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RESEARCH ARTICLE

Studying effectiveness of post-emergence herbicides in chickpea

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ABSTRACT

Broad spectrum post-emergence herbicides are being popular among the chickpea growers. However, systematic study is required to assess the effectiveness of these in comparison with popular pre-emergence herbicides and hence a field study was conducted at Indira Gandhi Krishi Vishwavidyalaya, Raipur in Alfisols during winter (*Rabi*) season of 2020-21 and 2021-22 to study the effect of pre-emergence and combination of pre- and post-emergence herbicides in chickpea (*Cicer arietinum* L.) with mechanical/hand weeding. The experiment was designed in randomized block design with three replications. Major weeds were *Chenopodium album* and *Cichorium intybus. Echinochloa colona, Cynadon dactylon* with almost 50% dominance of *Medicago denticulata*. Among the chemical weed management treatments, the lowest count of the aforesaid individual and total weeds was registered under the treatment topramezone 25.28 g/ha as POST at 90 DAS. Topramezone 25.28 g/ha as PoE (18 DAS) reduced total weed density by 50% at 90 DAS when compared with weedy check and eventually had higher weed control efficiency in both the years (81.1 in 2020-21 and 83.8% in 2021-22) than the other treatments. Comparable lower weed count was also observed under the hand weeding at 30 DAS/Farmers practice. Although, slight phytotoxicity (3 to 5 out of 10 scale) in terms of yellowing, stunting and scorching was observed upto 14 days in topramezone 25.28 g/ha as PoE, propaquizafop+ imazethapyr 125 g/ha as POST and flauzifop-p-butyl + fomesafen 250 g/ha PoE, but these symptoms were entirely disappeared and chickpea has recovered and regained its growth later. Application of topramezone produced average 275% more seed yield over weedy check and 133% over pendimethalin 678 g/ha PE. It also generated the highest net return (Rs. 53290 and 54630/ha) and B:C ratio (3.35 and 3.33).

Keywords: Chemical control, Chickpea, Comparison of pre- and post-emergence, Herbicide, Phytotoxicity, topramezone, WCE, Weed biomass

INTRODUCTION

In Chhattisgarh, chickpea is one of the most important *Rabi* crops in soybean and rice-based cropping system occupies an area of 0.32 m ha predominantly in Chhattisgarh plains in medium to heavy soils using residual moisture mainly by broadcast method, which resulted in low plant population and difficult to apply mechanical means of weed control. The productivity of chickpea is quite low (1026 kg/ha) due to various constrains, among them weed infestation is one of the most important constraints. Chickpea is poor competitor to weeds due to slow growth rate and limited leaf development at early stage of crop growth and establishment. The initial 30- 60 days of the crop growth period are very important for crop weed competition in chickpea (Kumar and Singh, 2010) and hence, chickpea is highly susceptible to weed competition and weeds causes up to 75% yield loss (Chaudhary *et al.* 2005). The farmers adopt hand weeding, which is totally labour dependent and costly in the present scenario. The availability of labour at critical crop weed competition becomes problematic due to labour scarcity. Chickpea crop mainly infested with broadleaf weeds especially *Medicago denticulata*, *Chinopodium album*, *Cichorium intybus*, *Convolvulus arvensis, Parthenium hysterophorus* and *Melilotus alba* etc. which are difficult to control with available pre-emergence herbicides. Application of pre-emergence (PE) herbicides does not control the second flushes of many weeds. There is no alternative recommendation except using pendimethalin as pre-emergence in chickpea for the farmers which is not effective after 30 days (Kumar *et al.* 2015) and eventually, weed management is often the costliest agronomic input in chickpea. Although, they are using some early post-emergence herbicides like quizalofop-p-ethyl at 100 g/ha available in market inadvertently for narrow-leaf weeds, but dominated broad-leaf weed flora consist of *Medicago denticulata*, *Chinopodium album* caused huge crop yield loss if not controlled (Nath *et al.* 2018). Topramezone as post-emergence herbicide, specially recommended for weed management in maize could be effective in chickpea under the rice-based cropping system for higher WCE and achieving good

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crop yield (Nath *et al*. 2021). There is an urgent need to identify an effective early post-emergence and post-emergence herbicides for comprehensive control of weeds in chickpea and replace costly affair of HW. Hence, an experiment has been framed with the objectives to study the effect of pre- and post-emergence herbicidal weed management on weed flora in chickpea and their effectiveness in chickpea crop.

MATERIALS AND METHODS

Experiment was conducted during *Rabi* 2020-21 and 2021-22 on Alfisols under AICRP on Weed Management, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh in mid land ecosystem. Twelve treatments comprised of single as well as combination of pre and post-emergence herbicides i.e. pendimethalin 678 g/ha PE, pendimethalin + imazethapyr 1000 g/ha as PE, oxyfluorfen 140 g/ha as PE, topramezone 25.28 g/ha as PoE (18 DAS), pendimethalin 678 g/ha PE *fb* quizalofop 50 g/ha PoE, pendimethalin 678 g/ha PE *fb* propaquizofop 50 g/ha PoE, flauzifop-p-butyl + fomesafen 125 g/ha PoE, flauzifop-p-butyl + fomesafen 250 g/ha PoE, propaquizafop + imazethapyr 125 g/ha PoE on active ingredient basis, mechanical weeding at 20 *fb* 40 DAS, hand weeding at 30 DAS/farmers' practice and one weedy check were studied in randomized block design with three replications. All the post-emergence herbicides were applied at 20 days after sowing. The soil was clay loam with low organic carbon and available nitrogen (196 kg/ha) but medium (16.5 kg/ha) in phosphorus and high (328 kg/ha) in potassium with neutral soil reaction. Chickpea cultivar '*Indira Chana 1*' was taken as test crop. Sowing of chickpea crop was done on 13/11/2020 and 15/11/2021 using seed rate of 75 kg/ha and row spacing of 30 cm with the help of seed cum fertilizer drill. The recommended fertilizer dose of 20:50:30 kg/ha N:P:K was applied to chickpea as basal through urea, SSP and murate of potash, respectively. The crop did not suffer from any kind of incidence like drought, insect, disease etc. during its entire growth period. The observations, *viz*. weed flora, weed density, weed biomass and their effect on yield of chickpea and economic viability of different treatments were taken and analyzed as per the standard procedure. Visual scoring for phytotoxicity (like- yellowing, chlorosis, stunting, scorching and death) was recorded for applied post-emergence herbicides at 1, 3, 7, 14 and at 28 days after application on a 0-10 scale for crop. For chickpea, 0 meant no phytotoxicity and 10 meant complete death of the plant and scoring of <3 was considered acceptable. The crop was harvested on 08/03/2021 and 11/03/2022. All other agronomic practices were kept normal and uniform for all the treatments of the experiment. A quadrate of 0.5 x 0.5 m (0.25 m^2) was used for taking species wise data. Weed samples were sun dried for two days and then oven dried at 70°C for 72 hrs. Number and biomass of weeds were transformed through square root ($\sqrt{x+0.5}$) for statistical analysis. The herbicides were applied by using knapsack sprayer with 375 liters of spray volume per hectare.

RESULTS AND DISCUSSION

Weed density and weed biomass

The experimental field was dominated by the *Medicago denticulata* which accounts for 50% of the total weed population during entire crop growth. Other major weeds were *Chenopodium album* and *Cichorium intybus*. *Echinochloa colona* and *Cynadon dactylon*. All the weed management practices reduced the total weed density and weed biomass over the weedy check. Topramezone 25.28 g/ha as PoE (18 DAS) has performed best to reduce the total weed density and significantly the lowest total weed bio mass (4.38, 4.22 and 6.54 and 5.71 g/m^2) over rest of the chemical weed management treatments and registered 41.8 and 41.1% and 43.7 and 40.5% less weed biomass recorded as compared to the weedy check at 60 and 90 DAS during 2020-21 and 2021-22, respectively. Lowest weeds density and total weed dry weight were also registered with topramezone 25.7 g/ha PoE at 21 DAS by Gajanand *et al*. (2023) and topramezone 25.2 g/ha (PoE) *fb* mechanical weeding at 40 DAS by Sanketh *et al*. (2021). Single application of pendimethalin 678 g/ha as PE did not control weed density as compared to the pre-emergence *fb* post-emergence application of herbicides *e.g*. pendimethalin 678 g/ha PE *fb* quizalofop 50 g/ha PoE or pendimethalin 678 g/ha PE *fb* propaquizofop 50 g/ha PoE. Even combination of herbicides either as PE or PoE controlled weeds effectively to that of pendimethalin as PRE. Flauzifop-p-butyl + fomesafen 125 g/ha PoE or flauzifop-p-butyl + fomesafen 250 g/ha PoE both performed well to reduce the weed density at 60 and 90 DAS. Similar observations were made by Kashyap *et al*. (2022) at 30 DAS. While, propaquizafop + imazethapyr 125 g/ha PoE could not diminish the much density and weed biomass as compared to the others. On the otherhand, prolonged effect of hand weeding at 30 DAS was found to control total weeds (5.34 and 5.87/m^2) upto maturity stage over the others during both the years (**Table 3**).

Highest weed control efficiency, WCE (81.1 and 83.8%) was derived under weed management treatments of topramezone 25.28 g/ha as PoE (18 DAS) during 2020-21 and 2021-22 respectively at 90 DAS. It is a highly selective phenyl pyrazolyl ketone herbicide for controlling broad spectrum weeds that controls weeds by inhibiting carotenoid biosynthesis (HPPD inhibitor). Flauzifop-p-butyl + fomesafen 250 g/ha PoE also performed well next to the topramezone 25.28 g/ha over other chemicals tested for lowering the weed biomass and increasing WCE. Hand weeding at 30 DAS has also performed appreciably and achieved WCE of 78.2 and 81.7% at harvest during both the years, respectively. Sanketh *et al*. (2021) also reported noticeable WCE using topramezone 25.2 g/ha (PoE) *fb* mechanical weeding at 40 DAS. The lowest weed control efficiency was recorded in post-emergence application of propaquizafop + imazethapyr 125 g/ha (**Table 4**).

Phytotoxicity

Phytotoxicity observations were recorded at 1, 3, 7, 14 and 28 days after post-emergence herbicide application (DAHA). Chlorosis and necrosis-like symptoms were not observed on crop plants in herbicide application. All the four post-emergence herbicides applied had yellowing, stunting and scorching symptoms after 3 and 7 DAHA.

Table 1. Phyto-toxicity of different herbicide on chickpea plants during 2020-21and 2021-22

	Herbicidal phyto-toxicity effect on Chickpea (DAHA)																	
	Yellowing						Stunting						Scorching					
	0	1	3	7	14	28	0	1	3	7	14	28	0	1	3	7	14	28
Topramezone 25.28 g/ha as PoE (18 DAS)	0	0	5	2	0	0	0	0	5	2	0	0	0	0	5	2	0	0
Flauzifop-p-butyl + fomesafen 125 g/ha PoE	0	0	4	2	0	0	0	0	4	2	0	0	0	0	4	2	0	0
Flauzifop-p-butyl + fomesafen 250 g/ha PoE	0	0	5	4	1	0	0	0	5	4	1	0	0	0	5	4	1	0
ropaquizafop+ imazethapyr 125 g/ha PoE	0	0	3	2	1	0	0	0	3	2	1	0	0	0	3	2	1	0
Weedy check	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DAHA= Days after herbicide application

Table 2. Weed density in chickpea as influenced by different pre- and post-emergence herbicides

Treatment	Weed density (no./m^2) at 60 DAS							
	Medicago denticulata		*Chinopodium Album*		*Cichorium intybus*		Other weeds	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
Pendimethalin 678 g/ha PE	3.67 (13.00)	3.39 (11.00)	2.55 (6.00)	2.35 (5.00)	3.08 (9.00)	2.92 (8.00)	3.54 (12.00)	3.39 (11.00)
Pendimethalin + imazethapyr 1000 g/ha as PE	3.39 (11.00)	3.24 (10.00)	2.92 (8.00)	2.55 (6.00)	2.55 (6.00)	2.35 (5.00)	3.67 (13.00)	3.24 (10.00)
Oxyfluorfen 140 g/ha as PE	3.08 (9.00)	2.92 (8.00)	2.35 (5.00)	2.12 (4.00)	2.74 (7.00)	2.35 (5.00)	3.08 (9.00)	2.92 (8.00)
Topramezone 25.28 g/ha as PoE (18-20 DAS)	2.12 (4.00)	2.12 (4.00)	2.12 (4.00)	1.87 (3.00)	2.74 (7.00)	2.55 (6.00)	2.12 (4.00)	1.87 (3.00)
Pendimethalin 678 g/ha PE *fb* quizalofop 50 g/ha PoE	3.24 (10.00)	3.24 (10.00)	3.08 (9.00)	2.74 (7.00)	3.08 (9.00)	3.08 (9.00)	2.12 (4.00)	1.58 (2.00)
Pendimethalin 678 g/ha PE *fb* propaquizofop 50 g/ha PoE	3.54 (12.00)	3.24 (10.00)	3.39 (11.00)	3.24 (10.00)	2.92 (8.00)	2.74 (7.00)	2.55 (6.00)	2.35 (5.00)
Flauzifop-p-butyl + fomesafen 125 g/ha PoE	3.08 (9.00)	2.74 (7.00)	2.92 (8.00)	2.74 (7.00)	2.74 (7.00)	2.55 (6.00)	2.35 (5.00)	2.35 (5.00)
Flauzifop-p-butyl + fomesafen 250 g/ha PoE	2.55 (6.00)	2.35 (5.00)	2.74 (7.00)	2.55 (6.00)	2.92 (8.00)	2.92 (8.00)	2.35 (5.00)	2.12 (4.00)
Propaquizafop + imazethapyr 125 g/ha PoE	4.85 (23.00)	4.53 (20.00)	3.24 (10.00)	3.08 (9.00)	2.35 (5.00)	2.12 (4.00)	3.54 (12.00)	3.24 (10.00)
Mechanical weeding at 20 *fb* 40 DAS	2.74 (7.00)	2.35 (5.00)	2.92 (8.00)	2.74 (7.00)	2.92 (8.00)	2.55 (6.00)	2.55 (6.00)	2.35 (5.00)
Hand weeding at 30 DAS/Farmers practice	1.87 (3.00)	2.35 (5.00)	1.58 (2.00)	1.87 (3.00)	1.87 (3.00)	1.87 (3.00)	2.12 (4.00)	2.35 (5.00)
Weedy check	6.44 (41.00)	6.20 (38.00)	3.81 (14.00)	3.67 (13.00)	3.54 (12.00)	3.24 (10.00)	3.39 (11.00)	3.08 (9.00)
LSD (p=0.05)	-	-	-	-	-	-	-	-

Original values are given in the parentheses

Topramezone acts as inhibiting 4- hydroxy-phenyl-pyruvate dioxygenase (HPPD) enzyme and preventing carotenoid biosynthesis, which lead to photo-oxidation of chlorophyll molecules (Wang *et al*. 2018). Spray of topramezone 25.28 g/ha at 18 DAS controlled weeds properly with some phytotoxic effects on the crop (rating 3-4), as well as weeds also emerged at later stage, due to slow early growth of crop. Topramezone application was safe for crop and also controlled all narrow and broad-leaf weeds and hence score of yellowing, stunting and scorching symptoms was higher at 3 days as compared to 7 DAHA. These symptoms were entirely disappeared and crop has recovered and regained its growth very well in topramezone 25.28 g/ha after 14 days of application. Study conducted at ICAR-DWR, Jabalpur showed that topramezone 20.6 g/ha at 25 DAS resulted in higher phytotoxicity on weeds (toxicity scale of 7-10) without any phytotoxicity on chickpea (Annual Report (Bilingual), 2018-19). Flauzifop-p-butyl + fomesafen 125 g/ha also showed regrowth of the crop at 14 DAHA. Slight effect of phytotoxicity was observed upto 14 DAHA in propaquizafop + imazethapyr 125 g/ha PoE and flauzifop-p-butyl + fomesafen 250 g/ha PoE due to higher dose (**Table 1**).

Yield attributing characters, seed yield and economics

Significantly the highest number of branches/ plant (21.3 and 21.6), pods/plant (37.6 and 37.8) and 100 seed weight (25.46 and 25.79 g) were observed under application of topramezone 25.28 g/ha as PoE (18-20 DAS) which was closely followed by hand weeding at 30 DAS, oxyfluorfen 140 g/ha as PE and mechanical weeding at 20 *fb* 40 DAS among all weed management options. Effectively managed weed density under these treatments brought more space to

Table 3. Weed density and weed biomass in chickpea as influenced by different pre- and post-emergence herbicides

Treatment	Total weed density		Total weed biomass at 60 DAS (g/m^2)		Total weed biomass (g/m^2) at 90 DAS	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
Pendimethalin 678 g/ha PE	6.36(40.0)	5.96(35.0)	7.46	7.33(53.24)	11.22(125.32)	9.96(98.78)
Pendimethalin + imazethapyr 1000 g/ha as PE	6.20(38.0)	5.61(31.0)	7.14(50.43)	6.99(48.38)	10.94(119.12)	9.61(91.85)
Oxyfluorfen 140 g/ha as PE	5.52(30.0)	5.05(25.0)	6.19(37.81)	6.04(35.96)	9.96(98.72)	8.48(71.34)
Topramezone 25.28 g/ha as PoE (18-20 DAS)	4.42(19.0)	4.06(16.0)	4.38(18.67)	4.22(17.32)	6.54(42.27)	5.71(32.05)
Pendimethalin 678 g/ha PE *fb* quizalofop 50 g/ha PoE	5.70(32.0)	5.34(28.0)	6.73(44.82)	6.57(42.64)	10.20(103.46)	8.99(80.36)
Pendimethalin 678 g/ha PE *fb* propaquizofop 50 g/ha PoE	6.12(37.0)	5.70(32.0)	6.92(47.36)	6.81(45.83)	10.55(110.84)	9.37(87.36)
Flauzifop-p-butyl + fomesafen 125 g/ha PoE	5.43(29.0)	5.05(25.0)	5.55(30.26)	5.41(28.76)	8.43(70.54)	7.66(58.25)
Flauzifop-p-butyl + fomesafen 250 g/ha PoE	5.15(26.0)	4.85(23.0)	5.14(25.91)	5.01(24.64)	7.83(60.86)	7.03(48.96)
Mechanical weeding at 20 *fb* 40 DAS	5.43(29.0)	4.85(23.0)	4.55(20.16)	4.36(18.53)	8.03(63.96)	7.17(50.84)
Hand weeding at 30 DAS/Farmers practice	3.54(12.0)	4.06(16.0)	3.56(12.18)	3.47(11.57)	7.01(48.68)	6.05(36.15)
Weedy check	8.86(78.0)	8.40(70.0)	10.48(109.3)	10.27(105.1)	14.96(223.4)	14.08(197.6)
LSD (p=0.05)	-	-	0.10	0.08	0.04	0.05

Original values are given in the parentheses

Table 4. No. of branches/plant, pods/plant, 100 seeds weight, WCE, seed yield and economics of chickpea as influenced by weed management practices

Treatment	No. of branches/plant (at harvest)		No. of pods/ Plant		100 seeds weight (g)		Seed yield (t/ha)		Net returns (Rs/ha)		B:C		WCE at 90 DAS	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
Pendimethalin 678 g/ha PE	18.4	18.5	33.0	33.2	22.46	22.52	1.12	1.15	36165	37250	2.75	2.74	43.9	50.0
Pendimethalin + imazethapyr 1000 g/ha as PE	18.5	18.6	33.2	33.5	23.18	23.36	1.13	1.23	36930	41330	2.78	2.93	46.7	53.5
Oxyfluorfen 140 g/ha as PE	20.2	20.4	36.2	36.3	24.96	25.28	1.29	1.34	45090	46940	3.18	3.19	55.8	63.9
Topramezone 25.28 g/ha as PoE (18-20 DAS)	21.3	21.6	37.6	37.8	25.46	25.79	1.49	1.53	53290	54630	3.35	3.33	81.1	83.8
Pendimethalin 678 g/ha PE *fb* quizalofop 50 g/ha PoE	18.9	19.1	34.7	34.9	23.83	23.99	1.18	1.22	37725	39320	2.70	2.72	53.7	59.3
Pendimethalin 678 g/ha PE *fb* propaquizofop 50 g/ha PoE	18.7	18.8	34.7	34.1	23.64	23.78	1.17	1.19	38055	38290	2.75	2.71	50.4	55.8
Flauzifop-p-butyl + fomesafen 125 g/ha PoE	19.4	19.7	35.1	35.2	24.54	24.83	1.24	1.28	42285	43880	2.04	3.05	68.4	70.5
Flauzifop-p-butyl + fomesafen 250 g/ha PoE	19.7	20	35.7	35.9	24.72	24.91	1.28	1.32	44050	45220	3.06	3.05	72.8	75.2
Propaquizafop + imazethapyr 125 g/ha PoE	18.1	18.3	32.8	33.1	22.28	22.46	1.11	1.13	35995	36230	2.74	2.69	38.1	43.7
Mechanical weeding at 20 *fb* 40 DAS	20.6	20.8	36.8	36.9	25.14	25.39	1.31	1.40	45610	49500	3.15	3.26	71.4	74.3
Hand weeding at 30 DAS/Farmers practice	21.0	21.3	37.5	37.7	25.28	25.57	1.39	1.43	44860	46030	2.71	2.71	78.2	81.7
Weedy check	14.5	14.6	20.5	20.8	21.65	21.86	0.53	0.56	8830	9660	1.49	1.51	-	-
LSD (p=0.05)	1.2	0.6	1.4	0.19	0.63	0.7	0.30	0.11	-	-	-	-		

the crop and reduced the competition for solar energy, moisture and nutrients eventually increased the number of branches and pods/plants which converted into higher seed yield.

Considerably higher seed yield (1.49 and 1.53 t/ha) was recorded in the topramezone 25.28 g/ha as PoE (18 DAS) produced average 275% more seed yield than the weedy check and 133% over pendimethalin 678 g/ha PE on mean basis and was found to be significantly superior over all the other chemical weed control treatments during 2021-22 and except oxyfluorfen 140 g/ha as PE (1.29 and 1.34 t/ha), flauzifop-p-butyl + fomesafen 250 g/ha PoE (1.28 and 1.32 t/ha) and flauzifop-p-butyl + fomesafen 125 g/ha PoE (1.28 t/ha) during 2020-21. Gajanand *et al.* (2023) also reported topramezone 25.7 g/ha (21 DAS) yielded the 82% higher seed yield of chickpea over weedy check. Mechanical weeding at 20 *fb* 40 DAS (1.31 and 1.40 t/ha) and hand weeding at 30 DAS/Farmers practice (1.39 and 1.43 t/ha) also produced comparable seed yield (**Table 4**). Higher seed yield under weed management treatments might be due to lesser infestation of weeds due to effective control of weeds during critical crop weed competition period that encourage adequate nutrient supply to the crop and proper translocation of photosynthesis from source to sink. Maximum reduction in seed yield was recorded in PE application of pendimethalin 678 g/ha and propaquizafop + imazethapyr 125 g/ha PoE. These results are in agreement with Dubey *et al.* (2018).

Topramezone 25.28 g/ha as PoE (18 DAS) also generated the highest net return (₹ 53,290 and 54630/ha) and B:C ratio (3.35 and 3.33). Pre-emergence application of oxyfluorfen 140 g/ha and mechanical weeding at 20 *fb* 40 DAS were the other two weed management option which were found comparable and performed well (**Table 4**). Grain yield under weedy check was reduced by 256 and 245% as compared to the hand weeding and mechanical weeding, respectively. Topramezone 25.28 g/ha as PoE (18-20 DAS) also generated the highest net return (₹ 53,290 and 54630/ha) and B:C ratio (3.35 and 3.33). Pre-emergence of oxyfluorfen 140 g/ha and mechanical weeding at 20 *fb* 40 DAS were the other two weed management option which found comparable and performed well to generate returns.

Post-emergence herbicides particularly topramezone (25.28 g/ha) and flauzifop-p-butyl + fomesafen (either 125 or 250 g/ha) could be better option for controlling weeds than hand weeding to achieve higher yield and net returns without any perceptible phytotoxic effects. Using oxyfluorfen 140 g/ha as pre-emergence also found to be better choice than pendimethalin 678 g/ha as PE or pendimethalin + imazethapyr 1000 g/ha as PE to harvest more seed yield.

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