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# Growth, weed control and yield of direct-seeded rice as influenced by different herbicides

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**ABSTRACT**

A field experiment was conducted at Varanasi to study the effect of different rates of carfentrazone-ethyl for controlling weeds in rice. Major weed flora were: *Echinochloa colona, Echinochloa crussgalli, Dactyloctenium aegyptium, Caesulia axillaris, Ammania baccifera, Eclipta alba* and *Phyllanthus niruri*. Application of carfentrazone-ethyl at 35 g/ha effectively reduced the density, dry matter accumulation and N, P, K depletion by weeds, and recorded the highest weed control efficiency. It also enhanced the growth parameters, grain and straw yield, nutrient uptake by the crop. Herbicides ethoxysulfuron at 15 g/ha, metsulfuron at 4 g/ha and carfentrazone at 15-35 g/ha applied as post-emergence and pendimethalin at 1.0 kg/ha as pre-emergence recorded higher values of yield attributes and yield.

**Key words:** Carfentrazone-ethyl, Direct-seeded rice, nutrient uptake, weed management

About 90% of the world rice is produced and consumed in Asia. India is the second largest producer of rice next to china where it is grown in an area of 45 million ha annually with a production of 90 million tonnes and accounts for about 45% of food grain production in the country. In eastern Uttar Pradesh, it is a key source for the rural livelihoods where growing rice during *Kharif* season is prominent. Dry seeding has been the principal method of rice establishment since the 1950s in the developing countries (Pandey and Velasco 2005). Studies have revealed that direct-seeded rice (DSR) has the potential to replace the traditional transplanted rice (Balasubramaniam and Hill, 2000 and Singh *et al*. 2008) and is becoming popular as it eliminates many farm operations like nursery raising, puddling and transplanting and hence it reduces the cost of production. High weed infestation is the major bottleneck in the success of direct-seeded rice and deters productivity and sustainability (Rao *et al*. 2007). Weeds cause heavy damage to direct-seeded rice (DSR) crop which may be to the tune of 50-100%. Weeds also deteriorate the quality of grain and enhance the cost of production. Continuous application of same herbicide leads to shift in weed flora and development of resistance to herbicides. Carfentrazone is a new herbicide which inhibits proto-porphyrinogen, has a broad spectrum of weed control and is rapidly degraded in the environment (Duke *et al.* 1991). It is difficult to raise weed free DSR with the application of only one herbicide. Therefore, an effective and economical weed control strategy needs to be implemented to meet the demand of staple food for increasing population of India. Keeping these facts in view, the present investigation was undertaken to study the effect of carfentrazone-ethyl on weeds, yield, nutrient uptake and economics of direct seeded rice.

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## MATERIALS AND METHODS

An investigation was conducted to evaluate the efficacy of different herbicides on complex weed flora of rice field at Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during the *Kharif* season of 2010 and 2011. The experimental site was situated at 23.2 ÚN latitude, 83.03ÚE longitude and at an altitude of 129 m above sea level in the north-eastern Gangetic plain and has a typical sub-tropical climate characterized by hot, dry summer and cool winter. The soil tested was sandy clay loam in texture, neutral in reaction (pH 7.4), low in organic C (0.35%), available P (28.1 kg/ha), available K (204.5 kg/ha) and low in available N (210.5 kg/ha). Rice-wheat rotation was being followed in the field from the previous five seasons. The experiment was laid out in randomized block design with ten treatments replicated thrice. Promising rice variety '*NDR-359*' was sown on 1 July at 25 x 10 row and plant to plant spacing with a seed rate of 100 kg/ha in a plot size of 5.0 x 3.6 m during 2010 and 2011. The required quantity of herbicides as per treatment was applied. A uniform dose of 120+60+40 kg/ha of N, P, and K was applied through urea, diammonium phosphate, muriate of potash respectively. Full dose of P and K and half dose of N were applied at the time of sowing and remaining half dose of N was applied in two equal splits at tillering and panicle initiation stage. The crop was raised with recommended package of practices. Herbicides were sprayed with knapsack sprayer fitted with flat fan nozzle with water as a carrier at 600 litres/ha. Pre-emergence herbicide was applied just after sowing and post-emergence herbicide was applied at 25 days after sowing of crop. The data on weed population were recorded at different growth stages of crop with the help of quadrate (0.5 x 0.5 m) at two randomly selected places in each plot and then converted into per square metre. Weeds were cut at ground level, washed with tap water, sun dried and thereafter oven dried at 75 C for 48 hr and then weighed. These were subjected to square root transformation to normalize their distribution before statistical analysis. Data on grain yield of rice was recorded at harvest. Weed control efficiency was calculated as per standard formula.

## RESULTS AND DISCUSSION

### Weed growth

Major weed species observed in the experimental field were: *Echinochloa colona* (L). Link, *Echinochloa crusgalli* (L.). Beav, *Dactyloctenium aegyptium* (L.), among grasses, sedges included *Cyperus* spp. and broad-leaf weeds dominated by *Caesulia axillaris*(L.), *Ammania baccifera* (L.), *Eclipta alba* (L.), *Phyllanthus niruri* (L.). The composition of grasses, broad-leaf and sedges was 35.5, 33.5 and 30.9% in 2010 and 37.7, 32.0 and 30.1% during 2011, respectively. Relative composition of narrow and broad-leaved weeds in weedy check recorded at 30 days stage of crop growth revealed that average weed population of narrow leaved weed species was more in comparison to broad-leaved weed species in both the years. It corroborates with the findings of Saini and Angiras (2002) who also reported dominance of grassy weeds over other species in direct seeded rice. Application of carfentrazone-ethyl effectively controlled broad-leaf weeds but failed to check grasses.

All the weed control treatments significantly suppressed both monocot and dicot weeds over weedy check during both the years (Table 1). During 2010, all the carfentrazone-ethyl based treatments significantly reduced the density and dry weight of broad-leaf weeds and were at par with metsulfuron 4 g/ha and 2,4-D 500 g/ha. During 2011, almost similar trend was observed (Table 2).The efficiency of various treatments with respect of weed control efficiency fluctuated to a greater extent under the influence of various weed control treatments. Among the various treatments, weed control efficiency was highest under the application of carfentrazone-ethyl at 30 g/ha (51.0 and 50.5%). In general, the control of weeds increased with increase in the dose of carfentrazone ethyl.

**Table 1. Effect of different doses of carfentrazone-ethyl on weed population (no./m$^2$) at 60 DAS of direct-seeded rice**

| Treatment | *Echinochloa* | | *Cyperus* | | *Caesulia* | | *Ammania* | |
|---|---|---|---|---|---|---|---|---|
| | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 |
| Carfentrazone-ethyl 5 g/ha | 5.24<br>(27.00) | 4.60<br>(20.67) | 6.57<br>(42.67) | 3.89<br>(14.67) | 3.24<br>(10.00) | 1.87<br>(3.00) | 2.86<br>(7.67) | 2.74<br>(7.00) |
| Carfentrazone-ethyl 20 g/ha | 4.45<br>(19.33) | 4.34<br>(18.33) | 6.12<br>(37.00) | 4.67<br>(21.33) | 2.97<br>(8.33) | 1.78<br>(2.67) | 2.55<br>(6.00) | 2.42<br>(5.33) |
| Carfentrazone-ethyl 25 g/ha | 4.06<br>(16.00) | 4.14<br>(16.67) | 6.15<br>(37.33) | 4.45<br>(19.33) | 2.92<br>(8.00) | 1.68<br>(2.33) | 2.35<br>(5.00) | 2.20<br>(4.33) |
| Carfentrazone--ethyl 30 g/ha | 3.98<br>(15.33) | 4.10<br>(16.63) | 5.99<br>(35.33) | 3.89<br>(14.67) | 2.86<br>(7.67) | 1.58<br>(2.00) | 2.35<br>(5.00) | 2.20<br>(4.33) |
| Carfentrazone-ethyl 35 g/ha | 3.94<br>(15.00) | 4.02<br>(15.67) | 5.93<br>(34.67) | 4.56<br>(20.33) | 2.74<br>(7.00) | 1.47<br>(1.67) | 2.20<br>(4.33) | 2.04<br>(3.67) |
| Ethoxysulfuron 15 g/ha | 5.24<br>(27.00) | 4.85<br>(23.00) | 5.90<br>(34.33) | 4.18<br>(17.00) | 3.24<br>(10.00) | 2.12<br>(4.00) | 2.48<br>(5.67) | 2.35<br>(5.00) |
| 2,4-D Na salt 500 g/ha | 5.61<br>(31.00) | 5.34<br>(28.00) | 5.79<br>(33.00) | 4.14<br>(16.67) | 3.54<br>(12.00) | 1.78<br>(2.67) | 2.04<br>(3.67) | 1.87<br>(3.00) |
| Metsulfuron 4 g/ha | 5.02<br>(24.67) | 4.85<br>(23.00) | 5.49<br>(29.67) | 3.94<br>(15.00) | 3.85<br>(14.33) | 1.68<br>(2.33) | 2.35<br>(5.00) | 2.27<br>(4.67) |
| Pendimethalin | 5.12<br>(25.67) | 4.78<br>(22.33) | 7.58<br>(57.00) | 4.88<br>(23.33) | 3.44<br>(11.33) | 1.58<br>(2.00) | 2.74<br>(7.00) | 2.61<br>(6.33) |
| Weedy Check | 6.67<br>(44.0) | 6.39<br>(40.33) | 5.79<br>(33.00) | 4.92<br>(23.67) | 4.78<br>(22.33) | 2.68<br>(6.67) | 3.44<br>(11.33) | 3.29<br>(10.33) |
| LSD (P=0.05) | 1.40 | 1.59 | 2.36 | 2.26 | 1.08 | 1.47 | 1.51 | 1.23 |

**Table 2. Effect of different rates of carfentrazone-ethyl on weed growth , nutrient depletion by weeds and uptake by direct-seeded rice**

| Treatment | Weed dry weight (g/m$^2$) | | Nutrient depletion by weeds (kg/ha) | | | | | | Nutrient uptake by rice (kg/ha) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N | | P | | K | | N | | P | | K | |
| | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 |
| Carfentrazone-ethyl 5 g/ha | 135.9 | 137.9 | 22.8 | 24.1 | 10.2 | 10.7 | 22.8 | 21.7 | 20.7 | 21.0 | 4.6 | 4.9 | 8.3 | 8.8 |
| Carfentrazone ethyl 20 g/ha | 121.5 | 122.8 | 20.2 | 21.2 | 9.5 | 9.9 | 21.9 | 20.8 | 22.8 | 23.2 | 5.3 | 5.7 | 11.0 | 11.1 |
| Carfentrazone ethyl 25 g/ha | 111.8 | 113.1 | 18.9 | 19.8 | 9.1 | 9.4 | 21.0 | 20.4 | 23.0 | 23.3 | 5.9 | 6.3 | 12.0 | 12.1 |
| Carfentrazone-ethyl 30 g/ha | 109.0 | 113.9 | 17.6 | 18.6 | 8.4 | 8.6 | 20.7 | 20.4 | 23.3 | 23.7 | 6.1 | 6.4 | 12.6 | 12.9 |
| Carfentrazone-ethyl 35 g/ha | 112.9 | 111.0 | 16.1 | 16.8 | 7.3 | 7.7 | 20.5 | 19.8 | 23.5 | 24.5 | 6.3 | 6.5 | 13.7 | 13.9 |
| Ethoxysulfuron 15 g/ha | 168.1 | 169.4 | 29.0 | 30.3 | 11.7 | 12.3 | 19.7 | 19.0 | 18.0 | 18.4 | 4.2 | 4.4 | 9.2 | 9.1 |
| 2,4-D Na salt 500 g/ha | 147.2 | 148.5 | 28.2 | 29.9 | 11.1 | 11.7 | 19.1 | 18.9 | 18.0 | 18.2 | 4.2 | 4.4 | 8.3 | 8.6 |
| Metsulfuron 4 g/ha | 161.9 | 163.6 | 24.3 | 25.4 | 11.9 | 12.3 | 17.5 | 16.7 | 19.3 | 19.9 | 4.3 | 4.5 | 8.5 | 8.5 |
| Pendimethalin | 152.1 | 153.8 | 24.5 | 25.6 | 11.4 | 11.8 | 21.6 | 21.1 | 20.1 | 20.3 | 4.3 | 4.6 | 9.1 | 9.2 |
| Weedy check | 222.6 | 224.6 | 39.6 | 40.7 | 17.9 | 18.5 | 31.3 | 30.2 | 12.8 | 13.3 | 2.0 | 2.1 | 4.6 | 4.7 |
| LSD (P=0.05) | 2.4 | 2.6 | 1.7 | 1.1 | 0.9 | 1.5 | 1.7 | 2.9 | 1.9 | 2.1 | 0.4 | 0.4 | 0.9 | 1.8 |

**Table 3. Effect of different rates of carfentrazone-ethyl on growth and yield of direct seeded rice**

| Treatment | Dose (g ha) | Plant height (cm) | | Grains/ panicle | | Panicles/m$^2$ | | 1000-grain weight (g) | | Grain yield (t/ha) | | Straw yield (t/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 |
| Carfentrazone-ethyl 5 g/ha | 15 | 85.5 | 86.3 | 65.0 | 66.3 | 231.0 | 234.6 | 20.3 | 20.3 | 3.04 | 3.12 | 4.28 | 431 |
| Carfentrazone-ethyl 20 g/ha | 20 | 86.4 | 87.2 | 67.0 | 67.6 | 244.0 | 247.0 | 20.9 | 21.0 | 3.51 | 3.52 | 4.73 | 4.78 |
| Carfentrazone-ethyl 25 g/ha | 25 | 87.0 | 86.9 | 67.3 | 68.0 | 245.3 | 247.6 | 21.5 | 22.0 | 3.67 | 3.73 | 4.88 | 4.93 |
| Carfentrazone-thyl 30 g/ha | 30 | 87.9 | 87.0 | 67.6 | 68.3 | 246.6 | 248.3 | 21.6 | 21.7 | 3.68 | 3.71 | 4.80 | 4.95 |
| Carfentrazone-thyl 35 g/ha | 35 | 87.6 | 87.5 | 68.3 | 68.6 | 247.3 | 249.0 | 22.1 | 22.1 | 3.69 | 3.75 | 4.81 | 5.01 |
| Ethoxysulfuron 15 g/ha | 15 | 84.0 | 86.1 | 59.6 | 60.6 | 226.3 | 227.3 | 19.4 | 18.0 | 2.57 | 2.60 | 3.80 | 3.86 |
| 2,4-D Na salt 500 g/ha | 500 | 83.9 | 85.1 | 60.3 | 62.0 | 228.6 | 230.6 | 20.0 | 20.0 | 2.90 | 3.02 | 4.05 | 4.10 |
| Metsulfuron 4 g/ha | 4.0 | 84.8 | 85.6 | 63.0 | 63.6 | 231.0 | 232.6 | 20.2 | 20.5 | 2.98 | 3.04 | 4.08 | 4.15 |
| Pendimethalin | 1000 | 84.5 | 84.8 | 61.6 | 62.3 | 227.3 | 229.0 | 20.0 | 20.0 | 2.78 | 2.86 | 4.00 | 4.10 |
| Weedy Check | - | 82.1 | 82.8 | 46.67 | 47.3 | 194.6 | 196.0 | 18.9 | 17.7 | 2.49 | 1.64 | 2.61 | 2.68 |
| LSD (P=0.05) | | 1.6 | NS | 2.8 | 4.4 | 4.6 | 5.5 | 0.9 | 1.6 | 0.18 | 0.19 | 0.18 | 0.14 |

## Nutrient depletion by weeds

Depletion of nutrients from soil is function of dry weight and nutrient content in weed plants. Weeds usually grow faster than crop plants and thus absorb mineral nutrients quicker, resulting in inadequate supply of nutrients to the crop plants. Application of carfentrazone-ethyl 35 g/ha recorded the lowest nutrient removal by weeds. Unweeded control resulted in highest depletion of nutrients by weeds throughout the crop growth period.

## Crop growth and yield

Herbicidal treatments had a favourable effect on the growth attributes, *viz*. plant height, tillers/plant and DMP of rice crop compared to un weeded check during both the years (Table 3). Application of carfentrazone-ethyl at 20 g/ha significantly increased plant height and was at par to carfentrazone-ethyl at 25, 30 and 35 g/ha. In general, number of effective tillers increased with corresponding increase in the dose of carfentrazone-ethyl. However, carfentrazone-ethyl 35 g/ha produced less number of tillers during 2011, while all other carfentrazone treatments remained at par with metsulfuron and pendimethalin.

Adoption of different weed control practices significantly influenced the yield attributes, *viz*. panicles/m$^2$, grains/panicle and 1000 grain weight during both the years. The enhanced yield attributes recorded may be due to lower density and dry weight of weeds and higher weed control efficiency which resulted in better growth of rice crop. Application of carfentrazone-ethyl 35 g/ha recorded maximum yield attributes *viz*., panicles/m$^2$, panicle length, filled grains per panicle and 1000-grain weight but it was comparable to other rates of carfentrazone-ethyl.

Rice grain yield increased with increase in dose of carfentrazone-ethyl but was statistically at par with other doses of carfentrazone ethyl. Among carfentrazone treatments, maximum yield was obtained under carfentrazone-ethyl 35 g/ha during 2010 and 2011. During both the years, all the herbicidal treatments produced significantly higher rice grain yield weedy check. However, unweeded control recorded lesser yield which might be due to higher weed competition and lesser availability of nutrients to the crop plants which resulted in lower grain and straw yield in control plots and this was in conformity with the findings of Singh *et al.* (1998) and Thakur *et al.* (2011).

Nutrient uptake being a function of dry matter production and partly due to increase in its concentration, carfentrazone-ethyl 35 g/ha gave more total dry matter and registered significantly higher uptake of NPK.

Based on the present investigation, it can be concluded that carfentrazone-ethyl 35 g/ha applied 25 DAS can be used for satisfactory weed control in rice fields that is pre-dominated with broad-leaved weeds. It can also be used to realize better rice yields without any residual toxicity. However, more specifically it was poor against grassy weeds but excellent against broad-leaved weeds. Further, from this research it is clear that it is effective in controlling annual weeds at very low application rates, whereas higher concentrations are required for controlling perennial weeds. Future research efforts are required to evaluate this herbicide in combination with other herbicides against broad-spectrum weed control in dry direct-seeded rice.

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