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Soil Microflora and Weed Management as Influenced by Atrazine 50 % WP in Sugarcane

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Abstract An experiment was conducted to know the effect of atrazine 50 % WP on the weeds, cane yield of sugarcane and its effect on soil microflora at 'C' Block Farm, BCKV, Kalyani, Nadia, West Bengal, India during 2010-11 to 2011-12. Higher dose of atrazine @ 4.0 kg ha^{-1} recorded better weed control efficiency (84.51, 81.74 and 78.94 %, respectively at 10, 35 and 60 DAA). All the treatments of weed control gave the significantly higher cane yield over the control. The data on cane yield revealed that highest cane yield was recorded where the Atrazine 50 % WP @ 4.0 kg ha^{-1} was applied as pre-emergence but it was at par in case of lower dose of atrazine 50 % WP @ 2.0 kg ha^{-1} followed by ametryn 80%WP@2.0kg a.i. ha^{-1}.Weed management treatments recorded no significant variation on brix %, sugar % and CCS%. All the herbicide treatments recorded detrimental effect on soil microflora (total bacteria, actinomycetes and fungi) immediately after application but after their persistence period, their populations were recovered and sometimes exceeds than their initial count.

Keywords Atrazine, Sugarcane, Microflora, Weed

1. Introduction

Sugarcane is an important crop, widely cultivated for cane sugar and chewing. Weeds have been a great problem in sugar production. Effect of weeds on the early growth of the plant cannot be compensated at the late stages as it caused substantial reduction in yield and yield components. Akobundu, 1987 and Fadayomi, 1996 reported yield losses by weeds in sugarcane to be over 95% under unweeded field condition and 31% of yield losses were observed in plot hand-weeded. The timely operations play significant role to realize the yield potential of a crop. Similarly, the timely control of weeds in case of sugarcane and keep the crop free from weeds up to the development of crop canopy means to the complete of tillering stage. This has great importance to increase the yield of sugarcane. The efficiency of some of the recommended herbicides on weed control is short between 7-8 weeks after application and has not been able to control weeds up to canopy formation stage. This has made farmers to supplement the herbicides with either hand weeding or application of post emergence herbicide, which is another cost to crop production. Therefore, the need to search for herbicides with longer efficacy on weed and with a high positive effect on the growth and yield of sugarcane is justifiable. Hence the objective was to compare the efficacy atrazine 50% WP with the conventional hand weeding on weed control, sugarcane yield and yield components. Whether there is any detrimental effect of herbicide on soil microflora or not, these need to be checked for soil health.

2. Materials and Methods

Experimental site

The experiment was conducted with 7 treatments replicated four times with Randomized Block Design. Each plot size was of 5m x 4m. The crop was grown during consecutive two *kharif* seasons of 2010-11 and 2011-12 at the 'C' Block farm (latitude: 22°57'E, longitude: 88°20'N and altitude: 9.75 m) of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. The experimental soil was well drained, alluvial in nature and sandy loam in texture, having pH 6.91, organic carbon 0.589%, available nitrogen 241.57 kg ha^{-1}, available phosphorus 18.85 kg ha^{-1} and available potassium 261.18 kg ha^{-1} respectively (Jackson, 1973). The variety used in this experiment was Co-1148.

Treatments

The treatments were as follows: Atrazine 50% WP @ 0.5 kg a.i. ha^{-1}, Atrazine 50% WP @ 1 kg a.i. ha^{-1}, Atrazine 50% WP @ 2 kg a.i. ha^{-1}, Atrazine 50% WP @ 4 kg a.i. ha^{-1}, Ametryn 50% WP @ 2 kg a.i. ha^{-1}. All the herbicides were applied at 5 DAS. Hand weeding twice (30 and 60 DAS) was also included in the experiment besides the unweeded control.

Cultivation procedure

Sugarcane was sown at the middle of the June of two consecutive years with full doses of Phosphorus through Single Super Phosphate and Potash through Muriate of Potash each @ 150 and kg ha^{-1} at basal. Recommended dose of Nitrogen @ 80 kg ha^{-1} through Urea was applied in 3 splits

half at basal, 1/4th at the beginning of tillering stage and 1/4th at grand growth stage. One day before sowing, the setts were treated by using *Trichoderma viridis* @ 4 g kg^{-1} of sugarcane setts. The treated seeds were kept under shade for overnight before sowing in the main field and sown at 90 cm x 50 cm spacing at was done with knapsack sprayer with floodjet deflector WFN 040 nozzle with 500 Littre of water ha^{-1}.

Data collection

Category wise predominant weed biomass, weed control efficiency were recorded at 10, 35 and 60 DAS and phytotoxicity observation as per CIB guidelines (observations on yellowing, stunting, necrosis, leaf injure on tips and leaf surface, wilting, epinasty and hyponasty) was recorded accordingly. At the time of harvest, the crop yield was measured. Microflora population (total bacteria, actinomycetes and fungi) was estimated by Thornton's agar medium, 1922 at 10^{-6} dilutions, Martin' Rose Bengal Streptomycin agar medium, 1950 at 10^{-4} dilutions and Actinomycetes - Jensen's agar medium, 1930 at 10^{-5} dilutions, respectively at Initil,5,10,15,30 DAA and at harvest. The enumeration of the microbial population was done on agar plants containing appropriate media following serial dilution technique and pour plate method (Pramer and Schmidt, 1965). The Plates were incubated at 28 ± 1^{0}C for different durations between 5-7 days in BOD incubator and observations in terms of counting of number of colonies plate^{-1} were made.

Chemicals and Materials used for microflora analysis

Total Bacteria		Fungi		Actinomycetes	
Chemicals	Amount	Chemicals	Amount	Chemicals	Amount
Dipotassium hydrogen phosphate	1.0 g	Potassium di hydrogen phosphate	1.0 g	Di potassium hydrogen phosphate	0.5 g
Calcium chloride	0.1 g	Magnesium sulphate	0.5 g	Magnesium sulphate	0.2 g
Magnesium sulphate	0.2 g	Dextrose	10.0 g	Ferric chloride	0.002 g
Sodium chloride	0.1 g	Peptone	5.0 g	Casein (dissolve in 10 ml of 0.1 (N) NaOH)	0.2 g
Ferric chloride	0.002 g	Agar	10.0 g	Dextrose	2.0 g
Potassium nitrate	0.5 g	Rose Bengal (1: 300 aq)	10 ml	Agar	15.0 g
Asparagines	0.5 g	Streptomycin	30 µg / ml	Distilled water	1000 ml
Mannitol	1.0 g	Distilled water	1000 ml		
Agar	15.0 g				
Distilled water	1000 ml				

Statistical analysis

The data were subjected to statistical analysis by analysis of variance method. The correlation studies were made to reveal the association among the variables in the investigation (Gomez and Gomez, 1984). As the error mean squares of the individual experiments were homogenous, combined analysis over the years were done through unweighted analysis. Here, the interaction between years and treatments were not significant.

3. Results and Discussion

Weed flora and weed biomass

Weed flora in sugarcane consisted of *Eleusine indica, Dactyloctaneum aegyptium, Digitaria sanguinalis, Cyperus rotundus, Cyperus difformis, Fimbristylis dichotoma*, *Alternanthera philoxeroides, Digera arevensis, Commelina benghalensis, Phyllanthus niruri, Spilanthus paniculata, Euphorbia hirta, Physalis minima, Portuloaca oleracea and Boerhaavia diffusa*.

Significantly decreased dry weights of weeds were recorded with imposition of weed control treatments over untreated control (Table 1). At 10 DAA, atrazine @ 4 kg ha^{-1} recorded least weed biomass which was statistically at par with atrazine @ 2 kg ha^{-1} and Ametryn 80% WP @ 2.0 kg a.i. ha^{-1}. Twice hand weeding recorded least weed biomass which was statistically at par with T_2 T_3 T_4 and T_5 at 35 DAA. Whereas, at 60 DAA, T_4 recorded lest weed biomass which showed statistical parity with all the treatments except T_1 and control.

Table 1. Effect of treatments on dry weight of dominant weeds g m^{-2} and WCE% (pooled over two years)

Treatments	Weed Biomass (g m^{-2})			WCE%		
	10 DAA	35 DAA	60 DAA	10 DAA	35 DAA	60 DAA
T_1-Atrazine 50%WP@ 0.5kg a.i. ha^{-1}	22.89	27.80	34.87	71.05	70.43	69.69
T_2-Atrazine 50%WP@ 1.0kg a.i. ha^{-1}	18.92	21.85	28.90	76.07	76.76	74.88
T_3-Atrazine 50%WP@ 2.0kg a.i. ha^{-1}	14.13	19.05	26.10	82.13	79.74	77.31
T_4-Atrazine 50%WP@ 4.0kg a.i. ha^{-1}	12.25	17.17	24.23	84.51	81.74	78.94
T_5-Ametryn 80%WP@2.0kg a.i. ha^{-1}	14.95	18.85	25.92	81.09	79.95	77.47
T_6-Twice Hand Weeding (30 and 60 DAS)	48.64	16.45	28.27	38.48	82.50	75.42
T_7-Control	79.06	94.02	115.03	0.00	0.00	0.00
LSD (P=0.05)	3.65	5.78	7.26			

Weed control efficiency

Regarding weed control efficiency % (Table 1), it is quite clear that at 10 and 60 DAA, T_4 offered high weed control efficiency (84.51) as compared to the other treatments mainly due to better efficacy against weeds and gave less weed dry weight. At 35 DAA, hand weeding twice (T_7) maintained its superiority over the chemical treatments which may be due to the fact that twice hand weeding at 30 and 60 DAS removes the weeds in addition to shading effect of the crop resulting least weed biomass. Avtar Singh and Charanjeet Kaur, 2004 reported the efficacy of atrazine in

sugarcane.

Phytotoxicity

No phytotoxic symptoms such as epinasty/hyponasty, leaf yellowing, necrosis, stunting growth, wilting etc were found. This is in conformity with the earlier findings of Kathiresan and Avudathai (2004).

Cane growth

Cane length, weight of one cane and no. of millable cane per hectare were significantly higher by all weed management treatments over control (Table 2). Highest cane length (2010 cm), weight of one cane (1.11 kg) and no. of millable cane per hectare (84220) was recorded to the treatment of atrazine @ 4 kg ha^{-1} (T_4). These findings were in conformity with the findings of Singh *et al.,* 2001.

Yield and quality of sugarcane crop

All the weed management treatments proved to be significantly superior over control regarding cane yield of sugarcane. Weed management treatments recorded 46.97 to 82.02% increase of cane yield over control. The maximum cane yield was recorded from atrazine 50% WP @ 4.0kg ha^{-1} (58.01 t ha^{-1}) which was statistically at par with atrazine 50% WP @ 4.0kg ha^{-1} (55.10 t ha^{-1}) while the minimum was from the control (31.87 t ha^{-1}). Regarding percentage increase in yield over control, the highest yield increase (82.02%) was obtained from the T_4 followed by the treatments T_3 (72.89%) and T_6 (71.79 %). The lowest yield increment (46.97%) was obtained from the treatment T_1 (Table 2).

Table 2. Effect of treatments on cane length, weight of one cane, no. of millable cane, yield, brix %, sucrose% and CCS% of sugarcane (pooled over two years)

Treatments	Cane length (m)	Weight of one cane (kg)	No. of millable cane ('000 ha^{-1})	Yield in t ha^{-1}	Brix (%)	Sucrose (%)	CCS (%)
T_1-Atrazine 50%WP@ 0.5kg a.i. ha^{-1}	1.80	0.94	66.67	46.84	21.25	18.64	14.64
T_2-Atrazine 50%WP@ 1.0kg a.i. ha^{-1}	2.01	1.02	74.67	50.45	21.31	18.21	14.70
T_3-Atrazine 50%WP@ 2.0kg a.i. ha^{-1}	2.07	1.08	80.67	55.10	20.97	18.43	14.34
T_4-Atrazine 50%WP@ 4.0kg a.i. ha^{-1}	2.10	1.11	84.22	58.01	21.28	18.68	14.54
T_5-Ametryn 80%WP@2.0kg a.i. ha^{-1}	2.06	1.05	77.33	53.34	21.04	18.54	14.25
T_6-Twice Hand Weeding (30 and 60 DAS)	2.04	1.10	83.00	54.75	21.47	18.92	14.76
T_7-Control	1.50	0.81	58.00	31.87	21.22	18.61	14.57
LSD (P=0.05)	0.24	0.09	5.214	3.781	NS	NS	NS

The brix%, sucrose% and commercial cane sugar (CCS %) did not have any perceptile variation under different weed management treatments (Table 2). The results were in accordance with the findings of Dashora and Singh, 2008.

This may be due to the reason that with initial application of chemicals offered less crop weed competition for moisture, nutrients, sunlight and space might have caused conspicuous enhancement in cane length, weight of one cane, no. of millable cane per hectare, cane yield and quality (Kathiresan and Avudathai, 2004).

Effect on soil microflora

Both the atrazine 50% WP and standards ametryn 80% WP did not show any significant influence on the population of total bacteria in *rhizosphere* of *kharif* sugarcane at initial stage though after the application of the chemicals, significant variations were found between the treated and non treated plots. The population of total bacteria decreased up to 60 DAA as compared to the observation before spraying and then increased for herbicidal treatments. Twice hand weeding and control recorded steady but very slow increase of the population (Fig.1). At harvest, herbicidal treatments recorded 0.19 to 32.16 % higher population of total bacteria than control. The decrease in the population up to different dates was due to competitive influence and the toxic effect as well as different persistence periods of different chemical herbicides in different soil ecosystems. On the other hand, the increase was affected by the commensalic or proto-cooperative influence of various micro-organisms on total bacteria in the rhizosphere of sugarcane. For all the cases of herbicidal treatments, total bacteria recovered from initial loss and exceeded than initial counts (Ghosh *et al.* 2012).

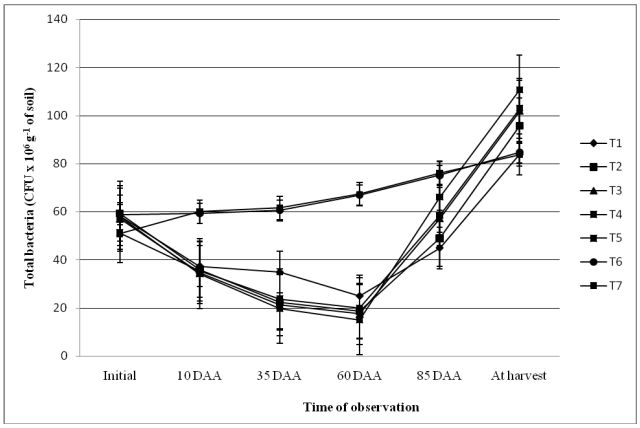

Figure 1. Effect of treatments on total bacteria population

The herbicide atrazine 50% WP and standards ametryn 80% WP, tested in this experiment, showed that there was significant adverse effect on the population of fungi in *rhizosphere* region up to two month after application of the herbicides but at harvest the data showed slightly higher than the initial population of the fungi (Fig.2). From 60 DAA the population is again significantly increased in all the treatments because chemicals are degraded at that time and no toxic effect in the soil remained after the persistence period of the concerned herbicides. But in case of twice hand weeding and unweeded control, it showed slow and steady increase of fungi population. Herbicidal treatments recorded 20.83 to 51.92 % higher population of total bacteria than control at harvest.

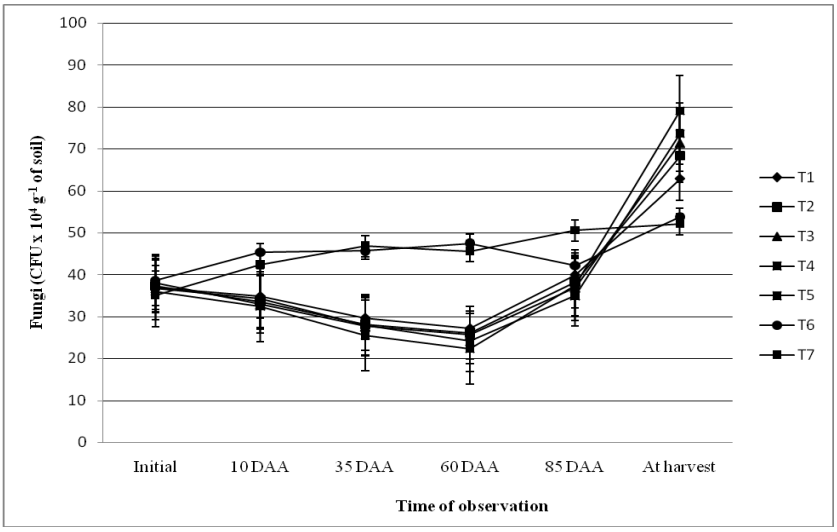

Figure 2. Effect of treatments on fungi population

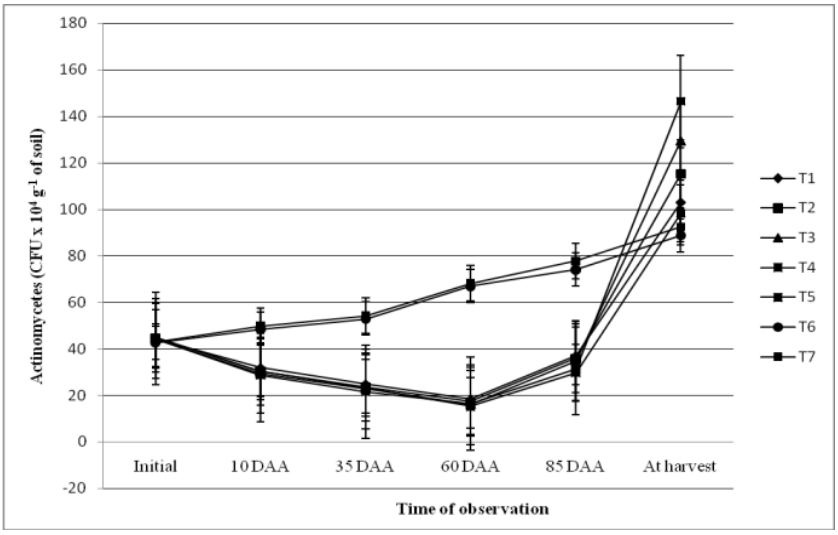

Figure 3. Effect of treatments on actinomycetes population

In case actinomycetes, the herbicide treatments did not vary significantly among themselves in all the four doses of the testing herbicide atrazine 50% WP and the standard herbicide application at initial observation but after herbicide application they differ significantly. The fate of actinomycetes was more or less similar as bacteria. The populations of actinomycetes in the rhizosphere soil of sugarcane decreased up to 60 DAA as compared to the observation before spraying and then increased at harvest for the herbicidal treatments (Fig.3). This might be due to the competitive influence of various micro-organisms on the population of actinomycetes in the rhizosphere soil of sugarcane as well as toxic effect of the chemicals applied. Sapundjieva *et al.* (2008) reported similar findings.

Therefore the testing herbicide did not show any adverse effect on the field soil of the experimental field of sugarcane and was safe in comparison to untreated control. All the treatments recorded no detrimental effect on soil microflora (total bacteria, actinomycetes and fungi) in the long run though the application of herbicides decreased the microflora population initially. With the degradation of applied herbicides within a considerable time, the population even exceeded at harvest than the initial count. Similar findings were recorded by Sokolova and Gulidova, 2010.

Correlation matrix

Weed control efficiency recorded significantly positive correlation with cane length (r=0.920**), weight of one cane (r=0.856*), no. of millable cane per hectare (r=0.750*) and yield (r=0.900**). Cane length had positive correlation with weight of one cane (r=0.977**) and cane yield (r=0.979**). No. of millable cane per hectare and yield are significantly correlated (r=0.950*). Weight of one cane and cane yield are positively correlated between them (r=0.990**). Srivastava *et al.*, 2005; Tomar *et al.,* 2005 earlier reported similar findings. Total bacteria and actinomycetes recorded positive correlation with cane yield (r=0.786* and r=0.754*, respectively). Brix % (r=0.926**) and sucrose % (r=0.860*) showed significant correlation with CCS %. Actinomycetes varied significantly with total bacteria (r=0.803*) (Table 3).

Table 3. Correlations matrix

	WCE%	Cane length	Weight of one cane (kg)	No. of millable cane	Yield (t ha^{-1})	Brix (%)	Sucrose (%)	CCS (%)	total bacteria	fungi	actinomycetes
WCE%	1.000										
Cane length	0.920**	1.000									
Weight of one cane (kg)	0.856*	0.977**	1.000								
No. of millable cane	0.750*	0.724	0.781	1.000							
Yield (t ha^{-1})	0.900**	0.979**	0.990**	0.950**	1.000						
Brix (%)	-0.137	-0.079	0.024	0.140	-0.035	1.000					
Sucrose (%)	-0.172	-0.076	0.104	0.237	0.077	0.469	1.000				
CCS (%)	-0.206	-0.225	-0.144	-0.050	-0.195	0.926**	0.860*	1.000			
Total bacteria	0.606	0.693	0.637	0.543	0.786*	-0.461	-0.319	-0.598	1.000		
fungi	0.745	0.696	0.601	0.460	0.583	-0.478	-0.405	-0.559	0.638	1.000	
actinomycetes	0.509	0.504	0.490	0.402	0.754*	-0.263	-0.320	-0.234	0.803*	0.701	1.000

* and ** denotes significant correlation at 5% and 1% level of significance, respectively

4. Conclusions

Though the microbial population of the soil in the *rhizosphere* region of the sugarcane decreased immediately after herbicide application, it increased at the harvesting time which is even higher than initial population. Overall there is no long-term adverse effect of herbicidal weed management (atrazine) on the microbial population of the soil in the *rhizosphere* region of the sugarcane. Considering effect on soil microflora, growth, yield and quality of sugarcane, atrazine 50 % WP @ 2 kg ha^{-1} can be successful alternative of twice hand weeding.

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