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Research Communication

Efficacy of doses of fenoxaprop-p-ethyl 69% EC and cyhalofop-butyl 10% EC on weed growth, yield and economics in transplanted rice (*Oryza sativa*)

SANJEEV KUMAR[1], MANOJ KUMAR SINGH[2] AND PRATIK SANODIYA[3]

Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh 221 005

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ABSTRACT

A field investigation was conducted during the rainy season of 2019 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, to study the efficacy of doses of fenoxaprop-p-ethyl 69% EC and cyhalofop-butyl 10% EC in transplanted rice (*Oryza sativa* L.). Among different herbicidal treatments fenoxaprop-p-ethyl 86.25 g/ha recorded lower weed density of awnless barnyard grass [*Echinochloa colona* (L.) Link], water grass [*Echinocloa crus-galli* (L.) Beauv.] and other weeds, total dry weight and higher weed-control efficiency at 58 days after transplanting, followed by cyhalofop-butyl 80.0 g/ha. Phytotoxicity on crop plants caused by the application of fenoxaprop-p ethyl 86.5 g/ha included yellowing, necrosis, stunting, and epinasty at various stages; however, phytotoxicity disappeared as the crop developed. Fenoxaprop-p-ethyl 86.25 g/ha markedly improved growth attributes, viz. plant height, tillers/hill, dry-matter accumulation/hill, leaf-area index, chlorophyll content and yield attributes and yield, viz. panicle length, panicle weight, panicles/hill, grains/panicle, 1,000-grain weight, grain and straw yields and net returns in comparison to cyhalofop-butyl 80.0 g/ha and lower dose of fenoxaprop-p-ethyl 69.0 g/ha.

Key words: Cyhalofop, Fenoxaprop, Herbicide, Phytotoxicity, Transplanted rice

In India, rice (*Oryza sativa* L.) is grown in an area of 43.8 million ha, with a production of 116.4 million tonnes, and productivity of 2.7 t/ha in 2020–21 (GoI 2021). In Uttar Pradesh, area under rice crop is 5.86 million ha, with a production of 12.75 million tonnes in 2018–19 (RBI, New Delhi, 2020). Rice plays a major role in diet, economy, employment, culture and history. It is the staple food for more than 65% of Indian population, contributing approximately 40% to the total foodgrain production, thereby, occupying a pivotal role in the food and livelihood security of people. The crop is grown in highly diverse conditions ranging from hills to coasts.

The weed flora under transplanted condition is very much diverse and consists of grasses, sedges and broad-leaf weeds, causing yield reduction of rice crop up to 76% (Singh *et al*., 2004). Normally the yield loss ranges between 15 and 20%, yet in severe cases the yield losses can be more than 50%, depending on the species and intensity of weeds in rice. It is almost impossible to produce rice economically without well-planned weed-management strategies, as weeds are a major problem in rice in eastern India due to favourable ecological conditions during the rainy season. Puddling for rice seedling establishment controls weeds initially; however, early-emerging weeds start competition with rice around 20 days after transplanting (Mukherjee and Maity, 2011). Rice farmers traditionally carry out 1 hand-weeding 3 weeks after transplanting; and if weed infestation is particularly severe, they carry out a second hand-weeding. Due to labour scarcity, higher labour costs, and the increased time required for manual weed control, Indian farmers have had severe challenges with manual weed control in recent years, resulting in poor weeding (Rodenburg and Johnson, 2009). In addition to hand-weeding, some farmers in India had also adopted herbicides to control weeds in rice fields due to their efficacy, cost-efficiency, and wide acceptability (Mahajan and Chauhan, 2013; Pinjari *et al*., 2019). Fenoxaprop-p-ethyl and cyhalofop-butyl controls monocot weeds more effectively which are predominant in rice fields. Therefore, present study was taken up to assess the efficacy of doses of fenoxaprop-p-ethyl 69% EC and cyhalofop-butyl 10% EC on weed growth, yield and economics in transplanted rice.

A field experiment was conducted during the rainy sea-

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[3]**Corresponding author's Email**: prsanodiya10@gmail.com
[1]M.Sc. Student; [2]Professor, [3]Assistant Professor, Department of Agronomy, Institute of Agricultural Science, Banaras Hindu University, Varanasi, Uttar Pradesh 221 005

son of 2019 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India. It is located in the South Eastern part of Varanasi at (25°18' N, 83° 03' E, 75.7 m above the mean sea-level) in the Eastern Gangetic alluvial plains. The soil was sandy clay loam, homogeneous in fertility status and had uniform textural make up with typical Indo-Gangetic alluvium soils (Inceptisols), with *p*H 7.32, low in available organic carbon (0.33%), available nitrogen (207.47 kg/ha) and medium in available phosphorus (23.43 kg/ha) and potassium (207 kg/ ha).

The experiment was laid out in a randomized block design with 3 replications and comprised 8 treatments, viz. T_1, weedy check; T_2, fenoxaprop-p-ethyl 51.75 g/ha; T_3, fenoxaprop-p-ethyl 69.0 g/ha; T_4, fenoxaprop-p-ethyl 86.25 g/ha; T_5, cyhalofop-butyl 80.0 g/ha; T_6, fenoxaprop-p-ethyl 60.38 g/ha; T_7, 2 hand-weeding; T_8, full-season weed-free. Rice variety 'MTU 7029' was transplanted manually at the rate of 20 kg seed/ha. Recommended dose of fertilizer (120 kg N, 60 kg P_2O_5 and 40 kg K_2O) was applied through urea, diammonium phosphate and muriate of potash. Full dose of P and K were applied basal, half amount of total nitrogen was applied basal and remaining half in 2 equal splits at tillering and panicle-initiation stages of rice. Post-emergence application of fenoxaprop-p-ethyl and cyhalofop-butyl was done as per the treatments using knapsack sprayer fitted with flat-fan nozzle using 300 litres water. The crop was raised under irrigated condition with the recommended package of practices. Density of *Echinochloa colona*, *Echinochloa crus-galli*, other weeds and total weed dry weight at 58 days after transplanting (DAT) was recorded by placing a quadrate of 0.50 m × 0.50 m randomly at 3 places in each plot. Weed-control efficiency (Tripathi and Mishra, 1971) at 58 DAT and weed index (Gill and Kumar, 1969) at harvesting were also calculated. Biometric characters, viz. growth attributes at 60 DAT, yield attributes and yields (grain and straw) of crop were recorded at harvesting stage. Prevailing price of inputs and outputs in the market during 2019 were used to calculate the economics of treatment under study. The weed data were subjected to square-root transformation before statistical analysis. Analysis of variance was done to test the significance of data as described by Gomez and Gomez (1984) and treatment mean pair comparison was done using least significant difference test.

The major weed flora with their relative composition observed in experimental field included *Echinochloa colona* (L.) Link, *Echinochloa crus-galli* (L.) Beauv., *Cynodon dactylon* (L.) Pers. among grasses; *Cyperus iria* L., *Cyperus difformis* L. and *Fimbristylis miliacea* (L.) Rottb., among sedges; and *Ammannia baccifera* (L.) Roxb, *Paspalum* spp. and *Sagittaria* spp. among broad-leaf weeds besides other minor weeds.

Density of weed species and their dry weight varied significantly at 58 DAT due to application of fenoxaprop-p-ethyl (Table 1). At 58 DAT, fenoxaprop-p-ethyl 86.25 g/ha had lower weed density, followed by cyhalofop-butyl 80 g/ha compared to rest of the doses of fenoxaprop-p-ethyl except 2 hand-weedings and season-long weed-free treatments. This might be due to effective killing of prominent

Table 1. Effect of herbicidal treatment on weed density (No./m^2), total weed dry weight (g/m^2) and weed-control efficiency at 58 days after transplanting, plant height (cm), number of tillers, leaf-area index, chlorophyll content and plant dry matter (g/hill) in transplanted rice

Treatment	(No./m^2)			Total weed dry-weight (g/m^2)	Weed control efficiency (%)	Plant height (cm)	Tillers/ hill	Leaf-area index	Chlorophyll content (SPAD)	Plant dry-matter (g/hill)
	Echinochloa colona	*Echinochloa crus-galli*	Other weeds							
Weedy check	2.4 (5.3)	1.9 (3.1)	4.67 (21.8)	7.0 (48.9)	0.0	87.9	11.6	3.9	29.5	12.9
Fenoxaprop-p-ethyl 51.75 g/ha	2.2 (4.4)	1.8 (2.7)	4.37 (18.8)	6.1 (36.5)	25.4	90.3	12.3	4.2	29.7	14.6
Fenoxaprop-p-ethyl 69.0 g/ha	1.9 (3.1)	1.2 (0.9)	4.21 (17.3)	5.2 (27.1)	44.7	91.9	12.9	4.5	30.5	15.6
Fenoxaprop-p-ethyl 86.25 g/ha	1.7 (2.7)	1.0 (0.5)	3.18 (9.6)	4.6 (20.8)	57.4	96.5	13.7	4.7	31.9	18.4
Cyhalofop-butyl 80.0 g/ha	1.8 (2.8)	1.1 (0.7)	3.54 (12.0)	5.1 (25.7)	47.5	95.1	13.2	4.6	31.1	16.4
Fenoxaprop-p-ethyl 60.38 g/ha	2.2 (4.2)	1.6 (2.2)	3.85 (14.3)	5.5 (29.4)	39.9	91.1	12.8	4.4	30.3	14.8
Two hand-weedings	1.4 (1.6)	0.9 (0.4)	2.97 (8.3)	4.4 (19.3)	60.6	97.6	13.8	4.7	31.4	18.8
Full season weed-free	0.7 (0.0)	0.7 (0.0)	0.71 (0.0)	0.7 (0.0)	100.0	98.3	14.3	4.8	32.6	19.2
SEm±	0.26	0.36	0.21	0.12	–	0.62	0.40	0.09	0.32	0.90
CD (P=0.05)	0.78	1.09	0.65	0.35	–	1.16	1.20	0.28	0.97	2.90

Data were subjected to square root ($\sqrt{x+0.5}$) transformation; figures in parentheses are original values weeds, especially grasses, due to application of fenoxaprop-p-ethyl. Further, it was also observed that fenoxaprop-p-ethyl 86.25 g/ha and cyhalofop-butyl 80 g/ha had statistically equivalent weed density of *Echinochloa colona* and *Echinochloa crus-galli* which were at par with each other. At 58 DAT, fenoxaprop-p-ethyl 86.25 g/ha had lower total weed dry weight than cyhalofop-butyl 80 g/ha, fenoxaprop-p-ethyl 69 g/ha, fenoxaprop-p-ethyl 60.38 g/ha, and fenoxaprop-p-ethyl 51.75. This could be because these treatments have decreased weed density, resulting in lower weed dry weight. These findings confirm the results of Teja *et al*., (2016). Weed-control efficiency followed trend of weed dry weight and the order was fenoxaprop-p-ethyl 86.25 g/ha > cyhalofop-butyl 80 g/ha > fenoxaprop-p-ethyl 69 g/ha > fenoxaprop-p-ethyl 60.38 g/ha > fenoxaprop-p-ethyl 51.75 g/ha. These results are in close conformity with those reported by Kailkhura *et al*., (2015).

Visual phytotoxicity/m^2 recorded at 7, 14, 21 and 35 days after herbicide spraying (Table 2) which was based on 1–10 scale where, 1=0–10%, 2=11–20%, 3=21–30%, 4=31–40%, 5=41–50%, 6=51–60%, 7=61–70%, 8=71–80%, 9=81–90%, 10=91–100%, indicated that after application of the highest dose of fenoxaprop-p-ethyl various types of phytotoxicity symptoms like yellowing, stunting, necrosis and epinasty were observed on the rice crop. Phytotoxicity signs vanished on successive observation dates, ranging from 7 to 35 days following herbicide treatment. Fenoxaprop-p-ethyl 86.25 g/ha had a lower scale of phytotoxicity symptoms than a double dose of fenoxaprop-p-ethyl (172.5 g a.i./ha) that had a larger scale of phytotoxicity.

At 60 DAT, amongst different herbicidal treatments, fenoxaprop-p-ethyl 86.25 g/ha resulted in higher values of plant height, tillers/hill, leaf-area index, chlorophyll content and plant dry matter than cyhalofop-butyl 80 g/ha and all the growth attributes due to application of fenoxaprop-p-ethyl 86.25 g/ha and cyhalofop-butyl 80 g/ha were found to be statistically at par with each other (Table 1). Application of fenoxaprop-p-ethyl 86.25 g/ha was also found statistically at par with the manual weeding like 2 hand-weedings and weed-free. Efficacy of other doses of fenoxaprop on growth attributes were in order of fenoxaprop-p-ethyl 86.25 g/ha > cyhalofop-butyl 80 g/ha > fenoxaprop-p-ethyl 69 g/ha > fenoxaprop-p-ethyl 60.38 g/ha > fenoxaprop-p-ethyl 51.75 g/ha. These results might be owing to better weed control at higher doses of fenoxaprop-p-ethyl. Similar results were also reported by Meher *et al*., (2018), wherein it was reported that the weed-free proved to be significantly superior in terms of growth but was found to be equivalent to fenoxaprop-p-ethyl.

Application of higher doses of fenoxaprop -p-ethyl resulted in marked increased in yield attributes and lower weed index, which had significantly higher grain and straw yields over weedy (Table 3). Fenoxaprop-p-ethyl 86.25 g/ha exhibited higher panicle length, panicle weight, number of filled grains/panicle, 1,000-grain weight, grain and straw yields, followed by cyhalofop-butyl 80 g/ha and both these treatments were at par with each other except 1,000-grain weight. These results might be owing to lower weed-competition index (Table 3) and higher weed-control efficiency (Table 1) compared to lower doses of fenoxaprop-p-ethyl except manual weeding treatments, viz. 2 hand-weedings and season-long weed-free. Fenoxaprop-p-ethyl 86.25 g/ha had lower weed index than cyhalofop-butyl 80 g/ha and fenoxaprop-p-ethyl 69 g/ha.

A critical analysis of data revealed that, amongst different doses of fenoxaprop-p-ethyl higher net returns were obtained owing to application of fenoxaprop-p-ethyl 86.25 g/ha, followed by cyhalofop-butyl 80 g/ha and fenoxaprop-p-ethyl 69 g/ha. However, the highest benefit: cost ratio was found in cyhalofop-butyl 80.0 g/ha (Table 3). Singh *et al.,* (2004) also reported similar findings in transplanted rice wherein fenoxaprop-p-ethyl applied on day 20 after transplanting registered the maximum net return.

Based on 1-year study it may be concluded that fenoxaprop-p-ethyl 86.25 g/ha and cyhalofop-butyl 80 g/ha could be applied for weed control, higher yield and more net returns in transplanted rice.

Table 2. Phytotoxicity evaluation of fenoxaprop-p-ethyl in transplanted rice at 7, 14, 21, 28 and 35 days after herbicide application

	Yellowing					Stunting					Necrosis					Epinasty				
	7	14	21	28	35	7	14	21	28	35	7	14	21	28	35	7	14	21	28	35
Weedy check	1	1	2	1	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
Fenoxaprop-p-ethyl 86.25 g/ha	5	4	4	3	3	0	0	0	0	0	8	6	5	4	3	1	2	2	1	1
Fenoxaprop-p-ethyl 172.5 g/ha	10	5	5	3	3	0	0	0	0	0	10	8	7	5	4	2	2	2	2	2

Scale 0–10 where: 0=0%, 1, 1–10%; 2, 11–20%; 3, 21–30%; 4, 31–40%; 5, 41–50%; 6, 51–60%; 7, 61–70%; 8, 71–80%; 9, 81–90%; 10, 91–100%

Table 3. Effect of herbicidal treatments on panicle length (cm), panicle weight (g/panicle), grains/panicle, 1,000-grain weight (g), grain and straw yield (t/ha), weed index (%), net return (× 10^3 ₹/ha) and benefit: cost ratio

Treatment	Panicle length (cm)	Panicle weight (g/panicle)	Grains/ panicle	1,000-grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Weed index (%)	Net returns (× 10^3 ₹/ha)	Benefit: cost ratio
Weedy check	19.5	1.9	52.0	20.6	3.0	5.0	20.4	45.1	1.2
Fenoxaprop-p-ethyl 51.75 g/ha	20.8	2.0	55.0	21.4	3.5	6.1	15.1	56.2	1.3
Fenoxaprop-p-ethyl 69.00 g/ha	21.3	2.3	70.3	22.2	3.7	6.3	14.0	60.6	1.4
Fenoxaprop-p-ethyl 86.25 g/ha	21.6	2.4	77.0	23.1	3.8	6.8	10.5	64.0	1.3
Cyhalofop-butyl 80.00 g/ha	21.5	2.3	76.3	22.5	3.7	6.5	11.9	63.2	1.5
Fenoxaprop-p-ethyl 60.38 g/ha	21.1	2.2	61.3	21.8	3.6	6.2	12.8	59.1	1.4
Two hand-weedings	21.7	2.5	82.6	23.2	4.1	7.2	4.1	64.8	1.3
Full season weed-free	22.2	2.7	101.3	23.4	4.2	7.3	0.0	66.7	1.3
SEm±	0.13	0.1	0.48	0.03	0.10	0.31	–	–	–
CD (P=0.05)	0.41	0.22	1.48	0.09	0.33	0.94	–	–	–

REFERENCES

Gill, H.S. and Kumar, V. 1969. Weed index - a new method for reporting weed control trials. *Indian Journal of Agronomy* **14**(2): 96–98.

GoI (Government of India). 2021. *Economic Survey – 2020–21*. Statistical appendix. Ministry of Finance, Government of India, New Delhi.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical procedures for Agricultural Research,* (edn 2, pp 680), John Wiley & Sons Inc., New York, USA.

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

Mahajan, G. and Chauhan, B.S. 2013. Herbicide options for weed control in dry-seeded aromatic rice in India. *Weed Technology* **27**(4): 682–689.

Meher, S., Tiwari, N., Saha, S., Mahapatra, A. and Jangde, H.K. 2018. Efficacy of herbicide mixtures on yield and yield attributes in wet direct seeded rice. *International Journal of Current Microbiology and Applied Sciences* **7**(7): 4,071–4,076.

Mukherjee, P.K. and Maity, S.K. 2011. Weed control in transplanted and wet seeded rainy season rice. *Indian Journal of Weed Science* **81**: 134–139.

Pinjari, S.S., Gangawane, S.B., Jadhav, M., Dnyaneshwar, J., Chavan, V. and Rajemahadik, V. 2019. Management of complex weed flora in transplanted rice by different herbicides and green manuring. *Journal of Research in Weed Science* **2**(1): 78–89.

RBI, New Delhi. 2020. *Handbook of Statistics on Indian States 2019-2020.* Reserve Bank of India, New Delhi.

Rodenburg, J. and Johnson, D.E. 2009. Weed management in rice-based cropping systems in Africa. *Advances in agronomy* **103**: 149–218.

Singh, V.P., Singh G. and Singh, M. 2004. Effect of fenoxaprop-p-ethyl on transplanted rice and associated weeds. *Indian Journal of Weed Science* **36**: 190–192.

Teja, K. C., Duary, B. and Dash, S. 2016. Sole and combined application of herbicides on composite weed flora of transplanted rice. *Indian Journal of Weed Science* **48**(3): 254–258.

Tripathi, R.S. and Mishra, R. 1971. Phytosociological studies of the crop weed association at Varanasi. *Journal of Indian Botanical Society* **50**: 142–152.