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Weed persistence, crop resistance and phytotonic effects of herbicides in direct-seeded rice

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ABSTRACT

Results of experiment conducted during *Kharif* season of 2010 and 2011 with ten different herbicides and combinations on yield of direct seeded rice revealed that crop resistance index and agronomic management index were maximum in hand weeding treatment followed by fenoxaprop + (chororimuron + metsulfuron) and cyhalofop butyl +(chlorimuron + metsulfuron). Weed persistence index was also maximum in Hand weeding treatment followed by cyhalofopbutyl and pyrazosulfuron. Hand weeding treatment has maximum phytotonic effect followed by fenoxaprop + (chororimuron + metsulfuron) and cyhalofop butyl + (chlorimuron + metsulfuron). Fenoxaprop + (chororimuron + metsulfuron) and cyhalofop butyl + (chlorimuron + metsulfuron) were best herbicides for direct seeded rice from economics and environmental point of view. Fenoxaprop + (chororimuron + metsulfuron) and cyhalofop butyl + (chlorimuron + metsulfuron) have recorded lower persistence of escaped weeds indicating broad spectrum effect in controlling the weeds

Key words- Agronomic management index, Crop resistance index, Phytotonic effect, Weed persistence index

Herbicides are used to control weeds in crop as pre or post emergence application which reduce the population of weeds significantly resulting in higher yield and profit. Some times, the pesticides apart from harming target species also affect the non target living being like microflora or fauna or biochemical reaction in soil and plant which may some times augment yield (Phytotonic effect) or some times produce detrimental effect (phytotoxic) on plant. Scientists many a times ignore such action of herbicides as it requires several cumbersome studies for the purpose (Mishra, 2014). Now, in the days of Global warming and climate change, it is needful to conserve ecosystem and biodiversity along with sustained production of higher yield. Mishra and Mishra (1997) have tried to quantify weed persistence, crop resistance and phytotonic effect of herbicidal treatments by using mathematical formula basing on growth characters where the effect of herbicide treatment can be easily identified which can give an indication basing on which further studies can be under taken for conformation. Prasanna *et al.* (2004) have identified phytotonic effect of thiamethoxam fungicide as seed treatment in cotton. Ribeiro *et al.* (2014) have identified the phytotonic effect of fungicide Pyraclostrobin+methyl thiophanate as seed treatment in soyabean. Such studies on herbicides are very much lacking. The present investigation was undertaken to identify the phytotonic effect of herbicides on weed and crop growth for sustained production.

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MATERIALS AND METHODS

The experiment was conducted during *Kharif* season of 2010 and 2011 at Central Research Station, OUAT under East and South Eastern Coastal Plain Zone of the State in a randomized block design with three replications. The soil of the experimental site was sandy loam with low in available N (168 kg/ha), medium in P (14.5 kg/ha) and K (170 kg/ha). Twelve different treatments consisting of different best herbicides/herbicide mixture for weed control in direct seeded rice (cv. *Lalat*) were evaluated for their performance. The crop was sown in the 2nd fortnight of june with seed rate of 75 kg/ha and was fertilized at N P_2O_5 K_2O 60-30-30 kg /ha. Herbicide treatments were applied as per treatment. All total there were 12 treatments constituting 10 different herbicide applications with their combinations and one weed free with one control. The details of treatments were as follows, pyrazosulfuron 25 g/ha at 5-7 DAS, pretilachlor 750 g/ha at 3-5 DAS, cyhalofop-butyl 90 g/ha at 25 DAS, fenoxaprop 60 g/ha at 30 DAS, cyhalofop-butyl + (chlorimuron + metsulfuron) at 90 + 20 g/ha at 25-30 DAS, fenoxaprop + (chlorimuron + metsulfuron) at 60 + 20 g/ha at 25-30 DAS, azimsulfuron at 35 g/ha at 20 DAS, bispyribac

sodium at 25 g at 20 DAS, fenoxaprop + ethoxy sulfuron at 60+ 15 at 25-30 DAS, oxyflorofen 300 g/ ha followed by 2,4-D 500 g/ha at 30 DAS along with one weed free and control

The observation on weeds at 60 days of sowing and dry weight of crop and grain yield at harvest have been presented in (Table 1). The various indices developed by Mishra and Misra (1997) have been used to identify the weed persistence, crop resistance and phytotonic effect due to herbicidal treatments as mentioned below calculated on the basis of mean data of two years and have been presented in (Table 2) along with economics of cultivation.

Weed persistence index (WPI): (Dry weight of weeds in treated plot/dry weight of weeds in control plot) x (weed count in the control plot / weed count in the treated plot).

Crop resistance index (CRI): (dry matter production by crop in the treatment plot/dry matter production by crop in the control plot) x (dry matter production of weed in control plot/dry matter production of weeds in treatment plot)

Agronomic management index (AMI): (percentage increase in yield over control - percentage reduction of weeds)/Percentage control of the pest (weed/insect).

RESULTS AND DISCUSSION

Major weed flora

The floristic composition of the experimental site was dominated with grasses like *Digitaria ciliaris, Cynodon dactylon, Echinochloa colona* and broad-leaf weeds like *Ageratum conyzoides, Cleome viscosa, Celosia argentia, Ludwigia parviflora, Physalis minima, Chrozoffera rottleri.* The dominant sedges observed were *Cyperus rotundus* and *Cyperus irea*. Other weeds observed in lower density were *Panicum repens, Sporobolus diander, Alternanthera sessilis, Eclipta alba.*

Weed density

Significant difference in weed densities was observed at 60 DAS due to weed control treatments in both the years (Table 1). Significantly lowest weed density of 3.6 and 3.5 g/m^2 were noticed with hand weeding treatment during 2010 and 2011, respectively which were at par with application of fenoxaprop + (chlorimuron + metsulfuron) followed by cyhalofop-butyl + (chlorimuron + metsulfuron) treatment in both the years. Significantly maximum weed density was observed in control plot (104.7 and 105.5 g/m^2) in both the years (2010 and 2011). Mean data of weed density of both the years indicated that the hand weeding was superior to all the herbicidal treatments in controlling weeds to the extent of 96.6% as compared to best herbicidal treatment like fenoxaprop + (chlorimuron + metsulfuron) [88.8%] and cyhalofop-butyl+ (chlorimuron + metsulfuron) [87.2%]. The treatment pretilachlor-S recorded the lowest percentage weed control (69.7%).

Weed biomass

The weed biomass recorded at 60 days of growth of rice are presented in Table 1. Different weed control methods exhibited significant effect on weed biomass. Hand weeding treatment recorded significantly lowest weed biomass (4.5/2.8 g/m^2) followed by fenoxaprop + (chororimuron + metsulfuron), cyhalofop-butyl + (chlorimuron + metsulfuron), bispyribac-sodium and fenoxaprop + ethoxysulfuron 5.7/4.7,7.8/6.8,9.8/9.8 g/m^2 as against control of 33.5/26.5 g/m^2 in both the years (2010/2011), respectively. The average data of both the years revealed that hand weeding recorded the lowest biomass of weeds 3.65 g/m^2 followed by fenoxaprop + (chororimuron + metsulfuron), cyhalofop-butyl + (chlorimuron + metsulfuron) and bispyribac sodium in increasing order.

Crop biomass

The total biomass production of crop (Table 1) indicated that the hand weeding treatment produced maximum biomass (7.75/7.55 t/ha) and also in average of two years (7.65 t/ha) followed by fenoxaprop + (chororimuron + metsulfuron), and fenoxaprop+ethoxy-sulfuron, bispyribac sodium, cyhalofop-butyl + (chlorimuron + metsulfuron) in decreasing order. Significantly lowest dry matter was produced in control (3.30/3.47 t/ha) in both the years (2010/2011) and in average of two years also (3.38 t/ ha).

Grain yield

The data on grain yield (Table 1) indicated that hand weeding plots recorded significantly highest yield of 3.43/3.43 t/ha where as weedy treatment significantly the lowest yield (1.49/1.55 t/ha) in both the years (2010/2011). Among different method of chemical control, significantly higher grain yield were obtained (3.23/3.18 t/ha) from application of fenoxaprop + (chororimuron + metsulfuron), which were at par with cyhalofop-butyl + (chlorimuron + metsulfuron) and bispyribac-sodium and fenoxaprop + ethoxy-sulfuron recording grain yield of 3.23/3.18 and 3.07/3.02 t/ha and 3.07/3.02 t/ha in both the years (2010/2011), respectively. The mean

Table 1. Effect of different weed control measures on weed density and weed biomass (60 DAS), total biomass and grain yield in direct-seeded rice (DSR)

Treatment	Weed density (g/m^2)*			Weed biomass (g/m^2)			Total biomass of plants (kg/m^2)			Grain yield (t/ha)		
	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean
Pyrazosulfuron	5.2(27.5)	5.3(28.5)	28.0	23.5	22.5	23.0	0.62	0.60	0.61	2.72	2.67	2.70
Pretilachlor –S	5.6(30.8)	5.7(32.8)	31.8	24.7	23.7	24.2	0.56	0.54	0.55	2.46	2.41	2.43
Cyhalofop-butyl	5.2(26.7)	5.4(28.7)	27.7	23.4	22.4	22.9	0.60	0.57	0.58	2.64	2.59	2.61
Fenoxaprop	4.9(23.5)	5.1(25.5)	24.5	18.5	17.5	18.0	0.65	0.63	0.64	2.92	2.87	2.89
Cyhalofop-butyl + (chlorimuron + metsulfuron)	3.5(12.5)	3.8(14.5)	13.5	7.8	6.8	7.3	0.73	0.61	0.67	3.23	3.18	3.20
Fenoxaprop + (chlorimuron + metsulfuron)	3.4(11.8)	3.4(11.8)	11.8	5.7	4.7	5.2	0.72	0.71	0.71	3.27	3.22	3.24
Azimsulfuron	4.7(21.7)	4.9(23.7)	22.7	16.5	15.5	16.0	0.68	0.66	0.67	3.00	2.95	2.97
Bispyribac-sodium	3.9(15.5)	4.2(17.5)	16.5	9.8	9.8	9.8	0.70	0.68	0.68	3.07	3.02	3.05
Fenoxaprop + ethoxysulfuron	4.3(18.3)	4.5(20.3)	19.3	12.7	11.7	12.2	0.70	0.68	0.69	3.07	3.02	3.04
Oxyfluorfen + 2,4-D	5.1(25.8)	5.2(27.8)	26.8	21.3	20.3	20.8	0.65	0.63	0.64	2.87	2.82	2.85
Hand weeding	1.9(3.6)	1.8(3.5)	3.55	4.5	2.8	3.65	0.78	0.76	0.77	3.49	3.43	3.46
Weedy	10.2(104.7)	10.3(105.5)	105.1	33.5	26.5	30.0	0.33	0.35	0.34	1.49	1.55	1.52
LSD (P=0.05)	4.60	4.39		2.73	2.73		0.12	0.09		1.39	1.09	

*Figures of weed densities are $\sqrt{x+0.5}$ transformed, values and in bracket are the original values

Table 2. Effect of weed control practices on various indices of direct-sown rice and economics of cultivation

Treatment	WCE	WI	WPI	CRI	AMI	Net returns ($x10^3$ `/ha)	B:C
Pyrazosulfuron	23.3	22.0	2.87	2.35	0.06	11.23	1.95
Pretilachlor –S	24.0	42.4	2.67	2.01	-0.14	9.23	1.79
Cyhalofop-butyl	31.0	32.6	2.89	2.26	-0.02	10.36	1.86
Fenoxaprop	66.7	19.7	2.57	3.13	0.18	13.14	2.13
Cyhalofop-butyl + (chlorimuron + metsulfuron)	75.7	7.5	1.89	8.29	0.27	15.78	2.36
Fenoxaprop+(chlorimuron + metsulfuron)	82.7	6.3	1.54	12.41	0.28	15.82	2.33
Azimsulfuron	46.7	14.2	2.47	3.72	0.22	13.92	2.01
Bispyribac-sodium	67.3	11.8	2.08	6.31	0.19	14.46	2.25
Fenoxaprop + ethoxysulfuron	59.3	12.2	2.21	5.05	0.23	14.52	2.26
Oxyfluorfen + 2,4-D	30.7	17.6	2.72	2.72	0.17	12.36	2.03
Hand weeding	87.8	0.0	3.59	18.83	0.32	13.90	1.89
Weedy	0.0	56.1	1.00	1.00	0.0	2.12	1.18

WPI - Weed persistence index, CRI - Crop resistance index, AMI - Agronomic management index

percentage increase in yield revealed that hand weeding recorded 127.6% increase in yield followed by fenoxaprop + (chororimuron + metsulfuron), cyhalofop-butyl +(chlorimuron + metsulfuron), bispyribac-sodium and fenoxaprop + ethoxysulfuron with respective increase in yield of 113.5,110.9, 100.7, 100.3% over control.

Weed control efficiency

The data (Table 2) indicated that maximum WCE was obtained from hand weeding (87.83) closely followed by fenoxaprop + (chororimuron + metsulfuron) (82.66) and cyhalofop-butyl + (chlorimuron + metsulfuron) (75.66). Amongst herbicide, lowest WCE was by pyrazosulfuron and pretilachlor. The WI was lowest in hand weeding (0.00) closely followed by fenoxaprop + (chororimuron + metsulfuron)-(6.35) and cyhalofop-butyl + (chororimuron + metsulfuron)-(7.51).

Weed persistence index (WPI): Weed persistence index indicating relative dry matter accumulation of weeds per count in comparison to control (Table 2) indicated that the hand weeding treatment resulted in higher persistence index (3.59) closely followed by cyhalofop-butyl (2.89) and pyrazosulfuron (2.87) indicating resistance of escaped weeds to control measures. whereas, fenoxaprop + (chororimuron + metsulfuron) [1.54] and cyhalofop-butyl + (chlorimuron + metsulfuron)[1.89] have recorded lower persistence of escaped weeds indicating broad spectrum effect in controlling the weeds.

Crop resistance index (CRI): The crop resistance index (Table 2) indicating increased vigour of crop plant due to weed control measures indicated that the hand weeding treatment recorded maximum crop resistance (18.83) to grow followed by fenoxaprop + (chororimuron + metsulfuron) [12.41] and cyhalofop-butyl + (chlorimuron + metsulfuron)

[8.29] indicating much less harmful effect of herbicides on crop as compared to other treatments. Unweeded control recorded the lowest value of CRI (1.0) indicating highest harmful effect on crop.

Agronomic management index (AMI): The agronomic management index (Table 2) indicating the effect of herbicides on environmental parameters revealed that hand weeding recorded the maximum AMI may be due to maximum phytotonic effect (0.32) closely followed by herbicidal treatments like fenoxaprop + (chororimuron + metsulfuron) [0.28] and cyhalofop-butyl + (chlorimuron + metsulfuron) [0.27]. Whereas, pretilachlor-S and and cyhalofop-butyl were found to have resulted in negative values of AMI indicating its harmful effect on nontarget factors.

Grain yield

The grain yield data (Table 1) indicated that hand weeding produced significantly maximum grain yield of 3.49/3.43 t/ha due to lowest weed count, weed weight and WI with highest WCE and AMI. Although WPI was highest in this treatment, the maximum CRI of this treatment might have also helped in recording maximum yield. The highest value of AMI of this treatment indicated phytotonic effect of hand weeding on growth and yield. This was in agreement with Mishra and Misra (1997). Among the herbicide treatments, fenoxaprop + (chororimuron + metsulfuron), cyhalofop-butyl + (chlorimuron + metsulfuron) were best treatments in yield due to significantly less weed count, weed weight and WPI with higher weed control efficiency as compared to other herbicide treatments. Similar findings have been reported by Ahmed and Chauhan (2014) further, the CRI and AMI of the said treatments were also higher which were next to hand weeding that have favoured to attend higher yield might be due to some phytotonic effect. The grain yields were lower in pretilachlor-S, cyhalofop-butyl and pyrazosulfuron as it recorded higher weed density, weed biomass, WPI with lower CRI, AMI and, WCE. The lower AMI of the said treatments might be due to herbicidal harmful effect on nontarget factors. Similar studies have been conducted by Ahmed and Chauhan *et al.* (2013) and Mallikarjuna *et al.* (2014) in direct seeded rice.

Although, hand weeding recorded maximum yield, the net return and B:C ratio in herbicidal treatments like fenoxaprop + (chororimuron + metsulfuron), cyhalofop-butyl + (chlorimuron + metsulfuron), fenoxaprop + ethoxysulfuron and bispyribac-sodium were higher than the hand weeding due to high cost of cultivation. Chauhan *et al.* (2013) have reported different herbicides have similar weed control effect and can be rotated in cropping system.

It can be concluded that hand weeding has maximum phytotonic effect than herbicides. Herbicide like fenoxaprop + (chororimuron + metsulfuron) and cyhalofop-butyl + (chlorimuron + metsulfuron) have exhibited phytotonic effects in rice. Herbicides like pretilachlor-S and cyhalofop-butyl have been found to have harmful effect under the said dose and method of application of herbicide. Hand weeding treatment has maximum tendency of weed persistence index followed by cyhalofop-butyl and pyrazosulfuron whereas fenoxaprop + (chororimuron + metsulfuron) and cyhalofop-butyl + (chlorimuron + metsulfuron) have lowest values. The crop resistance index was maximum in hand weeding treatment followed by fenoxaprop + (chororimuron + metsulfuron and cyhalofop-butyl + (chlorimuron + metsulfuron). fenoxaprop + (chororimuron + metsulfuron) and cyhalofop-butyl + (chlorimuron + metsulfuron) were best herbicides for rice.

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