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Effect of herbicides and fungicides application on fibre yield and nutrient uptake by jute (*Corchorus olitorius*), residual nutrient status and soil quality

B MAJUMDAR[1], A R SAHA[2], S SARKAR[3], B MAJI[4] and B S MAHAPATRA[5]

Central Research Institute for Jute and Allied Fibres, Barrackpore, Kolkata, West Bengal 700 120

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ABSTRACT

A field experiment was conducted during 2005–08 on a Aangetic alluvium soil to find out the effect of 2 pre-emergence (trifluralin and fluchloralin), 1 post-emergence herbicide (quizalofop ethyl) and 3 fungicides (carbendazim, mancozeb and copper oxychloride) applied on jute (*Chorchorus olitorius* L.) for fibre yield, nutrient uptake, residual nutrient status and soil quality parameters. Treatments having 2 hand weeding and hand weeding in combination with fungicides, and trifluralin @ 0.75 kg a i/ha recorded significantly higher fibre yield (74.7–78.9%) over the control and other herbicides but were at par among themselves. The nitrogen and phosphorus uptake by jute (3 years pooled data) follows the same trend as that of fibre yield, while fungicides along with hand weeding recorded significantly higher K and Zn uptake over the herbicides, hand weeding and the control. The residual nutrient status of soil after 3 years of cultivation increased in all treatments as compared to initial status, while hand weeding and trifluralin @ 0.75 kg a i/ha recorded substantially higher values of nutrients over other herbicides and fungicides. The enzyme activities (dehydrogenase, urease, fluorescein diacetate hydrolyzing activity and acid and alkaline phosphatase) in soil reduced significantly after 7 days of herbicide and fungicide application, while treatments having unweeded control and hand weeding maintained the same status as compared to initial status. The microbial biomass carbon and basic soil respiration rate of the soil follow the same trend as that of enzyme activities during 3rd year. The enzyme activities, microbial biomass carbon and basic soil respiration rate content in herbicides and fungicides treated plots started recovering after 15 days of their application and recovered almost to the extent of respective initial level at harvest. Among the herbicides and fungicides, trifluralin 0.75 kg a i/ha was the safest regarding soil quality next to hand weeding with higher fibre yield and residual nutrient availability.

Key words: Fungicides, Herbicides, Jute, Nutrient status, Soil quality

In India, jute (*Chorchorus olitorius* L.) is grown in the eastern region comprising West Bengal, Bihar, Orissa, Assam, Tripura, Meghalaya and some part of Uttar Pradesh covering an area of little over 0.8 million ha, producing nearly 10 million bales (1 bale = 180 kg) of fibre, which is about 40% of the world production. The use of herbicides for combating weeds and fungicides as seed treatment and spray to protect the crop from seed-borne and the other fungal diseases has become an integral and economically essential part of jute-based cropping system. There are reports of beneficial and adverse effect of herbicides and fungicides on growth and activities of beneficial microorganisms in soil (Das and Debnath 2006, Jastrzebska and Kucharski 2007, Sukul 2006). Microbial biomass being an important attribute of soil quality (Doran and Parkin 1994) is also a potential source of enzymes in soil and acts as a sink/source of plant nutrients. Analysis of soil enzymatic activity is one of the microbiological indicators of soil quality (Winding *et al*. 2005). Among the different enzymes in soil, dehydrogenase, urease, phosphatases and fluorescein diacetate hydrolyzing activity (FDHA) are more important in the transformation of various plant nutrients in the soil. Basal soil respiration rate is the most important tool for assessment of side effects of chemicals such as heavy metals, pesticides etc. (Alef 1995a). On the other hand, the FDHA is considered as a suitable tool for measuring the early detrimental effect of pesticides on soil microbial biomass, as it is a sensitive and non-specific test able to depict the hydrolytic activities of soil microbes (Dumontet *et al*. 1997).

However, little is known about the impacts of various agro-chemicals on microbial communities, enzyme activities and nutrient availability in jute-growing soils of India. The present study deals with the influence of few pre-and post-emergence herbicides and fungicides on fibre yield, nutrient

[1,2,3]Senior Scientist (e mail: bmajumdar@crijaf.org.in, amitsaha60@yahoo.co.in, sarkaragro@gmail.com), [4]Principal Scientist and Head (e mail: b_maji57@rediffmail.com), Division of Crop Production, Director (e mail: crijaf-wb@nic.in)

uptake by jute and residual effect after application of these chemicals continuously for 3 years on nutrient availability, enzyme activities, microbial biomass and basal soil respiration rate in the soil.

MATERIALS AND METHODS

A field experiment was conducted for 3 consecutive years during 2005–08 at the same site in the farm of the Institute, Barrackpore, West Bengal with 3 replications following randomized block design. The experimental soil belongs to Typic Ustochrept with sandy loam texture having the general characteristics: *p*H (1: 2.5 w/v) in water 7.20, organic carbon 5.50 g/kg, available N 335, P 30, K 155 kg/ha and available Fe, Mn, Zn and Cu 13.5, 10.5, 0.70 and 2.50 ppm, respectively. Two pre-emergence herbicides of di-nitro aniline group (trifluralin and fluchloralin) were applied as spray one day before sowing and mixed thoroughly as per treatment schedule. In fungicidal treatments, seeds were treated with 3 fungicides, namely carbendazim (bavistin) @ 2 g/kg of seeds, mancozeb (dithane M-45) and copper oxychloride (blitox) @ 5 g/kg of seed before sowing and then sowing was done. 'JRO 524' *Olitorius* jute was sown @ 5 kg/ha with a row-to-row 25 cm and plant-to-plant 5 cm spacing during second week of April in each year. A fertilizer dose of 30 kg/ha each of P and K as single superphosphate and muriate of potash was applied and mixed thoroughly with soil during land preparation. Post-emergence herbicide quizalofop ethyl was applied 21 days after emergence of the crop. The treatments were as follows: $T_{1,}$ control without hand weeding; T_2, 2 hand weeding; $T_{3,}$ trifluralin (pre-emergence) @ 0.75 kg a i/ha at 1 day before sowing; $T_{4,}$ trifluralin @ 1.5 kg a i/ha at 1 day before sowing; $T_{5,}$ fluchloralin (pre-emergence) @ 0.75 kg a i/ha at 1 day before sowing; $T_{6,}$ fluchloralin @ 1.5 kg a i/ha at 1 day before sowing; $T_{7,}$ quizalofop ethyl (post-emergence) @ 50 g a i/ha at 21 days after emergence; $T_{8,}$ quizalofop ethyl @ 100 g a i/ha at 21 days after emergence; T_9, carbendazim (Bavistin) as seed treatment + 2 hand weeding; $T_{10,}$ mancozeb (Dithane-M-45) as seed treatment + 2 hand weeding; $T_{11,}$ copper oxychloride (Blitox) as seed treatment + 2 hand weeding. Sixty kg/ha of N as urea was applied as top-dressing in 2 splits at 21 and 35 days after emergence of the crop. The crop was cultivated following normal cultural practices. Surface (0–15 cm) soil samples were collected periodically after 7, 15 and 30 days of application of respective herbicides and fungicides and at harvest. The crop was harvested after 120 days of sowing the crop. Plant samples (leaf, bark and wood) collected at the time of harvest were dried, processed and analyzed for total N, P, K and Zn following standard procedures (Tandon 1993). The chemical analysis of pre and post harvest soil for organic C, available N, P, K, Fe, Mn, Zn and Cu was done following the standard procedure (Page *et al*. 1982). The enzyme activities (dehydrogenase, urease and acid and alkaline phosphatase) of periodically collected soil samples were measured according to Tabatabai (1994). The FDHA was measured by the method of Alef (1995b). The microbial biomass carbon of soil samples was determined by the fumigation extraction method (Joergensen 1995) using a correction factor (Kec) of 0.38 according to Vance *et al.* (1987). The basal soil respiration rate was estimated according to the method given by Alef (1995a). The statistical analysis of the experimental data was carried out by using SPSS package (version 10.0).

RESULTS AND DISCUSSION

Fibre yield of jute

The 3 years pooled data on fibre yield (Table 1) showed that 2 hand weeding (T_2) alone and in combination with fungicides (T_9, T_{10} and T_{11}) and pre-emergence herbicide trifluralin @ 0.75 kg a i/ha (T_3) had registered significantly higher fibre yield over the control, fluchloralin, quizalofop ethyl and trifluralin@ 1.50 kg a i/ha. These treatments (T_2, T_3, T_9, T_{10} and T_{11}) were at par among themselves. The data indicates that 2 hand weeding is better means of weed control

Table 1 Effect of herbicides and fungicides on fibre yield and nutrient uptake (3 years pooled data) by jute

Treatment	Fibre yield (tonnes/ha)	Nutrient uptake (kg/ha)			
		N	P	K	Zn
T_1 Control	1.90	73.0	20.7	130.3	0.12
T_2 Two hand weeding	3.32	118.0	37.0	182.0	0.25
T_3 Trifluralin @ 0.75 kg a i/ha	3.33	119.8	36.9	180.3	0.27
T_4 Trifluralin @ 1.50 kg a i/ha	3.02	114.5	34.5	177.3	0.24
T_5 Fluchloralin @ 0.75 kg a i/ha	3.08	103.5	31.1	173.7	0.21
T_6 Fluchloralin @ 1.50 kg a i/ha	3.00	111.1	32.7	177.9	0.21
T_7 Quizalofop ethyl @ 50 g a i/ha	2.97	105.5	32.6	168.7	0.21
T_8 Quizalofop ethyl @ 100 g a i/ha	3.01	109.9	33.7	175.2	0.22
T_9 Carbendazim (Bavistin) as seed treatment + 2 hand weeding	3.35	118.8	38.6	184.0	0.30
T_{10} Mancozeb (Dithane-M-45) as seed treatment + 2 hand weeding	3.39	118.8	38.7	184.6	0.29
T_{11} Copper oxychloride (Blitox) as seed treatment + 2 hand weeding	3.40	119.6	37.5	182.5	0.32
CD (P= 0.05)	0.19	3.40	2.40	2.00	0.04

than pre- and post-emergence herbicides under study except trifluralin @ 0.75 kg a i/ha, and in producing fibre yield of jute. The same was also reported by Sarkar (2003), Barui (2006) and Majumdar *et al*. (2008). Two hand weeding (T_2) recorded 74.7% higher yield over the control (T_1), where no weeding, herbicides and fungicides were applied. The excessive weed population and their competition with the jute crops for plant nutrients might have reduced the fibre yield of jute in control plots which was confirmatory with the findings of Sarkar (2003). Among the herbicides, trifluralin @ 0.75 kg a i/ha had recorded significantly higher yield (8.1 to 12.1 5% higher) over the other pre (fluchloralin) and post-emergence (quizalofop ethyl) herbicides under study. Trifluralin @ 0.75 kg a i/ha was also superior over its higher dose, i e 1.5 kg a i/ha in achieving higher fibre yield. The weed control efficiency of trifluralin in jute crop with higher fibre yield was also reported by Sarkar *et al.* (2006). On the other hand, there was no significant difference among the fungicides in combination with hand weeding on fibre yield and the maximum fibre yield of jute (3.4 tonnes/ha) was recorded with T_{11}.

Nutrient uptake by jute

The nitrogen, phosphorus, potassium and zinc uptake by jute (3 years pooled data) crop increased significantly by 44.5 to 64.1%, 50.2 to 86.9%, 29.5 to 41.2% and 75 to 166.7% respectively over un-weeded control with hand weeding, herbicides and fungicides application in combination with hand weeding (Table 1). The lowest nutrient uptake in un-weeded control plot (T_1) is mainly because of lower absorption of nutrients by the crop as there was very high competition for the nutrients by weed flora present in the plot. The nitrogen and phosphorus uptake by jute follows the same trend as that of fibre yield. Two hand weeding alone (T_2) and in combination with fungicides (T_9, T_{10} and T_{11}) and trifluralin @ 0.75 kg a i/ha were at par among themselves but significantly higher over control, fluchloralin and quizalofop ethyl for N and P uptake. All the fungicides in combination with hand weeding registered significantly higher potash and zinc uptake over all the herbicides, only hand weeding and control. Among the herbicides, trifluralin @ 0.75 kg a i/ha recorded significantly higher N (119.8 kg/ha), P (36.9 kg/ha), K (180.3 kg/ha) and Zn (0.27 kg/ha) uptake over the fluchloralin and quizalofop ethyl. Higher dose of fluchloralin (pre-emergence herbicide) and quizalofop ethyl (post-emergence herbicide) recorded significantly higher N and K uptake and non-significantly higher P uptake over their respective lower doses.

Residual soil fertility status

The residual soil fertility status of soil after 3 years of jute cultivation improved substantially with various treatments including herbicides/fungicides compared to initial status (Table 2) of soil. In general, 2 hand weeding (T_2) and trifluralin @ 0.75 kg a i/ha (T_3) recorded comparatively higher values of organic C and available nutrients compared to other treatments under study. The organic carbon content of soil was comparatively higher with control (6.5 g/kg) and only hand-weeded plots (6.5 g/kg) over other treatments and significantly higher over T_4, T_7 and T_{11}.

The maximum available N content (346 kg/ha) was recorded with 2 hand weeding (T_2) which was at par with control, trifluralin @ 0.75 kg a i/ha, fluchloralin and fungicide treatments but significantly higher over T_4, T_7 and T_8. Trifluralin @ 0.75 kg a i/ha (T_3) recorded significantly higher (14.3 to 31.1%) available P (40 kg/ha) over all the treatments except control (37 kg/ha) and 2 hand weeding (38.5 kg/ha).

Table 2 Effect of herbicides and fungicides on soil fertility status after 3 years of jute cultivation

Treatment	Organic C (g/kg)	Available nutrient						
		N	P (kg/ha)	K	Fe	Mn (ppm)	Zn	Cu
T_1	6.5	345.0	37.0	171.0	15.8	10.8	0.87	2.87
T_2	6.5	346.0	38.5	173.0	14.9	11.6	0.98	2.91
T_3	6.3	343.7	40.0	165.0	16.3	14.7	0.86	3.14
T_4	6.0	340.0	35.0	157.6	14.9	11.0	0.83	3.00
T_5	6.1	341.0	31.8	166.0	15.1	13.7	0.91	2.87
T_6	6.4	339.5	30.5	158.0	14.8	12.2	0.78	2.81
T_7	6.0	338.0	34.7	162.5	15.0	12.5	0.89	2.96
T_8	6.3	335.0	31.0	158.5	13.7	10.8	0.79	2.94
T_9	6.4	342.0	30.5	162.5	14.7	12.2	0.72	2.93
T_{10}	6.3	343.5	32.0	163.2	14.6	10.7	0.74	2.92
T_{11}	5.6	341.5	33.5	166.0	14.8	11.3	0.76	2.90
CD (P= 0.05)	0.43	5.90	3.80	5.20	0.90	0.70	0.06	0.07
Initial status	5.5	335.0	30.0	155.0	13.5	10.5	0.70	2.50

Details of treatment are given under Table 1

It was revealed that application of herbicides, like trifluralin and fluchloralin increased the available N and P status in soil which might be due to greater mineralization of organic nitrogen as well as higher solubilization of insoluble phosphates resulting into the higher available N and P content in soil. Higher available N and P because of higher microbial activities in paddy soils treated with herbicides like oxyfluorfen, fluchloralin, oxadiazon and butachlor was also reported by Das *et al*. (2003) and Das and Debnath (2006). Two hand weeding (T_2) registered highest available K content (173 kg/ha) which was at par with control (171 kg/ha) but significantly higher by 4.2 to 9.8% over the other treatments.

In case of micronutrients, the maximum build up was recorded with trifluralin @ 0.75 kg a i/ha. The maximum available Fe content (16.3 ppm) was recorded with T_3 which was at par with control (15.8 ppm) but significantly higher by 7.9 to 19% over all other treatments under study. Trifluralin @ 0.75 kg a i/ha also recorded highest values of available Mn (14.7 ppm) and Cu (3.14 ppm) in soil which were significantly higher by 7.3 to 37.4 and 4.7 to 11.7% respectively over all other treatments under study. The available Zn status under only hand weeding (T_2) was maximum (0.98 ppm) which was significantly higher by 7.7 to 36.1% over all other treatments.

Changes in enzyme activities

Dehydrogenase activity: Dehydrogenase activity is a measure of the intensity of microbial metabolism in soil and thus the microbial activity in soil. The dehydrogenase activity in the soil reduced by 78.5 to 86.9 and 84.6 to 86% after 7 days of their respective application (Table 3). In case of herbicides, higher reduction in dehydrogenase activity was found with fluchloralin, followed by trifluralin and quizalofop ethyl. The reduction was more with higher doses of all herbicides. The reduction in dehydrogenase activity with herbicide and fungicide application was also reported by Demenaou *et al*. (2004), Sukul (2006) and Makoi and Ndakidemi (2008). A sharp recovery in dehydrogenase activity was noticed in fungicides and herbicides treated plots after 15 days onwards and at harvest it recovered by 81.5 to 89.2 and 85.4 to 87.7% of initial status, respectively under herbicides and fungicides treated plots. In contrast, the dehydrogenase activity in control and hand-weeded plots was significantly higher over all other treatments during all the stages of sampling, indicating the higher microbial activity in these plots.

Urease activity: Urease enzyme is responsible for the hydrolysis of urea into NH_3 and CO_2, hence, urease activity has a vital role in the regulation of N supply to plant system after urea fertilization. There was a drastic reduction in urease activity initially after 7 days by 43.6 to 56.5 and 49.2 to 51.4% with respective herbicides and fungicides application (Table 3). The reduction in urease activity with fungicides and herbicides application was also reported by Yu *et al.* (2006) and Jastrzebska and Kucharski (2007). The same was started recovering gradually after 15 days onwards and at harvest it recovered by 89 to 98.5 and 89.7 to 91.5% of initial status in herbicides and fungicides-treated plots, respectively. Among the herbicides, the higher recovery was found with quizalofop ethyl, followed by trifluralin and fluchloralin and the recovery was more in lower doses compared to higher doses of these herbicides. The urease activity was significantly higher in control and only-hand weeded plots throughout the jute-growing season over all other treatments.

Fluorescein diacetate hydrolyzing activity: The fluorescein diacetate hydrolyzing activity in the soil was significantly higher in control and hand-weeded plots compared to herbicides and fungicides treated plots in every stage of soil sampling (Table 3). Application of herbicides and fungicides resulted in the reduction of fluorescein diacetate hydrolyzing activity by 39.6 to 50.9 and 38.7 to 40% respectively after 7 days of their application from initial status. In case of herbicides, the reduction was more with their higher doses compared to lower doses with all the herbicides and the maximum reduction was found in trifluralin, followed by fluchloralin and post-emergence herbicide quizalofop ethyl. The initial reduction in fluorescein diacetate hydrolyzing activity with herbicides and fungicides was temporary and after 15 days onwards it started recovering. At harvest it recovered by 95 to 99.3% of initial status in herbicides and fungicides-treated plots.

Acid and alkaline phosphatase activity: Acid and alkaline phosphatases play a critical role in P-cycle of soil ecosystem and hence, apart from being good indicators of soil fertility, they play key roles in soil system (Makoi and Ndakidemi 2008). Application of herbicides and fungicides had only marginal effect on acid and alkaline phosphatase activity which was reduced by 16.7 to 27.7 and 12.7 to 22.1% respectively of initial status after 7 days of their application (Table 3). The acid and alkaline phosphatase activities were recovered at harvest by 85.5 to 94.6 and 86.3 to 94.8% respectively of initial status after starting recovering from 15 days onwards. The reduction in acid and alkaline phosphatases activity with herbicides and fungicides application was also reported by Sukul (2006), Yu *et al.* (2006) and Jastrzebska and Kucharski (2007). The unweeded control and hand-weeded plots which did not receive any herbicides/fungicides recorded significantly higher acid and alkaline phosphatase activity over all the treatments in all stages of their estimation.

Changes in microbial biomass carbon: There was a significant decrease in microbial biomass carbon content (ranged between 115 and 160 mg/kg) with herbicides and fungicides application initially after 7 days of their respective application in contrast to initial status (287 mg/kg) for 0 day, whereas in untreated soil i e control and only hand-weeded plots, there was slight increase in microbial biomass carbon content (Table 4). A sharp rise in microbial biomass carbon,

Table 3 Changes in enzymatic activities of jute soil during third year of herbicides and fungicides application

Treatment	Dehydrogenase (mg triphenyl formazan/ kg oven dry soil/hr)				Urease (mg urea hydrolyzed/ kg oven dry soil /hr)				FDHA (mg fluorescein/kg oven dry soil/ hr)				Acid phosphatase (mg para nitrophenol/ kg oven dry Soil/ hr)				Alkaline phosphatase (mg para nitrophenol / kg oven dry soil /hr)			
	1*	2*	3*	4*	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
T_1	6.50	6.60	6.60	6.65	332.0	337.5	340.8	342.8	105.2	106.2	110.5	115.6	247.5	248.5	249.0	250.5	250.5	251.0	252.5	254.0
T_2	6.55	6.60	6.65	6.75	328.0	332.0	345.0	349.7	104.0	106.3	115.0	119.5	246.8	247.8	248.5	250.0	251.0	252.0	253.5	254.5
T_3	1.40	3.20	5.40	5.70	169.1	225.0	255.5	325.7	60.5	80.5	95.1	104.0	208.0	215.5	225.7	234.0	218.5	225.0	230.8	236.0
T_4	1.00	2.65	5.00	5.45	145.6	215.7	238.5	310.5	54.4	72.0	90.8	102.0	190.5	197.0	203.4	213.5	208.0	215.0	223.0	230.5
T_5	1.30	3.00	5.25	5.60	172.5	220.6	250.0	319.6	62.0	81.4	92.8	105.3	202.5	208.5	216.8	225.0	215.0	223.0	228.5	233.5
T_6	0.85	2.50	4.85	5.30	154.8	211.4	230.0	298.3	52.0	68.5	85.9	100.7	197.2	205.0	213.0	215.5	195.0	201.4	210.5	216.0
T_7	1.60	3.40	5.30	5.80	189.0	230.8	265.0	330.0	64.0	83.0	91.4	105.2	196.5	207.5	218.0	230.7	217.0	224.5	231.2	237.5
T_8	1.20	2.70	5.20	5.50	175.4	220.5	248.0	325.5	58.0	70.5	88.6	101.7	178.8	188.5	200.0	211.5	206.0	212.5	218.5	227.5
T_9	0.90	3.00	5.10	5.60	170.0	209.5	241.6	306.4	65.0	85.5	95.7	102.8	193.5	201.4	212.0	228.5	212.0	218.0	225.0	231.5
T_{10}	0.95	2.90	5.15	5.55	165.5	206.5	242.9	300.7	63.5	83.5	92.7	103.1	197.0	205.5	215.0	230.0	210.5	216.6	223.0	232.0
T_{11}	1.00	3.10	5.25	5.70	162.8	210.0	239.1	305.8	65.0	84.0	97.1	101.1	195.5	206.5	217.0	232.5	213.5	220.5	2282.0	236.5
CD (P=0.05)	0.86	0.88	0.73	0.57	9.13	7.85	9.25	8.20	7.40	5.90	6.80	7.20	5.35	4.70	4.60	4.50	3.80	3.50	3.60	3.10
Initial status	6.5				335				106				247.3				250.4			

1* - After 7 days, 2* - after 15 days, 3* - after 30 days, 4* - at harvest

however, was observed after 15 days (ranged between 175 and 220 mg/kg) onwards in herbicides and fungicides-treated plots. The microbial biomass carbon content under herbicides and fungicides-treated plots recovered by 87.8 to 95.8% of initial status and ranged between 252 and 275 mg/kg at harvest. The initial detrimental effect of herbicides and fungicides on microbial biomass carbon could be because of reduction in the total microbial population which is also confirmed from the decrease in bacterial population after 7 days from 122×10^5 to $54–62.5\times10^5$/g of oven dry soil, fungal population from 116×10^3 to $54.5–60\times10^3$/g of oven dry soil and actinomycetes population from 98×10^5 to $42.5–50\times10^5$/g of oven dry soil with herbicides and fungicides application. However, after a period of 15 days, a recovery in microbial biomass carbon is observed which may be due to the adaptability of the microorganisms in utilizing these herbicides/fungicides as a source of carbon, resulting in increasing microbial population. The initial decrease and recovery with time in microbial biomass carbon with herbicide and fungicide application was also reported by Vischetti *et al.* (2002) and Sukul (2006). The control and hand-weeded plots, however, maintained higher microbial biomass carbon content throughout the study period.

Changes in basal soil respiration rate: The basal soil respiration rate is generally used to determine the metabolic activity of soil microbes as well as to assess the side effect of pesticides on them. The basal soil respiration rate of the soil almost follows the same trend as that of microbial biomass carbon. The basal soil respiration rate content of the soil reduced by 57.9 to 84.2% from the initial status (0.95 mg CO_2/kg oven dry soil) in herbicides and fungicides-treated plots after 7 days of their respective application, although it remained static in control and hand-weeded plots (Table 4). Thereafter, a sharp increase in basal soil respiration rate content was recorded in the herbicides and fungicides-treated plots after 15 days which continued till harvest, and at harvest it recovered (ranged between 0.65 and 1.10 mg CO_2/kg oven dry soil) to the extent of initial status. The initial decrease and recovery after 15 days onwards in basal soil respiration rate is mainly due to changes in microbial population with herbicides and fungicides application.

This can be inferred from the above study that, application of herbicides and fungicides had temporary detrimental effect on enzyme activities and other microbial properties of jute soil, which were replenished at the time of harvest of the crop. Although, hand-weeded plots maintained better microbial properties, but as the cost involvement is more under hand weeding, it can be substituted by pre-emergence herbicide trifluralin @ 0.75 kg a i/ha without affecting fibre yield and soil quality much but with less cost involvement and higher residual nutrient build-up in the soil.

REFERENCES

Alef K. 1995a. Estimation of soil respiration. *Methods in Applied*

Table 4 Effect of herbicides and fungicides application on microbial biomass carbon and basic soil respiration rate in jute soil during third year

Treatment	Microbial biomass carbon (mg /kg oven dry soil)				Basic soil respiration rate (mg CO_2/kg oven dry soil/hr)			
	1*	2*	3*	4*	1*	2*	3*	4*
T_1	290	292	294	295	1.00	1.00	1.10	1.20
T_2	290	293	296	298	1.00	1.00	1.20	1.30
T_3	149	206	242	265	0.35	0.60	0.80	0.90
T_4	130	185	212	255	0.20	0.40	0.65	0.80
T_5	140	175	230	260	0.30	0.50	0.75	0.92
T_6	115	163	215	252	0.15	0.35	0.50	0.65
T_7	155	215	245	270	0.40	0.75	0.90	1.10
T_8	135	190	220	260	0.20	0.65	0.80	0.90
T_9	160	220	250	275	0.20	0.60	0.85	1.00
T_{10}	155	212	240	270	0.25	0.50	0.75	0.90
T_{11}	150	205	238	268	0.25	0.60	0.85	0.95
CD (P=0.05)	9.4	7.9	7.5	7.4	0.19	0.15	0.17	0.25
Initial status		287				0.95		

1*, After 7 days; 2*, after 15 days; 3*, after 30 days; 4*, at harvest

Soil Microbiology and Biochemistry, Alef K and Nannipieri P (Eds). Academic Press, London **10**: 215–6.

Alef K. 1995b. Estimation of FDHA. *Methods in Applied Soil Microbiology and Biochemistry*, pp 232–3. Alef K and Nannipieri P (Eds). Academic Press, London, pp.

Barui K, Khuntia A, Ghosh S K, Ghosh P and Mondal D. 2006. Bio-efficacy of some new herbicides for eco-safe weed management in wheat (*Triticum aestivum* L.). *Journal of Crop and Weed* **2**: 9–12.

Das A C and Debnath A. 2006. Effect of systemic herbicides on N_2–fixing and phosphate solubilizing microorganisms in relation to availability of nitrogen and phosphorus in paddy soils of West Bengal. *Chemosphere* **65**: 1082–6.

Das A C, Debnath A and Mukherjee D. 2003. Effect of herbicides oxadiazon and oxyfluorfen on phosphates solubilizing microorganisms and their persistence in rice fields. *Chemosphere* **53**: 217–21.

Demenaou J, Monkiedje A, Nin T, Foto S M, Nola M and Kemka N. 2004. Changes in soil chemical properties and microbial activity response to the fungicide Ridomil Gold plus copper. *International Journal of Environment Research and Public Health* **1**: 26–34.

Doran J W and Parkin J B. 1994. Defining and assessing soil quality. (*in*) *Defining Soil Quality for Sustainable Environment*, pp 3–21. Special Pub. **35**. Doran J W, Coleman D C, Bezdicek D F and Stewart B A. (Eds). Soil Science Society of America Proceedings Inc. Madison, WI.

Dumontet S, Perucci, P and Bufo A S. 1997. Soil organic amendments and herbicidal treatments: Effects on soil microbial biomass. (*in*) *27th Group Congress on Pesticides of France*, pp 211. Orleans, France.

Jastrzebska E and Kucharski J. 2007. Dehydrogenases, urease and phosphatases activities of soil contaminated with fungicides. *Plant Soil Environment* **53**: 51–7.

Joergensen R G. 1995. Microbial biomass. (*in*) *Methods in Applied Microbiology and Biochemistry*, pp 382–6. Alef K and Nannipieri P (Eds). Academic Press, London.

Majumdar B, Sarkar S, Saha A R, Maitra D N and Maji B. 2008. Effect of herbicides and fungicides applied to jute (*Corchorus olitorius*L.) on fibre yield and nutrient uptake by jute and change in microbial dynamics of soil. *Environment & Ecology* **26 (4)** : 1613–8.

Makoi J H R J and Ndakidemi P A. 2008. Selected soil enzymes: Examples of their potential roles in the ecosystem. *African Journal of Biotechnology* **7**: 181–91.

Page A L, Miller R H and Keeney D R. 1982. *Methods of Soil Analysis*, Part II. *American Society of Agronomy Inc. and Soil Science Society of America Inc*, Madison, Wisconsin, the USA.

Sarkar S. 2003. 'Chemical and mechanical methods of weed management in two species of jute.' Ph D thesis, BCKV, Mohanpur, West Bengal.

Sarkar S, Bhattacharjee A K and Mitra S. 2006. *Annual Report* (2005–2006). Central Research Institute for Jute and Allied Fibres, Barrackpore, Kolkata.

Sukul P. 2006. Enzymatic activities and microbial biomass in soil as influenced by metalaxyl residues. *Soil Biology and Biochemistry* **38**: 320–6.

Tabatabai M A. 1994. Soil enzymes. Part 2: Microbial and Biochemical Properties. Weaver R W, Angel J S and Bottomley P S. (Eds), (*in*) *Methods of Soil Analysis*, pp 198–250. Soil Science Society America, Madison, WI, USA.

Tandon H L S. 1993. Methods of analysis of soils, plants, water and fertilizers. Fertilizer Development and Consultancy Organization, New Delhi.

Vance E D, Brookes P C and Jenkinson D S. 1987. An extraction method for measuring soil microbial biomass C. *Soil Biology and Biochemistry* **19**: 703–7.

Vischetti C, Casucci C and Perucci P. 2002. Relationship between changes of soil microbial biomass content and imazamox and benfluralin degradation. *Biology and Fertility of Soils* **35**: 13–7.

Winding A, Hund-Rinke K and Rutgers M. 2005. The use of microorganisms in ecological soil classification and assessment concept. *Ecotoxicology and Environmental Safety* **62**: 230–48.

Yu Y L, Shan M, Fang H, Wang X and Qiang X. 2006. Responses of soil microorganisms and enzymes to repeated applications of Chlorothalonil. *Journal of Agriculture and Food Chemistry* **54**: 10070–5.