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EFFECT OF DIFFERENT POST EMERGENCE HERBICIDES ON BIOCHEMICAL AND PHYSICO-CHEMICAL PROPERTIES OF RICE SOIL

Dipika and Tapas Chowdhury

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DIPIKA* AND TAPAS CHOWDHURY
Department of Agricultural Microbiology,
College of Agriculture, IGKV, Raipur - 492 012, Chhattisgarh, INDIA
e-mail: thakurdipika8389@gmail.com

ABSTRACT

A field study was conducted in an Inceptisol with summer season rice to evaluate the degradability of different post emergence herbicides applied alone or in combinations in term of biochemical and physico-chemical characteristics of rhizosphere soil. Five different herbicides (bispyribac sodium, metamifop, chlorimurone ethyl, metsulfuron methyl and cyhalofop butyl) were applied as an individual or in combination at post emergence stage (15 DAS). The study revealed that application of different herbicides had inhibitory effect on biochemical and physio-chemical activities of soil after their application, but their effects were not pronounced and the soil properties were restored. Different herbicides and their combination degraded at different rates but their degradability is almost equal and they look only 35 days or less period for complete degradation except cyhalofop butyl and bispyribac sodium + metamifop which are applied @ 80 g and 140 g a.i. ha^{-1} respectively and found completely degraded before harvest. At harvest stage of the crop the levels of biochemical and physico-chemical properties of soil were found normal and similar to that of unsprayed control condition which indicates that applied herbicides did not leave any harmful residues in soil system at harvest stage of the crop.

***Corresponding author**

INTRODUCTION

In general weeds reduce the crop yield by 31.5% (22.7% in winter and 36.5% in summer and *Kharif* seasons). Weed control technology integrates preventive, cultural, mechanical, chemical and biological practices in which the use of chemical herbicides is probably the most important component of weed management system. The ultimate destination of herbicidal chemicals is the soil system where they come in contact with different microfloras which are responsible for different biochemical transformations related to mineral nutrition to plants. Generally herbicides are not harmful when it is applied in recommended levels in soil (Selvamani and Sankaran,1993). Different microorganisms are efficient decomposers of herbicides which are generally aliphatic, hydroxyl and aromatic compounds. They easily decompose the aliphatic and hydroxyl group but they decompose aromatic substances at a slower rate. The application of several herbicides may lead to accumulate and develop toxic effects hazardous for humans and the ecosystem. Many new post and pre emergence herbicides are now introduced in developing countries like India whose economy is based on agriculture. These herbicides are used in different combinations with & without wetting agent for weed control by farmers. The fate and persistence of these newly introduced herbicides in soil are almost unknown. Herbicides with soil activity are still an important component of weed control in rice. These may include post applied herbicides with soil activity. The interaction of soil properties, water, and application timing affects efficacy, crop response, and potential for carryover. Herbicide-based weed management is becoming the most popular method of weed control in rice. Herbicides are specific regarding their toxic level. However, the application of several chemicals may lead to synergy and development of toxic effects hazardous for humans and the ecosystem (Michaelidou *et al.*, 2000). The problems caused by the increased application of herbicides call for multidisciplinary approach. Incorrect and indiscriminate application of herbicides affects negatively the health of humans, plants and animals. Particularly hazardous are the poorly degradable herbicides (Triazins) whose persistence may lead to long-term accumulation. Thus, keeping the above facts in view the present investigation was undertaken to test a new post emergence herbicide comparing with existing herbicides with and without wetting agent with respect to their ultimate effect on biochemical and physico-chemical properties of rice soil as well as their rate of degradation in rice rhizosphere soil.

MATERIALS AND METHODS

A field study was conducted during summer 2013 at Instructional cum Research farm, IGKV, Raipur in an inceptisol with summer season rice to evaluate the degradability of different post emergence herbicides applied alone or in combinations in terms of physico-chemical and biochemical characteristics of rhizosphere soil. Five different herbicides (bispyribac sodium, metamifop, chlorimurone ethyl, metsulfuron methyl and cyhalofop butyl) were applied as an individual or in combination at post emergence stage (15 DAS). A wetting agent (agrisol) was also used with some herbicides to increase the effectively applied herbicides. Combination of two herbicides *i.e.* bispyribac sodium and metamifop were also tested at different concentration to find out their suitable dose for optimizing rice yield and environmental safety. All the herbicide compared treatments compared with unsprayed control. The experiment was conducted on summer rice (*Oryza stativa* L.) with test variety MTU-1010. The soil was Inceptisol (pH: 6.29, EC: 0.20 dSm^{-1}, organic carbon: 22.33%, available N: 238.336 kg ha^{-1}, available P: 9.24 kg ha^{-1}, and available K: 252.712kg ha^{-1}). The treatments were replicated thrice under randomized block design. Rhizosphere soil was collected at a depth of 7.5-15cm from 13 locations at different stages of crop growth from the same plot & pooled together for the purpose of analysis. Soil sampling was done at 30, 50 days after sowing of crop and harvest stage of crop. The soil samples were subjected to analysis for dehydrogenase activity (Klein *et al.*,1971), acid phosphatase activity (Tabatabai and Bremner, 1969), N mineralization (Bremner and Kenney, 1965) soil pH (Piper, 1967) and electrical conductivity (Jackson, 1973). And all the post harvest observation were recorded and tabulated in a systematic manner. The final observations were statistically analyzed by randomized block design (Panse and Sukhatme, 1978).

Treatment	Dose g a.i./ha
T1	Bispyribac sodium + Metamifop@ 42g a.i./ha+ wetter
T2	Bispyribac sodium + Metamifop@ 56g a.i./ha + wetter
T3	Bispyribac sodium + Metamifop@ 70g a.i./ha + wetter
T4	Bispyribac sodium + Metamifop@ 140g a.i./ha + wetter
T5	Chlorimuran ethyl +Metsulfuron methyl @ 4 g a.i./ha
T6	Cyhalofop Butyl @80 g a.i./ha
T7	Bispyribac sodium @20g a.i./ha+ wetter
T8	Metamifop @ 50 g a.i./ha+ wetter
T9	Bispyribac sodium + Metamifop @ 70g a.i./ha
T10	Bispyribac sodium @20g a.i./ha
T11	Metamifop @ 50 g a.i./ha
T12	Agrisol A-150K wetter
T13	Unsprayed control

RESULTS AND DISCUSSION

In this experiment different post emergence herbicides were tested as an individual or in combination of other herbicides to evaluate their toxicity level with respect biochemical and physico-chemical properties of rhizosphere soil of rice.

Dehydrogenase activity

Dehydrogenase activity (DHA) study revealed that in comparison to different herbicides treated plots, (Table 1) there was a continuous increment in DHA in herbicide unsprayed plots from 0 to 50 DAS followed by a slight decrement up to harvest. It was observed that all the herbicides including wetter significantly inhibited the DHA after their application *i.e.* 15 DAS of rice crop. The degree of inhibition was noticed at various levels at 15 DAS. In this study the dehydrogenase activity reduced got with the increasing dose of bispyribac sodium + metamifop (T1 to T4). Among different herbicides cyhalofop butyl 10% EC (T6) exhibited maximum inhibition in dehydrogenase activities and minimum by metamifop 10% EC. Cyhalofop butyl reduce the DHA value from 36.16μg (7DAS) to 17.43 (15 DAS) soon after its application where as metamifop reduced the value from 37.59 to 22.24 μg within the same period. Wetting agent (Agrisol) also reduced the above activity significantly at 15 DAS after its application. Above observations were in close agreement with Nowark (1996) and Wyszkowska and Kucharski (2004) who claimed that dehydrogenase are an objective reflection of the biological state of soil. They also reported that highest rate of triflurotox depressed the dehydrogenase activity by 28.7 % before sowing and 35.6 to 72.6 % after harvest of crop, in comparison to the control. The inhibitory effect of herbicides on the activity of dehydroenase has also reported by Strzelec (1986) and Pietr and Jablonska (1987).

At 30 DAS all the herbicides treatment significantly reduced dehydrogenase activity over control, except the wetting agent. At 50 DAS all the herbicides treatment found at par with unsprayed control except cyhalofop butyl and bispyribac sodium + metamifop (140g a.i.ha^{-1}) which started to degrade at 30 DAS but did not completely degrade at 50 DAS, hence showed their presence by reducing DHA in comparison to control.

At harvest stage all the treatments found at par with control. This study showed that the applied herbicides started to degrade at 30 DAS and completely degraded before 50 DAS except bispyribac sodium + metamifop (@140g a.i.ha^{-1}) and cyhalofop butyl. Vandana *et al.* (2012) also studied the effect of herbicides on soil enzyme activity and found that there was an increase in soil enzyme activity from 0 to 60 DAS after transplanting of the crop growth irrespective of the treatment of the soil. They reported that the increase with age of the crop however, was less during the first two stages of the crop and with significant increase at later stages. In our study the wetter degraded completely before 30 DAS. The residual effect of other herbicides excluding bispyribac sodium + metamifop @140 g a.i.ha^{-1} and cyhalofop was d” 35 DAS.

Acid phosphatase activity

APA significantly affected by different herbicides molecules used in this experiment at different stages of crop growth. The application of cyhalofop butyl significantly reduced the APA at highest level soon after its application (Table 1). Similarly other herbicides including wetter significantly reduced the APA at 15 DAS. The cyhalofop reduced the APA from 123.39μg (7 DAS) to 103.05 μg (15 DAS) which was further reduced to 90.30μg at 30 DAS. The combined application of bispyribac with metamifop have shown with higher inhibitory property next to that of cyhalofop at higher concentration i.e. 140, 70, 56 g a.i.ha^{-1} . The metamifop alone exhibited least inhibition as it reduced the APA from 130.24 (7 DAS) to 115.52μg (15 DAS) and further to 107.39μg. Wetting agent agrisol has shown inhibitory property at 15 DAS but became ineffective at 30 DAS. At 50 DAS the APA value of all the herbicides treated plot was found at par with unsprayed control except cyhalofop butyl and bispyribac sodium + metamifop (@ 140 g a.i.ha^{-1})

Table 1: Effect of post-emergance herbicides on dehydrogenase activity (μg TPF/h/g) , acid phospatase activity (μg p-NP/h/g), nitrogen minralization (Kg/h^{-1}) of rhizosphere soil at different growth stages of rice

	Days after sowing																	
Treatment	0			7			15			30			50			At harvest		
	DA	APA	NM	DA	APA	NM	DA	APA	NM	DA	APA	NM	DA	APA	NM	DA	APA	NM
T1	31.21	121.23	76.02	37.30	129.24	84.64	21.28	113.41	69.81	40.31	104.29	62.90	41.79	169.19	143.47	22.64	112.32	75.32
T2	31.05	120.32	75.13	37.09	128.16	83.27	20.79	111.66	67.95	40.03	101.92	60.70	41.46	168.78	141.89	22.46	110.48	74.58
T3	30.72	119.24	74.63	36.82	127.03	82.31	19.84	109.90	66.50	39.71	99.67	58.63	41.29	167.24	139.93	22.27	109.79	73.96
T4	30.54	117.24	73.75	36.63	125.45	81.17	19.27	105.89	65.15	39.52	94.25	57.09	41.23	162.14	136.14	22.16	108.79	73.52
T5	31.18	120.84	75.74	37.24	128.32	84.10	21.11	112.18	69.06	40.14	102.66	61.99	41.58	168.93	142.33	22.59	110.97	74.89
T6	30.23	115.34	72.36	36.16	123.39	80.89	17.43	103.05	63.46	39.34	90.30	55.27	41.05	161.07	136.03	22.07	107.33	73.17
T7	31.25	121.56	76.39	37.35	129.36	85.19	21.47	113.90	70.60	40.53	104.96	63.95	41.93	169.52	144.79	22.79	112.80	76.03
T8	31.32	121.75	76.72	37.46	129.59	85.69	21.79	114.38	71.41	40.76	105.75	65.11	42.06	169.73	145.08	22.83	113.28	76.23
T9	30.85	119.57	74.85	36.94	127.24	82.78	20.42	110.51	67.17	39.86	100.46	59.58	41.39	168.16	140.48	22.35	110.40	74.21
T10	31.37	121.92	76.90	37.53	129.78	86.02	22.01	114.74	71.99	40.92	106.40	65.87	42.57	169.84	145.77	22.95	113.52	76.82
T11	31.40	122.03	77.14	37.59	130.24	86.52	22.24	115.52	72.63	41.06	107.39	66.61	42.84	169.90	146.02	23.13	114.43	77.02
T12	31.52	122.34	78.21	37.65	130.53	87.96	29.17	121.29	81.23	41.17	156.70	121.97	44.63	174.17	150.24	24.26	115.78	79.21
T13	31.56	122.39	79.85	37.70	130.61	89.81	46.96	138.32	108.64	45.94	164.36	128.76	45.98	178.24	153.51	24.49	117.54	81.34
CD(0.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	2.47	11.34	7.68	4.82	11.71	7.78	4.70	16.98	15.63	N.S.	N.S.	N.S.

Table 2: Effect of post-emergance herbicides, comparing with other herbicides on physico-chemical properties, grain yield of rhizosphere soil at different growth stages of rice

Days after showing					
pH		EC (dSm^{-1})		Grain yield (q/ha)	
Treatment	Initial	At har	Initial	At har	
T1	6.2	6.3	0.17	0.17	29.6
T2	6.4	6.4	0.17	0.18	33.3
T3	6.2	6.2	0.15	0.14	39.2
T4	6.6	6.7	0.14	0.14	39.5
T5	6.4	6.5	0.13	0.13	23.7
T6	6.5	6.5	0.13	0.13	21.0
T7	6.5	6.6	0.15	0.15	30.5
T8	6.7	6.8	0.16	0.15	21.7
T9	6.5	6.5	0.18	0.18	32.2
T10	6.6	6.6	0.17	0.16	30.0
T11	6.4	6.5	0.15	0.14	21.7
T12	6.7	6.8	0.15	0.16	06.9
T13	6.6	6.6	0.17	0.18	07.8
CD (0.05)	N.S.	N.S.	N.S.	N.S.	5.3

which indicated their complete degradation. Wyszkowska and Kucharski (2004) also expressed similar views and mentioned that Phosphatases are among those soil enzymes that usually respond negatively to herbicides. They found triflurotox caused some inactivation of acid phosphatase and alkaline phosphatase. At harvest stage of crop, all the values of APA in different herbicides treated plots found at par with control which showed the absence of herbicides molecules and their harmful secondary metabolites in rhizosphere. In unspread control plot a continuous increment of APA was visualized from 0 to 50 DAS which slightly narrowed down at harvest.

Nitrogen mineralization

NM stated that in comparison to herbicides treated plots there was a gradual increment noticed in unsprayed control plots from the date of sowing to active growth phase of crop (50 DAS) and then after a slight fall in mineralization rate was observed (Table 1). The soil treated with cyhalofop butyl found in a state of low NM rate at 15 DAS (63.46 kg) in comparison to 7 DAS (80.89 kg), followed by bispyribac sodium which applied with metamifop @ 140 g a.i ha^{-1}. Ghamry *et al*. (2000) also expressed similar view and reported that application of herbicides at 10 and 100 field rates significantly reduced the soil N-mineralization within first 5 days after treatment as compared to the control. The reason for the decrease in N-mineralization by chlorsulfuron may be related to the toxic effect of the herbicide as the effect of herbicides on soil fauna is either a direct toxic effect or through the influence on predator-prey interactions (Roper, 1995). Among different herbicides treatment metamifop 10% EC was found rather safe as it reduced the NM at a lower rate. Cyhalofop butyl reduced the NM value from 80.89 kg (7 DAS) to 63.46 kg (15 DAS) with a time span of 8 days. However, herbicides metamifop reduced the above value from 86.52 to 72.63 kg within the same duration. Wetting agent also showed significant impact on NM as it reduced the NM values significantly after its application at 15 DAS. At 30 DAS all the herbicides treatment have shown their effect on NM by reducing the NM value over control significantly. At 50 DAS all the herbicides treatment found at par with unsprayed control except cyhalofop butyl and bispyribac sodium + metamifop (140g a.i/ha^{-1}) which proved their presence in rhizosphere soil. Goring and Laskowski (1982) showed a range of effects of different pesticides on Nitrogen-mineralization, immobiloization, nitrification, dentrification and fixation. Nitrifying bacteria are most sensitive to herbicide application (Edward, 1989). Other herbicides were found in effective on NM at 50 DAS. At harvest stage all the treatments found at par with control. The nitrogen mineralization study showed that all the applied herbicides started to degrade at 30 DAS and completely degraded before 50 DAS except (bispyribac sodium + metamifop (@ 140g a.i.ha^{-1}) and cyhalofop which were degraded prior to harvest. This study elucidates that nitrogen mineralization process retarted due to herbicides application but due to detoxification of applied herbicides it became normal before harvest.

Soil pH and electrical conductivity

It was revealed from the pH study that the pH changed in some of the plots due to application of different herbicides (Table 2) but in most of the plots the concerned treatments did not impart any effect on soil pH. It is also apparent from the study that the changes in soil pH did not fluctuate significantly over control due to application of different herbicides. The treatments which impart their effect on soil pH are T1, T4, T5, T7, T8, T11, and T12 but we did not get any particular trend on changes on soil pH by herbicides. These findings are in close conformity with the results of Mishra (2010) and Borthkur (2011) who found pH of the hand weeded, herbicide applied and weedy check plots did not vary significantly from each other at different stages of crop growth. The study on the effect of different post emergence herbicides on the soil EC revealed that the treatment did not affect the soil EC after their application. In some treatments the EC reduce a little but it was negligible and found in significant in comparison to control. In unsprayed control plots the EC increased from 0.17 to 0.18 dsm^{-1} within the crop growth period. Hence, it can be concluded that the herbicides used in the experiments did not make any significant changes in soluble salt content in soil due to their application. Borthakur (2011) also found in his research work that there was a minute increase in water soluble salt content in soil within the crop growth period but the increment was non-consistent and non-significant over control in herbicides treated and non treated plots.

Yield study

Data of grain yield of rice at harvest are presented in (Table 2) revealed that grain yield of rice increased significantly due to use of herbicides over control. Grain yield recorded as highest (39.59 q ha^{-1}) due to application of bispyribac sodium and metamifop combination which applied @ 140 g a.i. ha^{-1}. The above yield was found significantly higher over all the herbicides treatment except. The treatment comprising the same herbicidal chemicals used a comparative lower dose *i.e.* 70 g a.i.ha^{-1}. Singh *et al.* (2014) and Gaurav *et al.* (2015) reported similar and significant effects of different combinations of herbicides on yield of rice and recommended use of herbicides in combination instead of single herbicide.

The lowest yield (6.9 q ha^{-1}) was recorded in plots sprayed with wetting agent (agrisol), followed by unsprayed control plot which yielded 7.8 q ha^{-1} grain yield. Among herbicide treated plots least yield was received due to application of cyhalofop butyl where only 21.0 q ha^{-1} yield was recorded. Looking to the above fact is conspicuous that cyhalofop was ineffective to control weeds and did not support to increase grain yield. In this comparative study, bispyribac sodium with metamifop @ 70. g a.i.ha^{-1} found best higher yield receive under this treatment followed by its lower dose of 56 g a.i.ha^{-1}.

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