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Integration of Stale Seedbed with Herbicides for Weed Management in Jute (*Corchorus olitorius*) and their Impact on Soil Microbes

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ABSTRACT

A field experiment was conducted in split-plot design with five main plot treatments comprised of conventional method of sowing, stale seed bed (SSB) for 20 days followed by (*fb*) pyrozosulfuron ethyl @ 60g/ha, SSB *fb* imazethapyr @100ml/ha, SSB *fb* glyphosate @ 1.25 kg/ha % $(NH_4)_2SO_4$ and SSB *fb* glyphosate @2.5 kg/ha +2% $(NH_4)_2SO_4$ superimposed with three sub-plot treatments of jute sown at 0, 5 and 15 days after herbicides application replicated thrice during 2010-11 and 2011-12.Stale seedbed (SSB) followed (*fb*) either glyphosate @1.25 or 2.5kg/ha or pyrozosulfuron ethyl @60g/ha or imazethapyr @100 ml/ha significantly reduced the *Cyperus*, broad leaved weeds (BLW) and grass weed. SSB *fb* glyphosate @1.25 and 2.50 kg/ha did not show jute seedling mortality even crop sown same day after application of herbicides). Imazathapyr @100g/ha and pyrozosulfuron ethyl @60 g/ha recorded seedling mortality up to 75-90% when jute crop was sown at 0, 5 and 15 days after application. SSB with glyphosate @1.25 and 2.50 kg/ha resulted in significantly higher jute seed yield (11 q/ha) compared to others.

Keywords: Stale seedbed, glyphosate, jute seed, soil microbes, weeds.

INTRODUCTION

Jute is the most important cash crop of eastern India, sown in summer and *kharif* season for fibre and seed, respectively. Both the crops face severe competition with weeds particularly *Cyperus rotundus* and broad leaved weeds, where pre and post emergence herbicides selective to grass weeds are being applied for long time (Kumar *et al.,* 2013 and Kumar *et al.,* 2014). There are no selective herbicides available to control broadleaved weeds and sedges in jute and manual weeding incurred 40% of total cost of cultivation (Ghorai *et al.,* 2013b). However, protected/ direct spray of glyphosate is being applied between the 40-50 cm spaced rows of jute seed crop but there may be chance for phytoxicity, if not properly sprayed (Ghorai *et al.,* 2013a). Hence, there is need for alternative weed management strategies for jute fibre and seed crops. The stale or false seedbed technique may be fitted well to control broad spectrum of weed species in jute crop. This technique involves soil preparation of seedbed to promote germination of weeds, a number of days or weeks before the actual sowing or planting of the crop followed by destruction of the emerging weed seedlings with minimal soil disturbance (Mohler, 2001). One major reason for the enhanced germination of the seeds in the soil during the preparation of a seedbed is the exposure to light. Seeds of many species are sensitive to short exposures to light at a certain moment in the life cycle of the seed (Milberg *et al.,* 1996 and Riemens *et al.,* 2007). The control of emerging weed seedlings is mostly done with herbicides mostly glyphosate and paraquate (Heatherly *et al.,* 1993 and Oliver *et al.,* 1993), although some studies included the use of non-chemical control methods, such as flame weeding and harrowing (Caldwell and Mohler, 2001 and Rasmussen, 2004). In general, crop sown 5-10 days after application of glyphosate/paraquate to avoid the phytotoxicity to crop (Kumar *et al.,* 2014). Since field remains fellow for 30-35 days stale seed bed is less popular. Moreover, herbicides applied for controlling weeds on stale seed bed should not harm the beneficial microorganism in soil. Therefore, a study was formulated to reduce the broad spectrum of weed and simultaneously the waiting time between herbicide application and sowing of crop without harming the jute seed germination and soil microorganism.

MATERIALS AND METHODS

A field experiment was conducted in split-plot design during 2010-11 and 2011-12 at Central Research Institute for Jute and Allied Fibres (CRIJAF), Barrackpore, Kolkata, West Bengal. The experimental soil belongs to Typic Ustochrept with sandy loam texture having the general characteristics: pH (1:

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2.5 w/v) in water 7.20, organic carbon 5.50 g/kg and available N, P and K were 335, 30 and155 kg/ha, respectively. Five main plot treatments comprised of conventional method of sowing (two ploughing + butachlor @ 1.0 kg/ha + one hand weeding), stale seed bed (SSB) for 20 days followed by (*fb*) pyrozosulfuron ethyl @ 60g/ha, SSB *fb* imazethapyr @ 100ml/ha, SSB *fb* glyphosate @ 1.25 kg/ha % $(NH_4)_2 SO_4$ and SSB *fb* glyphosate @ 2.5 kg/ha +2% $(NH_4)_2 SO_4$ superimposed with three sub-plot treatments of jute sown at 0, 5 and 15 days after herbicides application. Stale seedbed was prepared before sowing of crop and herbicides were applied on emerged weeds on seedbed at 20 days. The jute variety 'JRO 204' was sown on stale seed bed without second ploughing at seed rate of 5 kg/ha with row to row and plant to plant spacing of 50 and 10 cm respectively during second week of July in each year.. Nitrogenous fertilizers @ 30 kg N/ha was applied in two split doses; one basal and one 45 DAS after de-topping of jute seed crop. Whole amount of phosphate and potash fertilizer both @ 60 kgP_2O_5 and K_2O/ha were applied and mixed thoroughly with soil during land preparation. Weed density was recorded from randomly selected quadrats (0.50 m × 0.50m) at 45 days after sowing of jute and data was transformed by square root transformation before statistical analyses. Soil samples were collected at 10, 20 and 30 days after herbicides sprayed to analyze the change in microbial population after herbicide application. The enumeration of beneficial microbes was done on agar plate containing appropriate media following serial dilution technique and pour plate method (Parmer and Schmidt, 1966). Martin Rose Bengal agar medium (Martin, 1950) for fungi and soil extract nutrient agar medium (Allen, 1953) for bacteria were prepared for supporting the growth of different microorganisms and Kenknight and Munaier, media for total actinomycetes counts were used. Year-wise analysis of data showed the error variance to be homogeneous. The test of significance of the treatments was also similar over the years as well. Therefore, pooled data were used for the ANOVA (MSTAT C software) and the significance of treatments was tested by the variance ratio (i.e. F value) at P =0.05 (Gomez and Gomez, 1984). The least significant difference (LSD) for each variable was worked out for comparison of the treatment means

RESULTS AND DICUSSION

Weed flora

The weed flora in the experiment field consists of i) grasses: *Echinochloa colonum, Digitaria sanguinalis*., *Elusine indica*. and *Cynodon dactylon, Brachiaria repens, Setaria glauca,, Brachiaria ramosa*; ii) sedges: *Cyperus rotundus*, *Cyperus difformis* and iii) broad-leaved weeds: *Ageratum conyzoides, Eclipta alba, Phylanthus niruri, Portulaca oleracea Trianthema portulacatrum., Euphorbia hirta, etc.* The relative dominance of *Cyperus rotundus* was 67.9 % followed by broad leaved weeds (20.3 %) and the lowest was for grass weeds (11.8 %).

Effect on weeds

The highest density of sedges, BLW and grass weeds were recorded in conventional methods of sowing (Table 1). Stale seedbed (SSB) followed (*fb*) either glyphosate @1.25 or 2.5kg/ha or pyrozosulfuron ethyl @ 60g/ha or imazethapyr @ 100 ml/ha significantly reduced the *Cyperus*, broad leaved weeds (BLW) and grass weed density compared to conventional method. However, *Cyperus* density was significantly lower in SSB *fb* glyphosate @1.25kg/ha and 2.5 kg/ha compared to others. SSB enhanced the germination of many weed and one major reason for the enhanced germination of the seeds in

Table 1: Effect of treatments on weeds, yield attributes and seed yield of jute (pooled data of two year)

Treatments	Weed density (no./m^2) at 45 DAS			Total weed dry weight (g/m^2)	Nutrient uptake by weeds		
Methods of sowing	*Cyperus*	BLW$	Grass		N (kg/ha)	P (kg/ha)	K (kg/ha)
Conventional method	8.91 (80.0)#	4.98 (24.7)	3.80 (14.3)	13.3 (177)	16.6	6.6	25.4
SSB *fb*glyphosate @ 1.25 kg/ha + 2% $(NH_4)_2SO_4$	4.99 (25.5)	4.32 (18.6)	3.71 (13.7)	8.4 (74.6)	7.0	2.8	10.7
SSB *fb*glyphosate @ 2.5 kg/ha+2% $(NH_4)_2SO_4$	4.73 (22.5)	4.05 (16.5)	3.18 (9.9)	8.1 (66.5)	6.3	2.5	9.5
SSB *fb*imazethapyr @ 100g/ha	6.18 (37.81)	4.32 (18.7)	3.08 (9.7)	9.4 (99.6)	9.4	3.7	14.3
SSB *fb*pyrozosulfuron @60g/ha	6.99 (37.81)	4.35 (18.9)	3.58 (12.8)	9.8 (92.8)	8.7	3.5	13.3
SEm ±	0.16	0.15	0.14	0.38	0.23	0.14	0.60
LSD (P=0.05)	0.51	0.47	0.45	1.20	0.75	0.40	1.80
Sowing interval							
0 DAS	6.35 (44.5)	4.09 (20.0)	3.39 (11.5)	10.2 (102.4)	9.6	3.8	14.7
5 DAS	6.34 (41.3)	4.19 (21.7)	3.54 (12.5)	10.2 (103.4)	9.7	3.9	14.8
15 DAS	6.49 (44.8)	4.73 (23.4)	3.28 (10.7)	10.4 (109.4)	10.3	4.1	15.7
SEm ±	0.23	0.21	0.19	0.42	0.30	0.21	0.82
LSD	NS	NS	NS	NS	NS	NS	NS

#Original data in parentheses. Data was transformed by square root transformation before statistical analyses

$ Broad leaved weeds *low plant population due to jute seedling mortality the soil during the preparation of a seedbed is the exposure to light. Thereafter, application of post emergence application of glyphosate killed the almost all weeds including *Cyperus*. Glyphosate has high degree of translocation following its entry into the foliage and high herbicidal activity at the site of action has been reported (Bariuan *et al.,* 1999; Nelson and Renner, 2002 and Kumar *et al.,* 2012). Imazethapyr was reduced the *Cyperus* and other BLW as well as grass weeds. Imazethapyr is a broad-spectrum herbicide with a greater sedge killing activity than most of the selective herbicides recommended in soybean as reported by Grichar and Sestak (2000) and Kumar *et al.* (2012). SSB *fb* either glyphosate @1.25 or 2.5kg/ha or pyrozosulfuron ethyl @ 60g/ha or imazethapyr @ 100 ml/ha herbicides also significantly reduced the total dry weight of weeds compared to conventional method. The dry weight of weeds is proportionate to weed density and reduction in weed density by these herbicides reduced the dry weight of weeds. The weed density and its dry weight did not differ significantly due to different sowing interval. It is known that weeds removed huge amount of nutrient from crop field and same is true for the jute also. It has been observed that weeds removed 16.6 kg N, 6.6 kg P and 25.4 kg of K/ha at 45 DAS, when weed control was by conventional method. SSB fb glyphosate @ 1.25 and 2.50 kg/ha saved about 9-10 kg N, 4 kg P and 14-45 kg K/ha by reducing the weed dry compare to conventional method. The nutrient removal by weed did not differ significantly with sowing interval.

Effect on crop

SSB *fb* glyphosate @ 1.25 and 2.50 kg/ha did not show jute seedling mortality even at 0 DAS (crop sown same day after application of herbicides). Since, glyphosate is almost instantaneously inactivated by adsorption to clay minerals and cationic binding sites of the soil matrix (Piccolo *et al.,* 1992 and Dong-Mei *et al.,* 2004), while glyphosate in the soil solution is prone to rapid microbial degradation (Giesy *et al.,* 2000). However, risks of glyphosate toxicity to non-target organisms in soils are generally considered as marginal. Both imazathapyr @ 100g/ha and pyrozosulfuron ethyl @ 60 g/ha recorded seedling mortality up to 75-90% when jute crop was sown at 0, 5 and 15 days after application (Table 2). Imazethapyr has been shown to be less mobile and persist for a long time in soils (Stougaard *et al.,* 1990) and this is the reason why jute seedling is killed by activity of imazethapyr in soil. SSB with glyphosate resulted in significantly higher branch/plant, pods/plant and jute seed yield compared to others. Yield attributes like branch/plant and pods/plant were significantly lower in SSB *fb* imazathapyr @ 100 g/ha and SSB *fb* pyrozosulfuron-ethyl @ 60 g/ha. Jute seed yield was higher in SSB+ glyphosate @1.25 kg/ha + 2% $(NH_4)_2SO_4$ and non-significant difference in jute seed yield was observed among sowing interval. The seed yield is attribute of branch/plats and pods/plants which were significantly higher in this treatment because of vigorous crop growth.

Table 2: Effect of treatments yield attributes and seed yield of jute (pooled data of two year)

Treatments	**Plant population (no./m²)**	**Branch/ plant**	**Pods/ plant**	**Seed yield (q/ha)**
Methods of sowing				
Conventional method	20	3.22	46	8.5
SSB+ glyphosate @ 1.25 kg/ha + 2% $(NH_4)_2SO_4$	20	3.78	51	11.2
SSB+ glyphosate @ 2.5 kg/ha+2% $(NH_4)_2SO_4$	20	4.00	52	11.8
SSB+ imazethapyr @ 100g/ha	6*	1.89	10	2.0
SSB+ pyrozosulfuron @60g/ha	8*	1.78	6	3.4
SEm ±	0.3	0.21	1.5	0.23
LSD (P=0.05)	1.0	0.67	4.8	0.73
Sowing interval				
0 DAS	11	2.80	33.47	6.57
5 DAS	13	2.93	31.87	6.97
15 DAS	16	3.07	33.20	7.14
SEm ±	0.22	0.17	0.77	0.29
LSD	0.70	NS	NS	NS

Table 3: Effect of herbicide treatments on soil microbial population (means of two years)

Treatments	Bacteria population (CFU× 10⁴/g dry soil)			Actinomycetes population (CFU× 10⁴/g dry soil)			Fungal population (CFU× 10³/g dry soil)		
	10 DAS	20 DAS	30 DAS	10 DAS	20 DAS	30 DAS	10 DAS	20 DAS	30 DAS
Conventional method	6.7	8.7	9.3	12.0	32.3	73.1	19.6	34.7	30.6
SSB *fb*glyphosate @1.25 kg/ha + 2% $(NH_4)_2SO4$	17.4	24.9	17.9	37.4	61.1	71.6	22.8	34.7	22.7
SSB *fb*glyphosate @ 2.50 kg/ha + 2% $(NH_4)_2SO4$	12.6	16.1	17.6	29.4	18.4	34.2	16.0	18.4	12.6
SSB *fb* pyrozosulfuron ethyl @ 60 g/ha	2.5	8.7	6.5	13.5	43.8	31.1	46.8	15.0	15.5
SSB *fb*imazethapyr @ 100 ml/ha	15.0	9.8	12.9	32.4	51.7	41.3	54.8	20.9	10.3

#CFU: colony forming unit; *DAS: Days after herbicide spray

Effect on soil microbes

The soil microbial population varied with type of herbicide and days of herbicide application (Table 3). Glyphosate @ 1.25 kg/ha did not show significant variation in bacterial population and fungal population but slight increase in actinomycetes population was observed. It might be due to mineralization of ammonium compound and NH_2SO_4 which was mixed with glyphosate. The higher doses (@ 2.50 kg/ha) of glyphosate recorded slightly lower bacterial, actinomycetes and fungal population than lower dose, however, the difference was very less. Pyrozosulfuron ethyl @ 60 g/ha had the detrimental effect on bacterial, actinomycetes and fungal population. Imazethapyr reduced the bacterial and fungal population; however, actinomycetes population did not differ much as it recovered at later stages. Even the conventional method where butachlor was applied recorded lower bacteria actinnomycetes and fugal population, which recovered at later stages. 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).

CONCLUSION

It may be concluded that stale seedbed with glyphosate @1.25 and 2.50 kg/ha + 2% $(NH_4)_2SO_4$ reduced the broad spectrum weeds and did not induce the phytotoxicity to the jute seedling even at 0 days of application (same day of application) and did not shown any harmful effects on bacteria, actinomycetes and fungal population in soil.

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