Short Communication

# Efficacy of new generation herbicides for weed management in semi dry rice

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**Abstract**

A study was conducted during *kharif* season of 2014 to evaluate the weed control efficiency of low dose high efficiency new generation herbicides in semi dry rice in Kerala. The new herbicides evaluated were benzsulfuron methyl + pretilachlor @ 60 + 600 g a.i. $ha^{-1}$, pyrazosulfuron ethyl @ 25 g a.i. $ha^{-1}$ along with post emergent herbicide azimsulfuron @ 30 g a.i. $ha^{-1}$. Results of the study revealed substantial reduction in weed population and biomass in all the herbicide treated plots compared to weedy check. Pre-emergent herbicide application followed by either hand weeding at 40 DAS or application of post emergent herbicides recorded higher weed control efficiency in comparison with hand weeding twice (20 and 40 DAS). Grain yield (4817.67 kg $ha^{-1}$) and straw yield (7969.33 kg $ha^{-1}$) were significantly higher on application of benzsulfuron methyl + pretilachlor followed by hand weeding at 40 DAS. Yield loss due to weeds was found to be 52.22 per cent and the most economically viable weed management practice was pre emergent application of pyrazosulfuron ethyl followed by azimsulfuron with a B: C ratio of 1.76, which was on par with pre emergent application of benzsulfuron methyl + pretilachlor followed by azimsulfuron @ 30 g a.i. $ha^{-1}$. Hence pre-emergence application of either benzsulfuron methyl + pretilachlor @ 60 + 600 g a.i. $ha^{-1}$ or pyrazosulfuron ethyl @ 25 g a.i. $ha^{-1}$ on the day after sowing followed by post emergence application of azimsulfuron @ 30 g a.i. $ha^{-1}$ at 25 DAS could be recommended as the most effective weed management practice for semi dry rice.

**Keywords:** Dry direct seeded rice, Low dose herbicides, New generation herbicides, Semidry rice, Weed management

In India, the dry sown (semi dry) system of rice cultivation is a unique and extensively adopted system in 20 per cent rice growing area and in Kerala, it constitutes more than 60 per cent of the area under rice during *kharif* (Anitha et al., 2009). Direct seeding of rice helps to meet the challenges posed by water and labour shortage, time and edaphic conflicts, and it promises system sustainability (Chauhan et al., 2014). In this system, the early growth of rice, up to 30-40 days, is in a dry soil environment and thereafter the field gets submerged with the onset of southwest monsoon. The absence of stagnant water during the initial 4-6 weeks causes serious weed problems in dry sown rice with regard to weed management. Weeds grow quickly and there is abundance of weeds of diverse nature in direct seeded rice because of the absence of differential size between the crop and weed seeds (Rao et al., 2007). Weed management using herbicides has become an integral part of modern agriculture. New generations herbicides which are applied at very low doses are more effective with low mammalian toxicity and reduced risk of environmental pollution. Several new generation

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pre-emergence herbicides applied alone or supplemented with hand weeding or chemical weeding have been reported to provide a fair degree of weed control (Pellerin and Webster, 2004). However, their efficacy in semi dry system has not been evaluated so far in Kerala. Their selectivity and economic feasibility need to be assessed so as to formulate a low cost herbicide based weed management strategy for semi dry rice in Kerala. Keeping the above in view, the present was conducted to develop a herbicide based weed management strategy for semi dry rice.

The field experiment was conducted in a farmer's field near the College of Agriculture, Vellayani located at 8.5$^{o}$N latitude and 76.9 $^{O}$E longitudes at an altitude of 29 m above MSL. A warm humid tropical climate is experienced by the experimental area. The soil of the experimental site belongs to the textural class sandy clay, and the taxonomical order oxisol. The soil pH was 5.41 and EC was normal (0.4dS m$^{-1}$which is safe limit), high in organic carbon and available P, medium in available N and K. The field experiment was conducted during *kharif* season of 2014 by dry direct seeding of popular rice variety 'Uma' in Randomised Block Design with three replications. The treatments included different pre-emergent herbicides applied alone, and their combinations with either post emergent herbicides or hand weeding. The new low dose herbicides used were benzsulfuron methyl + pretilachlor, pyrazosulfuron ethyl (pre-emergent herbicides) and azimsulfuron (post-emergent herbicide) along with a traditional herbicide oxyfluorfen. The treatments were $T_1$: benzsulfuron methyl + pretilachlor @ 60 + 600g a.i.ha$^{-1}$ (pre-emergence), $T_2$: $T_1$ + hand weeding at 40 DAS, $T_3$: $T_1$ + azimsulfuron @ 30 g a.i. ha$^{-1}$ at 25 DAS, $T_4$: pyrazosulfuron ethyl @ 25 g a.i.ha$^{-1}$ (pre-emergence), $T_5$: $T_4$ + hand weeding at 40 DAS, $T_6$ : $T_4$ + azimsulfuron @ 30 g a.i. ha$^{-1}$ at 25 DAS, $T_7$: oxyfluorfen @ 0.15 kg a.i. ha$^{-1}$ (pre - emergence), $T_8$: $T_7$ + hand weeding at 40 DAS, $T_9$ : $T_7$ + azimsulfuron @ 30 g a.i. ha$^{-1}$ at 25 DAS and two controls: $T_{10}$: hand weeding at 20 and 40 DAS and $T_{11}$: weedy check. Pre-emergent herbicides were applied one day after sowing on to the surface of soil using knapsack sprayer with flood jet nozzle while post emergent herbicides were applied on to the emerged weed flora. A quadrat of size 50 x 50 cm was placed at random at two sites in the weed sampling area of each plot for weed observations. Ten sample plants were selected at random from the net plot area (avoiding two border rows) of each plot and tagged for recording crop observations. The data recorded at periodic intervals were subjected to Analysis of Variance techniques (ANOVA) after transformation wherever needed. Results of the study revealed substantial reduction in weed population and biomass in all the herbicide

*Table 1.* Effect of weed management practices on absolute weed density, number m$^{-2}$

| Treatments | Grasses | | | Broad leaved weeds | | | Sedges | | |
|---|---|---|---|---|---|---|---|---|---|
| | 15 DAS | 30 DAS | 45 DAS | 15 DAS | 30 DAS | 45 DAS | 15 DAS | 30 DAS | 45 DAS |
| $T_1$ | 4.33 | 10.33 | 16.67 | - | 19.25 (4.39) | 25.90 (5.09) | 7.28 (2.70) | 19.92 (4.46) | 37.32 (6.11) |
| $T_2$ | 4.33 | 8.33 | 3.33 | - | 15.96 (3.99) | 4.97 (2.23) | 6.63 (2.58) | 18.66 (4.32) | 4.32 (2.08) |
| $T_3$ | 4.00 | 9.67 | 18.00 | - | 3.32 (1.82) | 8.66 (2.94) | 8.33 (2.89) | 2.31 (1.52) | 10.30 (3.21) |
| $T_4$ | 4.67 | 10.33 | 18.67 | - | 19.25 (4.39) | 25.22 (5.02) | 8.33 (2.89) | 19.28 (4.39) | 33.30 (5.77) |
| $T_5$ | 4.67 | 10.00 | 3.00 | - | 16.32 (4.04) | 3.65 (1.91) | 7.64 (2.76) | 20.31 (4.51) | 5.32 (2.31) |
| $T_6$ | 5.00 | 9.67 | 16.33 | - | 3.32 (1.82) | 7.92 (2.81) | 6.32 (2.51) | 2.64 (1.63) | 9.63 (3.10) |
| $T_7$ | 4.67 | 10.67 | 20.33 | - | 19.97 (4.47) | 29.28 (5.41) | 8.66 (2.94) | 22.30 (4.72) | 40.31 (6.35) |
| $T_8$ | 4.33 | 8.00 | 3.67 | - | 18.62 (4.31) | 4.32 (2.08) | 8.33 (2.89) | 20.93 (4.570 | 7.28 (2.70) |
| $T_9$ | 4.00 | 10.33 | 20.67 | - | 4.62 (2.15) | 11.94 (3.46) | 9.33 (3.05) | 4.65 (2.16) | 12.30 (3.51) |
| $T_{10}$ | 5.67 | 4.67 | 2.67 | 13.33 | 5.97 (2.44) | 3.55 (1.88) | 20.31(4.51) | 5.66 (2.38) | 3.61 (1.90) |
| $T_{11}$ | 5.33 | 10.67 | 20.33 | 10.67 | 29.80 (5.46) | 39.22 (6.26) | 18.65(4.32) | 30.64 (5.54) | 48.31 (6.95) |
| SEm(±) | - | 0.201 | 0.703 | - | 0.166 | 0.185 | 0.094 | 0.117 | 0.122 |
| CD(0.05) | NS | 0.597 | 2.090 | - | 0.489 | 0.546 | 0.279 | 0.346 | 0.361 |

*Table 2.* Effect of weed management practices on total weed dry weight and weed control efficiency

| Treatments | Total weed dry weight (g) | | | Total weed control efficiency | | |
|---|---|---|---|---|---|---|
| | 20 DAS | 40 DAS | 60DAS | 20 DAS | 40 DAS | 60DAS |
| $T_1$ | 6.55 | 29.30 | 73.86 (8.59) | 53.57 (7.39) | 35.35 (6.03) | 22.63 (4.86) |
| $T_2$ | 6.86 | 28.35 | 25.55 (5.06) | 51.31 (7.23) | 36.19 (6.10) | 73.18 (8.61) |
| $T_3$ | 6.83 | 10.57 | 38.14 (6.18) | 51.58 (7.25) | 76.81 (8.82) | 59.96 (7.81) |
| $T_4$ | 7.04 | 31.53 | 64.16 (8.01) | 50.14 (7.15) | 30.72 (5.63) | 32.78 (5.81) |
| $T_5$ | 6.89 | 30.30 | 26.03 (5.10) | 51.17 (7.22) | 28.98 (5.48) | 72.72 (8.59) |
| $T_6$ | 7.06 | 12.61 | 37.83 (6.15) | 49.99 (7.14) | 72.32 (8.56) | 60.15 (7.82) |
| $T_7$ | 7.36 | 34.67 | 75.10 (8.67) | 47.75 (6.98) | 23.59 (4.96) | 21.30 (4.72) |
| $T_8$ | 7.26 | 34.41 | 30.96 (5.56) | 48.56 (7.04) | 20.18 (4.60) | 67.55 (8.28) |
| $T_9$ | 7.03 | 13.00 | 42.77 (6.54) | 50.20 (7.16) | 71.53 (8.52) | 55.20 (7.50) |
| $T_{10}$ | 13.67 | 14.05 | 20.43 (4.52) | 2.58 (1.89) | 71.32 (8.50) | 78.59 (8.92) |
| $T_{11}$ | 14.14 | 45.85 | 95.48 (9.77) | 0.00 | 0.00 | 0.00 |
| SEm (±) | 0.308 | 0.899 | 0.107 | 0.231 | 0.208 | 0.094 |
| CD (0.05) | 0.907 | 2.653 | 0.317 | 0.686 | 0.619 | 0.278 |

treated plots compared to weedy check (Tables 1 & 2). Treatments receiving pre-emergent application of oxyfluorfen recorded higher absolute density of weeds than benzsulfuron methyl + pretilachlor or pyrazosulfuron ethyl treated plots. Though no visual symptoms of phytotoxicity were observed in oxyfluorfen treated plots, its unfavourable effect on seed germination reduced the crop density. Reduced crop density at the initial stages might have resulted in higher absolute density of weeds at the critical stages of crop growth in oxyfluorfen treated plots.

Benzsulfuron methyl + pretilachlor @ 60 + 600 g $ha^{-1}$ and pyrazosulfuron ethyl @ 25 g a.i. $ha^{-1}$ were found to be promising broad spectrum herbicides for early season weed control in semi dry system of rice cultivation as evident from the lower weed count recorded at 15 DAS. The effect of pre-emergent herbicides lasted only up to 15-20 DAS and they were very effective in controlling broad leaved weeds as evidenced by zero absolute density at 15 DAS. There are reports of the effectiveness of pyrazosulfuron ethyl @ 25 g a.i. $ha^{-1}$ in controlling broad leaved weeds and sedges in DSR (Gopal et al., 2010). According to Sanjay et al., (2013), benzsulfuron methyl + pretilachlor @ 0.06 + 0.60 kg a.i. $ha^{-1}$ was effective for controlling weeds in aerobic rice. Hand weeding at 20 and 40 DAS ($T_{10}$) recorded lowest weed density, weed dry weight and highest weed control efficiency. The application of pre-emergent herbicides (except oxyfluorfen) followed by one hand weeding at 40 DAS was effective in controlling grasses, sedges and broad leaved weeds and resulted in reduced density of weeds. Pre-emergent herbicide application followed by either hand weeding at 40 DAS ($T_2$ and $T_5$) or application of post emergent herbicides ($T_3$ and $T_6$) recorded higher weed control efficiency and lower nutrient removal in comparison with hand weeding twice (20 and 40 DAS). Weed management practices involving application of pre-emergent herbicides (except oxyfluorfen @ 0.15 kg $ha^{-1}$) followed by post emergent application of azimsulfuron @ 30 g $ha^{-1}$ was found effective in reducing weed density and weed infestation. This is in conformity with the findings of Gianessi et al., (2002) who reported that diverse weed flora in dry seeded rice fields necessitate the use of two or more herbicides for wide spectrum weed control. As per Kim and Ha (2005), the first herbicide has to be used at the dry period just before rice emergence and the other at the flood period. However, grassy weeds like Echinochloa sp. and weedy rice that appeared after flooding were not controlled by azimsulfuron application at 25 DAS. This was in conformity with the findings of Pacanoski and Glatkova (2009) who reported that azimsulfuron gave excellent control of annual and perennial weeds in direct sown rice

*Table 3.* Effect of weed management practices on yield and yield parameters

| Treatments | Productive tillers $m^{-2}$ | Spikelets $panicle^{-1}$ | Filled grains $panicle^{-1}$ | Grain yield (kg $ha^{-1}$) | Straw yield (kg $ha^{-1}$) | Harvest index | Thousand grain weight (g) | Net income (Rs. $ha^{-1}$) | B:C ratio |
|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | 428.00 | 102.93 | 88.03 | 3857.33 | 6491.33 | 0.37 | 24.07 | 31782.33 | 1.50 |
| $T_2$ | 503.33 | 117.17 | 104.33 | 4817.67 | 7969.33 | 0.38 | 24.40 | 42980.33 | 1.57 |
| $T_3$ | 513.67 | 111.90 | 100.01 | 4684.33 | 7749.33 | 0.38 | 25.20 | 49300.33 | 1.75 |
| $T_4$ | 434.67 | 101.39 | 85.29 | 3601.67 | 6031.00 | 0.37 | 22.23 | 25864.00 | 1.41 |
| $T_5$ | 491.00 | 117.86 | 104.64 | 4790.67 | 7825.67 | 0.38 | 22.83 | 42444.67 | 1.57 |
| $T_6$ | 509.67 | 112.14 | 98.66 | 4673.33 | 7708.00 | 0.38 | 24.20 | 49462.00 | 1.76 |
| $T_7$ | 383.33 | 89.20 | 75.53 | 3179.33 | 5483.67 | 0.37 | 23.87 | 16052.67 | 1.25 |
| $T_8$ | 473.00 | 94.46 | 79.39 | 3474.67 | 5815.67 | 0.37 | 22.57 | 11696.67 | 1.16 |
| $T_9$ | 423.33 | 98.36 | 84.27 | 3528.00 | 6103.33 | 0.37 | 23.77 | 22407.33 | 1.34 |
| $T_{10}$ | 529.67 | 112.97 | 101.58 | 4732.00 | 7793.67 | 0.38 | 22.93 | 36460.67 | 1.46 |
| $T_{11}$ | 362.33 | 81.81 | 65.78 | 2301.67 | 4011.00 | 0.36 | 20.27 | 3812.50 | 1.06 |
| SEm (±) | 18.237 | 2.522 | 3.566 | 207.450 | 256.479 | 0.010 | 1.425 | 4252.949 | 0.063 |
| CD (0.05) | 53.799 | 7.439 | 10.521 | 611.988 | 756.627 | NS | NS | 12546.411 | 0.185 |

except for perennial grass. The relative reduction in weed dry weight measured by the weed control efficiency clearly indicated the superiority of the treatment hand weeding twice (20 and 40 DAS) throughout the crop growth period.

The effectiveness of low dose herbicides on yield attributing characters and yield represented in Table 3 clearly indicated the superiority of weed management practices in semidry rice. The productive tiller count was found highest under hand weeding twice (control-1) and remained on par with the weed management practices including pre-emergent herbicides (except oxyfluorfen) followed by (*fb*) hand weeding or azimsulfuron. It was 73-74 per cent higher than weedy check which was perhaps due to the lower tiller production in unweeded check. Spikelets $panicle^{-1}$ and filled grains $panicle^{-1}$ were highest for pyrazosulfuron ethyl *fb* hand weeding and was statistically on par with benzsulfuron methyl + pretilachlor *fb* either hand weeding or azimsulfuron and with pyrazosulfuron ethyl *fb* azimsulfuron.

Highest grain yield of 4817.67 kg $ha^{-1}$ was recorded with benzsulfuron methyl + pretilachlor *fb* hand weeding which was on par with pyrazosulfuron ethyl *fb* hand weeding, benzsulfuron methyl + pretilachlor *fb* azimsulfuron, pyrazosulfuron ethyl *fb* azimsulfuron and hand weeding twice. These results are in conformity with the findings of Awan et al., (2015) who reported that application of a single herbicide in dry seeded rice systems often provides sub optimal weed control because of complex weed flora and long critical periods. Therefore the best weed control option in dry seeded rice was the application of a pre-emergent herbicide followed by a post emergent herbicide (Chauhan and Opena, 2012) or a pre-emergent herbicide followed by a hand weeding. The yield realized was highest in treatments which could keep the field weed free during the critical period which is specifically the reason attributable for the better performance of weed management practices involving pre *fb* post emergent herbicide application or pre *fb* hand weeding at 40 DAS.

None of the herbicides produced any phytotoxic symptoms on rice plant. However, crop density and growth was lower at the initial stages in oxyfluorfen treated plots. This indicated that benzsulfuron methyl + pretilachlor and pyrazosulfuron can be treated as safe pre-emergent herbicides for dry sown (semi dry) system of rice cultivation. The net income and benefit cost ratio were substantially higher under all the herbicide treated plots compared to hand weeded control. The treatments involving post emergence

application of azimsulfuron @ 30 g $ha^{-1}$ with pre-emergent herbicides *viz*., benzsulfuron methyl + pretilachlor @ 60 + 600 g $ha^{-1}$ or pyrazosulfuron ethyl @ 25 g $ha^{-1}$ recorded higher net income and B: C ratio. So the best weed management practice for semi dry rice in terms of weed control, yield attributes, yield and economics is the pre-emergence application of benzsulfuron methyl + pretilachlor @ 60 + 600 g $ha^{-1}$on the day after sowing followed by azimsulfuron @ 30 g $ha^{-1}$ as post emergence application at 25 DAS or pre-emergence application of pyrazosulfuron ethyl @ 25 g $ha^{-1}$ on the day after sowing followed by azimsulfuron @ 30 g $ha^{-1}$ as post emergence application at 25 DAS.

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