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Changes in biochemical properties of rice rhizosphere as influenced by tillage and herbicide application

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ABSTRACT

A field study was conducted during 2009 at Raipur in an inceptisol with rainy season rice to evaluate the effect of herbicides application on biochemical characteristics of rhizosphere soil under different tillage systems. Four different types of tillage system were evaluated *viz*. (i) conventional-conventional (ii) conventional-zero (iii) zero-conventional and (iv) zero-zero. Among weed control measures, comparative effects of hand weeding and recommended herbicides application (butachlor as pre-emergence and fenoxaprop-p-ethyl + ethoxysulfuron as post-emergence herbicide 1.5 kg, 56.25 g and 15 g/ha, respectively) were tested compared with a weedy check (control). The conventional-conventional tillage system was found most effective to improve the biochemical characteristics of soil. Under this system, maximum organic C content was accumulated in rhizosphere soil and also found maximum enzyme activity (dehydrogenase activity, acidic phosphatase activity and alkaline phosphatase activity). Application of pre- and post- emergence herbicide reduced the biochemical activities in soil after its application (3 and 22 days after sowing, respectively) to 35 days of sowing of the crop thereafter it became normalize due to degradation of applied herbicides.

Key words: Dehydrogenase activity, Organic C, Phosphatase activity, Recommended herbicide, Tillage

In India, rice is cultivated in an area of about 44 million ha with a production of over 100 million tonnes. are one of the major constraints for increasing rice production. Hence, it is essential to eradicate weeds which are the main competitor for nutrients, sunlight, moisture and space. Besides, the weeds are also sink of different pests and disease causing organisms, and may also induce allelopathic effect. Different tillage practices have been shown to alter the chemical and microbiological properties of soils (Ferreira *et al*. 2000). Tillage systems alter the organic matter content in soil, which ultimately affects the microbial population and their activity.. Generally herbicides are not harmful when applied at recommended rates(Selvamani and Sankaran 1993) but some reports showed that herbicidal application may have adverse effect on bacterial (Rajendran and Lourduraj 1999) and fungal population (Shukla 1997). Nonetheless, some herbicides may even stimulate the growth and activities of microflora. In the present study, the microbiological parameters of rice rhizosphere under varying tillage and weed control practices were studied.

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MATERIALS AND METHODS

Rice-wheat cropping system was rotated for five continuous years (2005 -2009) in Instructional-cum-research farm of Indira Gandhi Agricultural University, Raipur, Chhattisgarh. In the fifth year, a study was conducted to find out the effect of different tillage systems vis-à-vis different weed control practices on enzymatic activity (dehydrogenase, acidic and alkaline phosphatase activity) and organic C content in rhizosphere soil. The soil was inceptisol with pH 6.78, EC 0.16 milimhos/cm, organic C 0.60%, available N 205.5 kg/ha, available P 14.8 kg/ha and available K 345.0 kg/ha. Four tillage systems in main plots, *viz.* conventional–conventional (CT-CT), conventional–zero (CT-ZT), zero–conventional (ZT-CT), and zero–zero (ZT-ZT); and weed control, *viz.* and weeding and recommended herbicideand weedy check in sub-plots were laid out in split plot design with 3 replications. For *Kharif* rice, butachlor was applied as pre-emergence and fenoxaprop-p-ethyl and ethoxysulfuron as post-emergence 1.5 kg, 56.25 g and 15.00 g/ha, respectively. Soil samples from rhizosphere were collected from 7.5-15.0 cm soil depth at 0, 7, 14, 21, 28, 35, 42, and 50 days after sowing and harvest. The samples were analyzed for organic C

and hydrogenase activity. Acid and alkaline phosphatase activity of collected soil samples was also determined.

RESULTS AND DISCUSSION

There was a little change in organic C content in rhizosphere soil during the crop growth stages. Significantly higher organic C was quantified in zero-zero over conventional-conventional tillage system at initial, 7, 14 and 21 DAS (Table 1). However, other three systems were found at par with each other Saffigna *et al.* (1989) reported that microbial biomass and soil organic matter was influenced by soil management practices.

There was slight inhibition of acid phosphatase activity (APA) from 0-7 DAS, followed by a continuous increase from 7-DAS. The activity of acid phosphatase enzyme again showed a declining trend from 50 DAS up to harvest. Maximum APA was found under conventional-conventional and minimum in zero-zero tillage system. The conventional - conventional and conventional- zero tillage systems significantly augmented APA over zero-zero tillage system, except at harvest when the differences were at par. There was a slight inhibition of alkaline phosphatase activity (AlPA) from 0-7 DAS, followed by a continuous increase up to 50 DAS and decline thereafter. Conventional- conventional and conventional-zero tillage systems significantly increased the AlPA in rhizosphere soil over zero-zero tillage at all the growth stages except 0, 50 DAS and at harvest (Table 3). There was an increase in dehydrogenase activity (DA) in rice rhizosphere soil from 0-50 DAS, followed by a decrease up to harvest in conventional-conventional and conventional-zero plots. The conventional-conventional and conventional-zero system significantly increased the DA over zero-zero system from 7-0 DAS. Maximum DA was measured in conventional-conventional system and minimum in zero-zero system.

At 50 DAS, maximum APA, AlPA and DA were recorded, which might be due to maximum rhizosphere effect of the root system which augmented the native microflora of the root system.

Organic C in hand-weeded, herbicide-applied and

Table 1. Effect of tillage practices and weed control measures on organic C (%) of rhizosphere soil of rice

Treatment	Days after sowing								
	0	7	14	21	28	35	42	50	At harvest
Tillage									
CT-CT	0.59	0.59	0.59	0.59	0.59	0.60	0.61	0.63	0.65
CT-ZT	0.60	0.59	0.59	0.60	0.60	0.60	0.61	0.62	0.64
ZT-ZT	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.62	0.62
ZT-Ct	0.60	0.60	0.60	0.60	0.60	0.60	0.61	0.62	0.62
LSD (P=0.05)	0.01	0.01	0.01	0.01	NS	NS	NS	NS	NS
Weed management									
Hand weeding	0.60	0.60	0.60	0.60	0.60	0.60	0.61	0.62	0.63
Herbicide	0.59	0.59	0.59	0.59	0.59	0.59	0.60	0.61	0.61
Weedy check	0.61	0.61	0.61	0.61	0.60	0.62	0.63	0.64	0.66
LSD (P=0.05)	NS	NS	NS	NS	NS	0.02	0.03	0.02	0.01

Table 2. Effect of tillage and weed control practices on enzume activities of rhizosphere soil of rice

Treatment	Days after sowing								
	0	7	14	21	28	35	42	50	At harvest
Tillage									
CT-CR	104.8	101.6	107.7	117.6	126.7	137.3	156.6	229.3	133.8
CT-ZT	101.6	98.1	101.4	109.8	116.9	125.0	151.4	229.4	132.8
ZT-ZT	94.0	86.8	88.6	95.8	102.2	108.3	138.2	206.5	130.6
ZT-CT	100.1	96.5	99.3	107.1	114.3	119.7	144.1	210.3	131.6
LSD (P=0.05)	5.2	9.5	9.0	9.2	12.3	11.5	12.8	20.3	NS
Weed management									
Hand weeding	99.0	100.03	112.7	132.4	147.3	161.3	184.9	217.6	130.7
Herbicide	98.7	82.03	69.7	54.7	45.7	39.8	63.6	207.4	131.9
Weedy check	102.7	103.05	115.3	135.6	152.1	167.8	193.3	231.7	134.0
LSD (P=0.05)	NS	9.8	8.5	2.0	11.5	12.4	13.7	21.4	NS

Table 3. Effect of tillage practices and weed control measures on alkaline phosphatase activity (mg *p*-NP/h/g soil) status of rhizosphere soil of rice

Treatment	Days after sowing								
	0	7	14	21	28	35	42	50	At Harvest
Tillage									
CT-CT	88.9	88.1	92.8	101.7	106.3	117.4	142.1	199.7	110.6
CT-ZT	86.2	79.9	84.6	91.8	95.6	105.3	134.3	192.5	109.2
ZT-ZT	83.4	68.7	71.7	76.3	79.8	86.0	116.9	183.6	106.3
ZT-CT	84.7	76.5	77.9	83.8	87.6	95.7	125.5	181.9	107.8
LSD (P=0.05)	NS	7.1	7.8	8.4	8.2	11.0	11.9	NS	NS
Weed management									
Hand weeding	83.7	81.7	91.6	103.1	111.5	127.2	160.7	187.9	106.2
Herbicide	85.8	68.4	58.4	53.6	47.1	40.7	60.2	183.2	108.2
Weedy check	88.0	84.9	95.3	108.5	118.3	135.5	168.3	197.1	111.1
LSD (P=0.05)	NS	7.8	7.9	2.2	7.9	11.8	12.7	NS	NS

Table 4. Effect of tillage practices and weed control measures on dehydrogenase activity (mg TPF/h/g soil) status of rhizosphere soil of rice

Treatment	Days after sowing								
	0	7	14	21	28	35	42	50	At harvest
Tillage									
CT-CT	26.5	31.3	33.7	36.6	39.6	42.6	51.8	87.7	37.7
CT-ZT	25.2	28.7	30.8	32.7	35.0	37.6	46.1	82.3	35.5
ZT-ZT	23.4	21.7	23.1	23.9	27.9	28.9	36.2	70.6	31.1
ZT-CT	24.8	23.1	25.3	26.5	30.7	32.0	41.4	73.4	33.4
LSD (P=0.05)	NS	2.9	2.7	2.8	3.4	3.1	5.2	7.5	NS
Weed management									
Hand weeding	23.7	27.9	33.1	36.8	42.7	46.9	53.2	79.1	33.6
Herbicide	24.8	17.5	12.6	9.1	7.6	4.5	18.3	74.2	33.7
Weedy check	26.4	33.2	39.1	44.2	49.5	54.8	60.1	82.1	36.1
LSD (P=0.05)	NS	1.3	3.2	1.4	3.6	3.5	4.6	7.8	2.0

weedy check did not vary significantly up to 28 DAS. However from 35 DAS to harvest, significantly higher organic C was recorded in weedy check in comparison to herbicide-treated plots (Table 1). At harvest, significant quantity of organic matter accumulated in weedy check and hand-weeded conditions over herbicide application. This might be due to higher crop-weed density these treatments in comparison to herbicide-treated plots.

Recommended herbicide application decreased the acid phosphatase activity from initial stage (98.7) to 35 DAS (39.8), but thereafter the APA recovered and increased up to 50 DAS (207.4 mg *p*-NP/h/g soil). The APA was found significantly higher in hand-weeded and weedy check plots over herbicide-treated plots, excluding initial and harvest stage of the crop. These observations are in close agreement with Shukla and Mishra (1997). Recommended herbicide application inhibited the alkaline phosphatase activity from 0-35 DAS, followed by an increment up to 50 DAS. In rhizospere of hand-weeded and weedy check plots, the AlPA increased from 0-50 DAS, followed by decreased up to harvest. The hand weeding and weedy check conditions significantly increased AlPA in soil over recommended herbicide application except 0, 50 DAS and at harvest (Table 3). In recommended herbicide treated plots, the dehydrogenase activity decreased from 0-35 DAS (4.5), then recovered and reached its highest value at 50 DAS. There was an increase in DA under hand-weeded and weedy check plots from 0-50 DAS, followed by a decrease up to harvest. The DA was found significantly higher in hand-weeded and weedy check plots over herbicides-treated plot except at 0, 50 DAS and harvest.

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