365** |  |  |  |  |

**Weed control efficiency, weed index and economics:** At all growth stages, highest weed control efficiency was observed under hand weeding at 20 and 40 DAT followed by penoxsulam1.02% + cyhalofop butyl 5.1% OD (RM) @ 135 g ha-1, bispyribac sodium 10% SC @ 25 g ha-1 and bentazone 48 % SL @ 960 g ha-1. Weed control efficiency ranges from 41.83 to 99.17 % at 25 DAA, 43.32 to 83.5 % at 50 DAA and 45.70 to 82.05 % at 75 DAA. Among all treatments, unweeded control recorded the highest (38.13 %) weed index, representing the highest reduction in yield due to weed competition. Lowest weed index (2.13%) was recorded under penoxsulam 1.02% + cyhalofop butyl 5.1% OD (RM) @ 135 g ha-1 (Table 2).

The highest cost of cultivation (Rs. 36661 ha-1)and gross return (Rs. 132755 ha-1) was recorded in hand weeding at 20 and 40 DAT while highest net return (Rs. 98843 ha-1) and B:C ratio (4.2) was obtained under application of penoxsulam 1.02% + cyhalofop butyl 5.1% OD (RM) @ 135 g ha-1 (Table 1).

**Conclusion**

The maximum plant growth, yield attributes, grain yield, minimum weed density and weed dry weight were achieved with hand weeding at 20 and 40 DAT, which was closely followed by the application of penoxsulam 1.02% + cyhalofop butyl 5.1% OD (RM) @ 135 g ha-1 followed by bispyribac sodium 10% SC @ 25 g ha-1 and bentazone 48 % SL @ 960 g ha-1. Post emergence application of herbicide mixtures have resulted in effective control of broad- leaved weeds, grasses and sedges due to their broad-spectrum action.

**Disclaimer (Artificial intelligence)**

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

 **REFERENCE**

Bhurer, KP, Yadav, DN, Ladha, J.K., Thapa, R.B., and Pandey, K., 2013. Effect of integrated weed management practices on performance of dry direct seeded rice (Oryza sativa L.). Agronomy Journal of Nepal 3: 53–63

Das, Rajib, Bera, Soumen, Pathak, A., Mandal, M. K., 2015. Weed management in transplanted rice through bispyribac sodium 10% SC and its effect on soil microflora and succeeding crop blackgram. *International Journal of Current Microbiology and Applied Sciences* ISSN: 2319-7706 Volume 4 pp. 681-688

Das, T., Mandal, B., Banerjee, M. and Malik G. C. 2017. Evaluation of bispyribac- sodium and other herbicides in transplanted rice*. International Journal of Applied and*

 *Pure Science and Agriculture* **03**, Issue 5.

Hossain, A. and Malik, G. C. 2017. Herbicides combinations for control of complex weed flora in transplanted rice in lateritic belt of West Bengal. *Indian Journal of Weed Science* 49(3): 276-278.

Kailkhura S, Pratap T, Singh VP, Guru SK and Singh SP. 2015. Herbicide combinations for control of complex weed flora in transplanted rice. Indian Journal of Weed Science 47(4): 414–416.

Mahapatra, Ashirbachan, Saha, Sanjoy, Munda, Sushmita, Satapathy, B.S., Meher, Sunita, Jangde, Hemant Kumar, 2023. Bio-efficacy of herbicide mixtures on weed dynamics in direct wet-seeded rice. *Indian Journal of Weed Science* (2023) 55(1): 18–23.

Mohapatra, S., Tripathy, S.K. 2017. Tank mix application of selected herbicides and insecticides for weed and insect control in transplanted rice. *Indian Journal of Weed Science* 49(4): 312–316.

Singh VP, Singh SP, Pratap T, Joshi V, Kumar A, Tripathi N, Banga A and Bisht N.2016. Efficacy of ready mix of penoxsulam and cyhalofop-butyl for weed control in transplanted rice. The Ecoscan 10(1&2): 217–221.

Yadav, D. B., Yadav, A. and Punia, S. S., 2008. Efficacy of penoxsulum against weeds in transplanted rice. Indian J. Weed Sci., 40 (3 & 4): 122-146.

Yadav, Dharam Bir, Singh, Narendra, Duhan, Anil, Yadav Ashok, Punia S.S., 2018, Penoxsulam + cyhalofop-butyl (premix) evaluation for control of complex weed flora in transplanted rice and its residual effects in rice-wheat cropping system. *Indian Journal of Weed Science* 50(4): 333–339

Raghuwanshi M, Jha AK, Verma B, Yadav PS, Shrivastava A. Weed dynamics of fodder maize as influenced by different herbicides. International Journal of Environment and Climate Change. 2023 May 3;13(7):245-51.

Prajapat AL. Effect of Different Herbicides on Weed Dynamics in Wheat (Triticum aestivum L.). Asian Research Journal of Agriculture. 2024 Oct 2;17(4):348-53.