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# Integrated weed management in rice (*Oryza sativa* L.) grown by system of rice Intensification method

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**Abstract**
A field experiment was conducted during *kharif* season of 2011 at Indian Agricultural Research Institute, New Delhi with ten weed control treatments ($T_1$- Hand weeding at 15 and 30 DAT; $T_2$- Cono weeding at 15, 30 and 45 DAT; $T_3$- Pretilachlor @ 1000 g/ha as PE; $T_4$- Pretilachlor @ 750 g/ha as PE followed by (*fb)* one cono weeding at 30 DAT;$T_5$- One cono weeding at 15 DAT *fb* bispyribac sodium @ 25 g/ha at 30 DAT; $T_6$- Pyrazosulfuron-ethyl @ 25 g/ha at 10 DAT; $T_7$- Pyrazosulfuron-ethyl @ 20 g/ha at 10 DAT *fb* one cono weeding at 40 DAT; $T_8$ - One cono weeding at 15 DAT *fb* cyhalofop-butyl @ 60 g/ha at 30 DAT;$T_9$- Weed free check; $T_{10}$- Weedy check) in randomized block design with three replications to find effect of weed control measures on weeds as well as crop growth. Cono weeding done thrice at 15, 30 and 45 DAT caused highest reduction in weeds growth, recorded highest weed control index and produced significantly higher rice grain yield over weedy check. The said treatment was found statistically on par with one cono weeding at 15 DAT *fb* bispyribac sodium application @ 25 g/ha at 30 DAT and with pyrazosulfuron-ethyl application @ 20 g/ha at 10 DAT *fb* one cono weeding at 40 DAT treatments.

**Keywords:** Bispyribac sodium, cono weeding, cyhalofop-butyl, SRI, weed control efficiency, pyrazosulfuron-ethyl

## Introduction

Rice (*Oryza sativa* L.) is the King crop of Asia, because 90% of rice is being produced and consumed in Asia alone. Globally, rice crop occupies 158 million ha (m ha) of arable land and has total global production and productivity of 744.9 million tonnes (mt) and 4.71 t/ha, respectively (FAO, 2014) [3]. In our country India, rice is grown in about 43.0 mha area with the production and productivity of 154.5 mt and 2.41 t/ha, respectively (USDA, 2016) [10]. Rice crop is known to have very low water use efficiency and under irrigated conditions it consumes about 3,000 to 5,000 litres of water to produce one kilogram of rice. A comparison of water requirement and utilizable supplies showed that, by the year 2025, the magnitude of the scarcity would be 26.2 million hectare meter (Kumar, 2003) [5]. Under increasingscarcity of water, it becomes pivotal to grow rice with less water requiring production technologies like system of rice intensification (SRI). The SRI method uses young seedlings of 8 to 12 days old that are transplanted at the spacing of 25×25 $cm^2$ @ 1 seedling/hill into the puddled fields, which are managed by intermittent irrigation regime. Such ecological situations under SRI favour the growth of complex weed flora. Season long weed competition has reduced grain yield by 50-60% and 70-80% in transplanted and direct seeded rice cultures, respectively (Dass *et al.*, 2017) [2]. The pre-emergence application of grass weeds killer herbicide (pretilachlor, butachlor, and anilofos) only controls initial weed flushes and render luxurious weed growth in later crop growing season (Yadav *et al*., 2008) [12]. Consistent use of grass weed killers over the years has shifted the weed flora from grassy weeds to sedges and broad-leaved weeds and from annuals to perennials weed flora (Rajkhowa *et al*., 2006). So there is need to evaluate wide range of weed control strategies like hand weeding, mechanical control, herbicides and suitable combination of above in the form of an economically and ecologically justifiable method to make SRI more profitable and sustainable rice growing technique under limited water conditions. Hence, the present experiment was conducted to find out the most appropriate set of weed control schedule under SRI.

## Material and Methods

The field experiment was conducted at Indian Agricultural Research Institute, New Delhi (28.4 °N, 77.1 °E,228 m above mean sea level) during *kharif* 2011-12.The soil was sandy loam with pH 7.5, organic carbon (0.53%), available nitrogen (236.8 kg/ha), phosphorus (15 kg/ha) and potassium (247 kg/ha). Crop received 487.8 mm rainfall during the growing season.

Ten weed control treatments, *viz.*, ($T_1$- Hand weeding at 15 and 30 DAT; $T_2$- Cono weeding at 15, 30 and 45 DAT; $T_3$- Pretilachlor 1000 g/ha as PE; $T_4$- Pretilachlor 750 g/ha as PE followed by (*fb)* one cono weeding at 30 DAT; $T_5$- One cono weeding at 15 DAT *fb* bispyribac sodium 25 g/ha at 30 DAT; $T_6$-Pyrazosulfuron-ethyl 25 g/ha at 10 DAT; $T_7$- Pyrazosulfuron-ethyl 20 g/ha at 10 DAT *fb* one cono weeding at 40 DAT; $T_8$ - One cono weeding at 15 DAT *fb* cyhalofop-butyl 60 g/ha at 30 DAT; $T_9$- Weed free check; $T_{10}$ - Weedy check) were laid out in randomized block design with three replications. The nursery of rice variety 'Pusa Sugandh 5' for transplanting was sown on 19th June, 2011. Standard agronomic practices were followed to raise the crop as per basic principles of SRI. The crop was fertilized with N, $P_2O_5$, and $K_2O$ @ 120, 60 and 60 kg/ha respectively in all the treatments. Half of the total N requirement was made through the organic source (Farm yard manure (FYM) @ 10 t/ha) and remaining half through inorganic sources (DAP and urea). FYM @ 10 t/ha was incorporated at second ploughing. The rest dose of phosphorus was applied through DAP as basal application. Remaining dose of nitrogen was top dressed at panicle initiation (50th day) stageof the crop through urea. Whole potassium requirement was fulfilled through FYM. Mechanical weedings were carried out with manually operated cono weeder at respective crop growth stages. Herbicides were applied with manually operated knapsack sprayer fitted with flat-fan nozzle at spray volume of 500 litres/ha. Pre-emergence application of pretilachlor was made within 1-2 days after transplanting of seedlings and early post-emergence application of pyrazosulfuron-ethyl was done at 10 days after transplanting as per the treatments. The data on weeds were recorded at 60 days after transplanting in each plot with two randomly placed quadrates (size 0.25 $m^2$). Weeds were separatedspecies wise, counted, sun dried and finally dried in the oven at $60^0$C till constant weight. Crop growth parameters *viz.*, shoot dry weight and leaf area were recorded at 60 days crop growth stage. The yield attributing characters *viz.*, panicles/$m^2$, filled grains per panicle, panicle weight and 1000 grain weight were recorded at harvest. Weed data were subjected to square root transformation ($\sqrt{X + 0.5}$) before statistical analysis to normalize their distribution. Weed control efficiency (WCE) was calculated by using the total dry weight of weeds. The data were analyzed using ANOVA and the least significant difference (LSD) values were calculated at $P$=0.05 level of significance to test significant differences between treatment means.

## Result and Discussion

The major weed flora in the field comprised of *Echinochloa crus-galli*(L.), *Echinochloa colona* (L.), *Leptochloachinensis* (L.), and *Cyperusdifformis* (L.) among monocots. Among dicot weeds *Ecliptaalba*(L.) was dominant one. Besides, the above mention weed species, some other minor weeds like *Cyperusiria* (L.), *Lippianudiflora* and *Ammanniabaccifera* (L.) were also observed at different stages of crop growth. All weed control treatments significantly reduced the density and dry weight of weedsas compared to weedy check at 60 days crop growth stage (Table 1). Cono weeding at 15, 30 and 45 DAT was the best treatment but it was found at par with integrated weed control schedules *viz.*, one cono weeding at 15 DAT *fb* bispyribac sodium 25 g/ha at 30 DAT and pyrazosulfuron-ethyl 20 g/ha at 10 DAT *fb* one cono weeding at 40 DAT. The treatment cono weeding thrice has recorded weed control efficiency (WCE) of 92.1% and weed index (WI) of 2.96% thought the highest WCE and lowest WI were observed with weed free treatment. Hand weeding twice at 15 and 30 DAT was at par with pretilachlor 750 g/ha *fb* one cono weeding at 30 DAT and one cono weeding at 15 DAT *fb* cyhalofop-butyl 60 g/ha at 30 DAT. However, treatment one cono weeding at 15 DAT *fb* bispyribac sodium 25 g/ha at 30 DAT was found at par with the treatments pretilachlor 750 g/ha *fb* one cono weeding at 30 DAT, one cono weeding at 15 DAT *fb* cyhalofop-butyl 60 g/ha at 30 DAT and hand weeding at 15 and 30 DAT in reducing the density and dry weight of *Leptochloa chinensis* (L.). Pretilachlor 1000 g/ha was the lowest efficient in controlling weeds and was at par to pyrazosulfuron-ethyl 25 g/ha at 10 DAT. Three weedings with rotary weeder at 14, 28 and 42 DAT was the best treatment for controlling weeds under SRI method (Pandey, 2009) [7]. Yadav *et al.*, (2009) reported that bispyribac applied at 15 or 25 DAT was found equally effective against grassy weeds, but control of broad-leaved weeds and sedges was comparatively more when applied at 15 DAT. Pre-emergence application of pendimethalin 1 kg/ha *fb* cono weeding at 30 DAS and one hand weeding at 45 DAS recordedthe lowest weed density and dry weight (Pasha *et al.*, 2011) [8]. The highest weed control efficiency was associated with cono weeding at 15, 30 and 45 DAT (92.1%) followed by one cono weeding at 15 DAT along with bispyribac sodium 25 g/ha at 30 DAT (90.5%) and pyrazosulfuron-ethyl 20 g/ha at 10 DAT combined with one cono weeding at 40 DAT (89.5%). In rice at 60 days crop growth stage, Ghosh *et al.* (2017) [4] recorded lowest total weed dry biomass with combined application of bispyribac-sodium+azimsulfuron (25 + 17.5 g/ha) at 15 days after sowing (DAS).

All the crop growth and yield attributes attained significant improvement under different weed control treatments then weedy check (Table 2). Among weed control treatments, cono weeding at 15, 30 and 45 DAT registered the highest crop growth attributes (shoot dry weight/$m^2$ and leaf area index), yield attributes (panicles/$m^2$, filled grains/panicle, panicle weight and test weight), grain yield (4.68 t/ha), straw yield (10.03 t/ha) and the lowest weed index (2.96). It was found at par with integrated treatments *viz.*, one cono weeding at 15 DAT *fb* bispyribac sodium 25 g/ha at 30 DAT and pyrazosulfuron-ethyl 20 g/ha at 10 DAT *fb* one cono weeding at 40 DAT. Mohanty and Mohanty (2010) [6] obtained significantly the highest grain and straw yield of rice through three cono weeding at 10, 20 and 30 DAT in system of rice intensification method. Arthanari *el al.*, (2012) [1] also found identical results of increased grain and straw yield with pre-emergence application of pyrazosulfuron-ethyl @ 30 g/ha integrated with finger type double row rotary weeder weeding at 40 DAT under SRI method. The highest yield of zero-till direct-seeded rice was registered with combined tank mix application of bispyribac-sodium+azimsulfuron herbicides as well as through integration of cowpea green-manuring *fb* 2,4-D + glyphosate *fb* bispyribac-sodium treatment due to the effective management of versatile weed flora (Ghosh *et al.*, 2017) [4].

**Table 1:** Effect of weed control treatments on growth of different weeds at 60 days crop growth stage

| Treatment | *Echinochloa crusgalli* | | *Cyperus difformis* | | *Eclipta alba* | | *Echinochloa colona* | | *Leptochloa chinensis* | | WCE (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Density ($No/m^2$) | Dry weight ($g/m^2$) | Density ($No/m^2$) | Dry weight ($g/m^2$) | Density ($No/m^2$) | Density ($No/m^2$) | Dry weight ($g/m^2$) | Density ($No/m^2$) | Dry weight ($g/m^2$) | Density ($No/m^2$) | |
| Hand weeding at 15 and 30 DAT | 3.89 (14.67) | 3.10 (9.2) | 3.87 (14.67) | 2.74 (7.07) | 3.30 (10.67) | 3.89 (14.67) | 3.10 (9.2) | 3.87 (14.67) | 2.74 (7.07) | 3.30 (10.67) | 81.0 |
| Cono weeding at 15, 30 and 45 DAT | 2.39 (5.33) | 1.78 (2.8) | 2.39 (5.33) | 1.80 (2.80) | 2.12 (4.00) | 2.39 (5.33) | 1.78 (2.8) | 2.39 (5.33) | 1.80 (2.80) | 2.12 (4.00) | 92.1 |
| Pretilachlor @ 1000 g/ha as pre-emergence | 5.19 (26.67) | 4.02 (15.73) | 5.27 (28.00) | 3.62 (12.67) | 4.78 (22.67) | 5.19 (26.67) | 4.02 (15.73) | 5.27 (28.00) | 3.62 (12.67) | 4.78 (22.67) | 57.6 |
| Pretilachlor @ 750 g/ha as pre-emergence *fb* one cono weeding at 30 DAT | 4.04 (16.00) | 3.17 (9.6) | 4.04 (16.00) | 2.83 (7.60) | 3.50 (12.00) | 4.04 (16.00) | 3.17 (9.6) | 4.04 (16.00) | 2.83 (7.60) | 3.50 (12.00) | 78.4 |
| One cono weeding at 15 DAT *fb* bispyribac sodium @ 25 g/ha at 30 DAT | 2.65 (6.67) | 1.87 (3.07) | 2.65 (6.67) | 1.91 (3.20) | 2.39 (5.33) | 2.65 (6.67) | 1.87 (3.07) | 2.65 (6.67) | 1.91 (3.20) | 2.39 (5.33) | 90.5 |
| Pyrazosulfuron-ethyl @ 25 g/ha at 10 DAT | 5.08 (25.33) | 3.78 (13.87) | 5.19 (26.67) | 3.41 (11.20) | 4.67 (21.33) | 5.08 (25.33) | 3.78 (13.87) | 5.19 (26.67) | 3.41 (11.20) | 4.67 (21.33) | 61.9 |
| Pyrazosulfuron-ethyl @ 20 g/ha at 10 DAT *fb* one cono weeding at 40 DAT | 2.86 (8.00) | 1.95 (3.33) | 2.86 (8.00) | 1.96 (3.47) | 2.59 (6.67) | 2.86 (8.00) | 1.95 (3.33) | 2.86 (8.00) | 1.96 (3.47) | 2.59 (6.67) | 89.5 |
| One cono weeding at 15 DAT *fb* cyhalofop-butyl @ 60 g/ha at 30 DAT | 3.71 (13.33) | 3.12 (9.33) | 3.87 (14.67) | 2.78 (7.33) | 4.37 (18.67) | 3.71 (13.33) | 3.12 (9.33) | 3.87 (14.67) | 2.78 (7.33) | 4.37 (18.67) | 78.5 |
| Weed free | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 100.00 |
| Weedy check | 8.65 (74.67) | 7.10 (50.27) | 6.26 (38.67) | 4.91 (23.6) | 6.34 (40.00) | 8.65 (74.67) | 7.10 (50.27) | 6.26 (38.67) | 4.91 (23.6) | 6.34 (40.00) | 0.00 |
| SEm± | 0.25 | 0.18 | 0.30 | 0.17 | 0.26 | 0.25 | 0.18 | 0.30 | 0.17 | 0.26 | 1.83 |
| LSD(P=0.05) | 0.73 | 0.54 | 0.89 | 0.49 | 0.77 | 0.73 | 0.54 | 0.89 | 0.49 | 0.77 | 5.42 |

PE= Pre-emergence, DAT = Days after transplanting, *fb*=followed by, Data were subjected to $\sqrt{X + 0.5}$) transformation before statistical analysis. Figure in parentheses are the original values, WCE=Weed control efficiency

**Table 2:** Effect of weed control treatments on weeds, crop growth, yield attributes, yields and weed index

| Treatment | Total weed density (($No/m^2$) | Total weed dry weight ($g/m^2$) | Shoot dry weight at 60 DAT ($g/m^2$) | Leaf area index (60 DAT) | Panicles/ $m^2$ | Filled grain/panicle | Panicle weight (g) | Test weight (g) | Grain yield (t/ha) | Straw yield (t/ha) | Weed index (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hand weeding at 15 and 30 DAT | 9.01 (81.33) | 5.94 (34.80) | 300.67 | 5.60 | 365.80 | 126.2 | 3.1 | 23.6 | 3.98 | 8.49 | 17.91 |
| Cono weeding at 15, 30 and 45 DAT | 6.00 (36.00) | 3.83 (14.40) | 334.33 | 6.35 | 438.60 | 148.3 | 3.9 | 24.9 | 4.68 | 10.03 | 2.96 |
| Pretilachlor @ 1000 g/ha as pre-emergence | 12.86 (165.33) | 8.82 (77.47) | 258.00 | 4.78 | 292.00 | 107.4 | 2.4 | 23.0 | 2.92 | 6.80 | 39.56 |
| Pretilachlor @ 750 g/ha as pre-emergence *fb* one cono weeding at 30 DAT | 9.38 (88.00) | 6.30 (39.33) | 294.33 | 5.52 | 362.93 | 125.9 | 3.0 | 23.4 | 3.69 | 8.08 | 23.63 |
| One cono weeding at 15 DAT *fb* bispyribac sodium @ 25 g/ha at 30 DAT | 7.05 (49.33 | 4.19 (17.20) | 334.00 | 6.33 | 432.06 | 146.2 | 3.7 | 24.7 | 4.49 | 9.66 | 7.16 |
| Pyrazosulfuron-ethyl @ 25 g/ha at 10 DAT | 12.45 (154.67) | 8.36 (69.60) | 260.67 | 4.85 | 295.79 | 111.7 | 2.6 | 23.2 | 2.99 | 6.91 | 38.00 |
| Pyrazosulfuron-ethyl @ 20 g/ha at 10 DAT *fb* one cono weeding at 40 DAT | 6.86 (46.67) | 4.37 (19.07) | 332.67 | 6.29 | 425.60 | 143.3 | 3.7 | 24.5 | 4.47 | 9.56 | 7.33 |
| One cono weeding at 15 DAT *fb* cyhalofop-butyl @ 60 g/ha at 30 DAT | 9.26 (85.33) | 6.29 (39.47) | 297.33 | 5.63 | 368.29 | 127.6 | 3.3 | 23.9 | 3.93 | 8.42 | 18.37 |
| Weed free | 0.71 (0.00) | 0.71 (0.00) | 337.33 | 6.40 | 450.01 | 152.9 | 4.1 | 25.1 | 4.83 | 10.35 | 0.00 |
| Weedy check | 17.62 (310.67) | 13.54 (183.07) | 215.33 | 4.17 | 231.03 | 90.3 | 2.0 | 20.0 | 2.03 | 5.13 | 57.85 |
| SEm± | 0.36 | 0.27 | 9.38 | 0.20 | 17.87 | 4.62 | 0.11 | 0.98 | 0.12 | 0.36 | 2.52 |
| LSD(P=0.05) | 1.06 | 0.82 | 27.88 | 0.59 | 53.09 | 13.72 | 0.34 | 2.92 | 0.36 | 1.08 | 7.48 |

PE= Pre-emergence, DAT = Days after transplanting, *fb*=followed by, Data were subjected to $\sqrt{X + 0.5}$) transformation before statistical analysis. Figure in parentheses are the original values

**Summary**
A field experiment was conducted during *kharif* 2011 at experimental farm of Indian Agricultural Research Institute, New Delhi to find out the most appropriate set of weed control schedules under SRI method of rice cultivation. Among weed control treatments, cono weeding at 15, 30 and 45 DAT registered the lowest weed density and dry weight, the highest growth attributes, yield attributes, grain yield (4.68 t/ha), straw yield (10.03 t/ha) and the lowest weed index (2.96). Integrated treatments *viz.*, one cono weeding at 15 DAT *fb* bispyribac sodium 25 g/ha at 30 DAT and pyrazosulfuron-ethyl 20 g/ha at 10 DAT *fb* one cono weeding at 40 DAT were at par with the former treatment in reducing weed pressure, improving crop growth and yield attributes under SRI method of rice cultivation.

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