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Effect of Herbicides and Fungicides Applied to Jute (*Corchorus olitorius* L.) on Fiber Yield and Nutrient Uptake by Jute and Changes in Microbial Dynamics of Soil

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Abstract

A field experiment was conducted during 2005-06 and 2006-07 to find out the effect of two pre-emergence (trifluralin and fluchloralin) and one post-emergence herbicide (qizalofop-ethyl) and three fungicides (bavistin, dithane M-45 and blitox) applied to a jute crop on fiber yield, nutrient uptake and microbial dynamics in soil. Two hand weeding (T_2) alone recorded significantly higher fiber yield over all the herbicides and control except trifluralin at 0.75 kg a.i./ha (T_3) which was at par with T_2. Whereas, two hand weeding in combination with fungicides (T_9, T_{10} and T_{11}) recorded significantly higher fiber yield as compared to hand weeding (T_2) alone. The nutrient uptake pattern followed the same trend of fiber yield of jute. The total microbial (bacteria, fungi and actinomycetes), *Azotobacter* and *Azospirillum* population in the soil decreased significantly in all the herbicides and fungicides treated plots after 7 days of their respective application while the control and two hand weeding (T_2) maintained significantly higher population of microbes over all other treatments at all stages of counting. The periodical observations of microbes in soil showed that total microbial, *Azotobacter* and *Azospirillum* population again started recovering after 15 days of application and at harvest the total microbial population recovered to the tune of initial population. The *Azotobacter* and *Azospirillum* population recovered in fungicides treated plots but they could not cope up with initial population under herbicides treated plots even at harvest. Trifluralin at 0.75 kg a.i./ha was the safest among the herbicides with regard to microbial population and it also recorded significantly higher fiber yield over all the herbicides.

Key words : Jute, Herbicide, Fungicide, Microbial dynamics, Nutrient uptake.

Jute (*Corchorus olitorius* L.) is the most important cash crop of eastern India and West Bengal in particular. Jute crop faces serious weed infestation during its early growth and can reduce the fiber yield by 75 to 80% (1) if not controlled. Manual weeding in Jute is costly and it costs around 35% of total cost of production of jute. So, attempts are being made for chemical weed control by using various pre- and post-emergence herbicides. Further, various fungicides are also used to jute crop either as seed treatment to protect from fungal diseases at earlier growth stage and as spray during later growth stages of jute. Application of various herbicides and fungicides to various crops is found to decrease total microbial population including some beneficial N fixers, P solubilizers and enzymatic activities controlled by microbes in soil (2—6). The use of agro-chemicals (herbicides, fungicides) to jute crop in long run on continuous basis may affect the microbial dynamics and enzymatic activities in jute growing soil which in turn may affect the jute productivity and quality. The information on effect of various agro-chemicals applied to jute crop on soil microbial dynamics is meager. The present study was therefore undertaken to find out the effect of some pre- and post-emergence herbicides and fungicides as seed treatment applied to jute crop on fiber yield and nutrient uptake by jute and microbial dynamics in soil.

Methods

A field experiment was conducted for 2 consecutive years during 2005—07 at the same site in the farm of Central Research Institute for Jute and Allied Fibers, Barrackpore, West Bengal. The experimental soil was Typic Ustochrept with sandy loam texture and

Table 1. Effect of herbicides and fungicides application on fiber yield and nutrient uptake of jute (2 years pooled mean data).

Treatments		Fiber yield (q/ha)	Nutrient uptake (kg/ha) N	P	K	Zn
T_1	(Control)	15.20	55.90	15.80	145.10	0.10
T_2	(Two hand weedings)	32.20	106.00	31.40	198.90	0.21
T_3	(Trifluralin 0.75 kg a.i./ha)	33.10	111.20	32.70	199.50	0.27
T_4	(Trifluralin 1.50 kg a.i./ha)	30.60	114.40	32.60	197.70	0.26
T_5	(Fluchloralin 0.75 kg a.i./ha)	29.80	88.50	26.40	190.90	0.18
T_6	(Fluchloralin 1.50 kg a.i./ha)	28.90	102.40	31.00	200.40	0.23
T_7	(Quizalofop ethyl 50 g a.i./ha)	29.50	94.20	31.40	187.70	0.20
T_8	(Quizalofop ethyl 100 g a.i./ha)	30.00	104.90	31.50	200.10	0.24
T_9	(Bavistin as seed treatment + 2 hand weedings)	33.60	110.30	36.60	205.90	0.32
T_{10}	(Dithane-M-45 as seed treatment + 2 hand weedings)	34.10	111.00	36.30	206.40	0.30
T_{11}	(Blitox as seed treatment + 2 hand weedings)	35.00	113.25	35.30	204.30	0.34
	CD ($P = 0.05$)	1.30	3.35	2.40	2.95	0.05

had a pH of 7.20, organic carbon 0.55%, available N, P and K 365, 30 and 155 kg/ha respectively. There were 11 treatments which were replicated thrice in a randomized block design. Two pre-emergence herbicides of di-nitro aniline group (trifluralin and fluchloralin) were applied as spray one day before sowing in the soil and mixed thoroughly while post-emergence herbicide quizalofop-ethyl (targa super) was applied 21 days after emergence of the crop. In fungicidal treatments, seeds were treated with carbendazim (bavistin) at 2 g/kg of seed, mancozeb (dithane M-45) and copper oxychloride (blitox) at 5g/kg of seed before sowing and then sowing was done. Olitorius jute cultivar JRO 524 was sown at 5 kg/ha with a row to row 25 cm and plant to plant 5 cm spacing during week 2 of April. N, P and K at 60 : 30 : 30 was applied to the crop. The whole amount of P and K through single superphosphate and muriate of potash and one-third of N through urea were applied at the time of sowing as basal dose. Rest of N was applied as split dose, one-third of N was applied after first weeding and thinning at 21 days after emergence of the crop, rest one-third of N was applied after 35 days of emergence of the crop. The crop was harvested after 120 days of sowing. Plant samples (leaf, bark and wood) were taken at the time of harvest, dried, processed and analysed for total N, P, K and Zn following standard procedures (7). Soil samples were taken periodically after 7, 15 and 30 days of application of respective herbicides and fungicides and at harvest. The soils were then analyzed for total microbial (bacteria, fungi and actinomycetes). *Azotobacter* and *Azospirillum* population. The enumeration of microbial population was done on agar plate containing appropriate media following serial dilution technique and pour plate method (8). Thronton's agar media (9) for total bacterial count, Martin's rose Bengal streptomycin agar media (10) for total fungi count and Kenknight and Munaier's media for total actinomycetes counts were used. For *Azotobacter* Ashby's mannitol agar media and for *Azospirillum* N free malic acid semi-solid media were used and *Azospirillum* population was counted by most probable number (MPN) method. The jute crop after harvest was kept for 2—3 days in the field for defoliation. The jute plants were then retted in retting tank. After retting, the fiber was extracted from the jute plants and fiber after washing in water was sun-dried and dry weight of fiber was taken.

Results and Discussion

Fiber Yield

The fiber yield data (Table 1) showed that two hand weeding (T_2) recorded significantly higher yield over pre-emergence herbicide trifluralin at 1.50 kg a.i./ha (T_4), fluchloralin and post-emergence herbicide

Table 2. Effect of herbicides and fungicides application on *Azotobacter* population in soil (2 years pooled mean data). Initial population : 16.50 × 10^3, CFU = colony forming units.

Treatments	After 7 days (CFU× 10^3/ g of dry soil)	After 15 days (CFU× 10^3/ g of dry soil)	After 30 days (CFU× 10^3/ g of dry soil)	At harvest (CFU× 10^3/ g of dry soil)
T_1	15.50	16.00	16.90	18.75
T_2	16.00	16.25	17.25	19.40
T_3	10.50	11.20	12.00	13.50
T_4	9.00	9.60	10.40	11.00
T_5	9.50	10.60	11.30	12.00
T_6	8.70	9.40	10.00	10.80
T_7	10.75	11.50	12.40	13.70
T_8	8.50	10.70	10.90	11.20
T_9	10.20	12.75	13.80	15.5
T_{10}	10.00	12.90	13.50	15.00
T_{11}	9.80	11.90	13.20	14.80
CD (P = 0.05)	0.33	0.46	0.47	0.42

Table 3. Effect of herbicides and fungicides application on *Azospirillum* population in soil (2 years pooled mean data). Initial population : 6.70×10^4, CFU=colony forming units.

Treatments	After 7 days (CFU× 10^4/ g of dry soil)	After 15 days (CFU× 10^4/ g of dry soil)	After 30 days (CFU× 10^4/ g of dry soil)	At harvest (CFU× 10^4/ g of dry soil)
T_1	6.50	6.70	6.90	7.20
T_2	6.60	6.90	7.20	7.50
T_3	2.00	2.30	3.00	4.00
T_4	0.71	1.00	1.40	2.00
T_5	1.70	2.00	3.00	3.50
T_6	0.60	0.90	1.40	1.70
T_7	1.50	1.70	2.10	2.60
T_8	0.60	0.80	1.10	1.75
T_9	1.50	2.30	3.50	5.00
T_{10}	1.60	2.00	3.20	4.60
T_{11}	1.60	2.20	3.30	4.80
CD (P = 0.05)	0.29	0.26	0.27	0.28

quizalofop-ethyl but was at par with trifluralin at 0.75 kg a.i./ha (T_3). The superiority of hand weeding over herbicides in producing higher fiber yield of jute and grain yield of wheat was also reported by Sarkar (5) and Barui et al. (11). Two hand weeding (T_2) recorded 111.8% higher yield over control where no herbicides/fungicides were applied and no hand weeding was done. The lower yield at control plot could be due to excessive weed growth and their competition with jute crop for plant nutrients compared to hand weeded plots. The same was also reported by Mishra (12) and Sarkar (5). Among the herbicides (pre- and post-emergence) trifluralin at 0.75 kg a.i./ha was found to be significantly superior over all other herbicides including post-emergence one, but these herbicides were at par among themselves. The efficacy of trifluralin in controlling weeds in jute crop and in increasing the fiber yield was also reported by Sarkar et al. (13). On the other hand, seed treatment with fungicides with two hand weeding (T_9, T_{10} and T_{11}) were significantly superior over two hand weeding only and T_9 and T_{10} were at par with T_3 for fiber yield of jute. The highest fiber yield of jute (35 q/ha) was recorded with T_{11} (blitox as seed treatment + two hand weeding) which was significantly superior over all other treatments except T_{10}.

Nutrient Uptake

The N, P, K and Zn uptake by jute crop increased significantly with hand weeding, herbicides and fungicides + hand weeding over unweeded control (Table 1). The lower nutrient uptake in control plot (T_1) is because of lower absorption of nutrients by the crop as there was huge competition for the same by weed flora present in the plot. Two hand weeding (T_2) again significantly recorded lower values of nutrient uptake compared to two hand weeding + fungicides as seed treatment (T_9, T_{10} and T_{11}). Among the herbicides, trifluralin at 0.75 kg a.i./ ha was better than others for nutrient uptake and it recorded significantly higher N and Zn uptake over two hand weeding (T_2). In pre-emergence herbicide fluchloralin it has been found that the higher dose of it i.e. 1.5 kg a.i./ha recorded significantly higher N, P, K and Zn uptake over its lower dose and the same is true for post-emergence herbicide quizalifop ethyl for N and K uptake. All the three fungicides as seed treatment with two hand weeding (T_9, T_{10} and T_{11}) were at par among themselves for nutrient uptake.

Azotobacter Population

The data on periodical changes in *Azotobacter*

Table 4. Effect of herbicides and fungicides on microbial population (2 years pooled mean data). Initial population : Bacteria : 122 × 10^5, Fungi : 116 × 10^3, Actinomycetes : 98 × 10^5, CFU = colony forming units.

Treatments	Bacteria (CFU×10^5/g of dry soil)				Fungi (CFU × 10^3/g of dry soil)				Actinomycetes (CFU × 10^5/g of dry soil)			
	After 7 days	After 15 days	After 30 days	At harvest	After 7 days	After 15 days	After 30 days	At harvest	After 7 days	After 15 days	After 30 days	At harvest
T_1	120.5	122.0	124.0	128.0	115.0	118.0	120.5	123.0	97.0	99.0	102.0	105.0
T_2	121.5	123.5	126.0	131.5	115.5	119.5	122.0	125.0	97.5	100.5	104.0	107.5
T_3	62.5	72.0	85.0	115.0	60.0	70.0	85.0	110.0	50.0	60.0	72.0	87.5
T_4	58.0	68.0	80.0	110.0	57.5	66.0	80.5	106.5	46.0	55.5	68.0	82.0
T_5	61.0	70.0	82.0	112.5	60.0	70.5	83.5	110.5	50.0	60.5	70.5	88.0
T_6	56.5	65.5	78.0	108.5	56.0	63.5	78.5	105.0	45.0	56.0	66.5	80.5
T_7	58.0	68.0	84.0	118.0	58.0	68.5	84.0	112.0	48.0	58.5	71.5	90.0
T_8	54.0	61.5	80.0	115.0	56.5	65.0	80.0	106.5	42.5	54.5	65.5	86.0
T_9	60.0	68.0	90.0	120.0	56.0	60.5	86.0	113.0	50.5	62.0	74.0	92.0
T_{10}	60.5	66.5	88.0	118.0	55.0	62.0	84.2	112.0	49.0	59.5	71.5	90.5
T_{11}	58.0	65.0	86.5	116.5	54.5	60.0	82.0	110.5	50.0	60.5	72.5	91.0
CD (*P*= 0.05)	3.40	3.30	3.60	3.00	3.20	2.85	3.00	2.70	2.75	2.60	3.00	2.50

(Table 2) as a result of herbicides and fungicides application indicated that application of herbicides and fungicides as seed treatment reduced its population by 34.8 to 48.5% and 38.2 to 40.6% respectively compared to initial population after 7 days of their respective application. The control (no weeding and no pesticides) and two hand weeding (T_2) recorded significantly higher *Azotobacter* population compared to all other herbicides and fungicides at all stages of counting. The higher doses of herbicides (pre and post) recorded significantly lower *Azotobacter* population over their lower doses at all stages of counting. The *Azotobacter* population again increased gradually in all herbicides and fungicides treatments after 15 days of application of respective pesticides and at harvest the *Azotobacter* population recovered by 65.4 to 81.8% by herbicides. The herbicides (T_3 to T_8) were more harmful compared to fungicides (T_9, T_{10} and T_{11}) for *Azotobacter* population. Among the herbicides, the effect of trifluralin and post-emergence herbicide quizalofop ethyl was similar and they were at par compared to fluchloralin. The decrease in *Azotobacter* population and their N fixing activity with herbicides application was also reported by Min et al. (14) and Barui et al. (11). Among the fungicides, bavistin recorded higher *Azotobacter* population at all intervals compared to dithane M-45 and blitox and the recovery of *Azotobacter* population was in the range of 89.7 to 93.9% of initial population at harvest of the crop in all fungicides treated plot.

Azospirillum Population

The *Azospirillum* population in the soil decreased significantly by 70.1 to 91% with herbicides and by 76.1 to 77.6% with fungicides application over initial population after 7 days of their respective application (Table 3). The control (T_1) and two hand weedings (T_2) recorded significantly higher *Azospirillum* population over all herbicides and fungicides at all stages of counting. The higher *Azospirillum* population in control and hand weeded plots compared to herbicides and fungicides treated plots was also reported by Barui et al. (11) and Banerjee and Dey (2). The higher doses of herbicides (pre- and post-)recorded significantly lower *Azospirillum* population over their lower doses at all stages of counting. The *Azospirillum* population in all herbicides and fungicides treated plots increased again after 15 days of application and at harvest there was variable recovery of *Azospirillum* population under different herbicides and fungicides. Among the herbicides, the most reduction in *Azospirillum* population was recorded with quizalofop ethyl followed by fluchloralin and trifluralin and highest recovery of its popula-tion at harvest was recorded with trifluralin followed by fluchloralin and quizalofop ethyl. The recovery of *Azospirillum* population un-

der various fungicjdes ranged from 68.6 to 74.6% and the highest recovery was recorded with bavistin followed by blitox and dithane M-45.

Soil Bacteria

The population of total soil bacteria in post-harvest soil decreased significantly by 48.8 to 55.7 and 50.4 to 52.4% respectively by herbicides and fungicides after 7 days of their respective application compared to initial bacterial population (Table 4). The bacterial population was significantly higher in control (T_1) and twice hand weeded plot (T_2) compared to herbicides and fungicides treated plots at all stages of counting. The higher soil bacterial count under weedy check (control) and hand weeding over herbicides/fungicides treated plots was also reported by Sarkar (5), Barui et al. (11) and Shukla and Mishra (3). Among the herbicides the lower bacterial population was recorded with quizalofop ethyl followed by fluchloralin and trifluralin although at harvest the recovery was more under quizalofop ethyl treated plots. The higher level of all herbicides recorded significantly lower bacterial population compared to their lower doses at all stages of counting. The highest recovery of bacterial population was recorded with bavistin (98.4%) followed by dithane M-45 and quizalofop ethyl at 50 g a.i./ha (96.7%).

Soil Fungi

The total fungal population was significantly higher in control and hand weeded plots compared to herbicides and fungicides treated plots where the population significantly reduced after 7 days of their respective population from initial population (Table 4). The depression in fungal population was more under fungicides treated plots than the herbicides treated plots. The lower fungal population in fungicides (benomyls, copper oxychloride and mancozeb) treated plots in potato field soil vthan untreated plot was also observed by Shukla and Mishra (3). The fungal population again started recovering after 15 days of their respective application and at harvest recovery of 90.5 to 96.5 and 95.2 to 97.4% of initial population respectively in herbicides and fungicides treated plots was recorded.

Soil Actinomycetes

The total actinomycetes population in the soil decreased significantly (Table 4) with the application of herbicides and fungicides after 7 days of their respective application in the soil compared to initial population while its population was significantly higher in control and hand weeded plots over herbicides and fungicides. The significant negative effect on the population of actinomycetes was also observed with herbicides and fungicides application by Sarkar (5) and Shukla et al. (4). The actinomycetes population again started recovering after 15 days of application of herbicides and fungicides and at harvest the population recovered by 82.1 to 91.8 and 92.3 to 93.9% respectively in herbicides and fungicides treated plots. The higher doses of herbicides have significantly lower population of actinomycetes compared to their corresponding lower doses.

Conclusion

It can be inferred that pre-emergence herbicide trifluralin at 0.75 kg a.i./ha and two hand weedings produced equivalent fibre yield of jute and two hand weeding in combination with fungicides produced significantly higher yield over only hand weeding. Two hand weeding and weedy check recorded significantly higher microbial and *Azotobacter* and *Azospirillum* population than all herbicides and fungicides at all stages of counting. Although at harvest the total microbial population recovered in all herbicides and fungicides treated plots, but the recovery of *Azotobacter* and *Azospirillum* population in fungicides treated plots were higher than herbicides but as the cost involvement is more under hand weeding, it can be substituted by pre-emergence herbicide trifluralin at 0.75 kg a.i./ha without affecting yield and microbial population much.

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