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Impact of insecticides on soil microbial biomass and its activity inegg plant (*Solanum melongena* L.) under field condition

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ABSTRACT

*The effect of application of different insecticides either alone in repeated dose or in sequential combination on soil microbial biomass and its activity were assessed under eggplant cultivation in field conditions for three consecutive years (2015-2018) in both kharif and rabi seasons at Agricultural Experimental Farm, University of Calcutta, Baruipur, Kolkata. Four different insecticides namely Triazophos 40% EC, Cypermethrin 10% EC, Carbaryl 50% WDP and Azadiractin 10000 ppm were sprayed 35-45 days after transplanting and thereafter insecticidal applications were done at an interval of 15 days till harvest. Parallely, these four insecticides in sequences were sprayed 35-45 after transplanting and applied sequentially at an interval of 15 days till harvest at two possible sequences namely Triazophos, Carbaryl, Cypermetrin, Azadiractin or (S1) and Azadiractin, Cypermethrin, Carbaryl, Triazophos or (S2).Soil samples from treated and untreated plots were collected at the time of transplanting, before insecticide application (BIA), Two days after application of all the insecticide (AAIA), and at harvest in both the seasons. The results revealed that samples collected before insecticide application (BIA) showed non-significant (p>0.05) increase or decrease in different microbiological parameters i.e. Soil microbial biomass carbon (SMBC), Basal Soil Respiration (BSR), Substrate induced soil respiration(SIR), Fluorescein diacetate hydrolyzing activity***(***FDHA) with different treatments in both seasons as determined by Duncan's multiple range test (DMRT). However, two days after application of all insecticide in both seasons showed significant (p<0.05) inhibition in different microbiological parameters in comparison to untreated control with maximum inhibition in Triazophos treated plots and minimum in Azadiractin treated plots. Sequential treatments (S1) showed lesser inhibition than all the other treatments except the azadiractin plots while in (S2) the inhibition was found to be more than Cypermethrin and Azadiractin treatment in both the seasons. At harvest, all the microbiological parameters in the treated fields were statistically par with control fields.*

Keywords: Insecticides, soil microbial biomass carbon, Basal soil respiration, Substrate induced soil respiration, Fluorescein diacetate hydrolyzing activity

INTRODUCTION

Soil is the first repository of different insecticides applied to different crops under field condition. It is reported that about 0.1%applied pesticides reaches the target organism whereas the soil environment is contaminated by the remaining bulk (Rajesh *et al.*, 2015).Soil harbors a variety of micro and macrofauna and flora *viz*., bacteria, actinomycetes, fungi, arthropods, crustaceans, earthworms etc. which forms the living dynamic system of the soil. Soil organisms, particularly micro-organisms play a myriad of essential processes in soil starting from organic residue degradation to cycling of nutrients. (Aislabie andDeslippe,2013). Insecticides used frequently ultimately reaches the soil as insecticidal "run off " from the crop plants and is accumulated usually in top 0-15 cm layer of soil where the microbial activities are found to be maximum (Bhavya*etal.* 2017). Pesticides in the soil affect the non target and beneficial microorganisms (Shao & Zhang,2017)and their activities that are essential for maintaining soil fertility (Bowles *et al.* 2014).The effect of pesticide on soil microorganisms is governed not only by the chemical and physical properties of the pesticide itself but also by soil type, soil properties, and prevailing environmental conditions (Kumar *etal.* 2017)**.**The microbial biomass is considered to be the living component of soil organic matter, having 1-5% of total organic matter content(Cardoso *et. al.* 2013,Ma *et.al.* 2016,Arora*et al.* 2019)and it react more quickly to the changes in soil conditions than the soil organic matter(Chaudhary*et al.* 2018).Soil respiration means that the living biomass of soil respires CO_2,where soil organisms gain energy from catabolizing organic matter to support life.

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Therefore, the metabolic activities of soil microorganisms can be quantified by measuring CO_2 evaluation (Ananyeva*et al.*, 2016).Microbial activity measurement in soilassoil respiration has been reported as a criteria for evaluating pesticide toxicity(Jail *et. al.* 2015). Fluorescein diacetate is hydrolyzed by a number of different enzymes such as protease, lipase, and esterase, and its hydrolysis was found by a wide array of primary decomposers such as bacteria and fungi (Patle *et. al.*, 2018).Aziz *et al.* (2013) showed that soil biological quality indices including soil microbial biomass carbon and basal soil respiration are more sensitive and early indicators of soil quality in comparison to soil physical and chemical quality indicators. Fluorescein diacetate hydrolyzing activity (FDHA) can therefore be considered as a suitable tool for measuring the early detrimental effect of pesticides on soil microbial biomass and activity (Majumdar *et. al.* 2010).Many studies have been conducted to assess the effects of single applications of pesticides on soil properties either in laboratory controlled conditions or in the field(Baćmaga *et. al.* 2018, Seth *et. al.* 2016, Arora *et al.* 2019).However, in realistic situations where farmers use different types of insecticides on a crop in one growing season, the situation might be different. The combinations of various pesticides may result in interactions that show additive, synergistic, or antagonistic effects and may deviate from the behaviour of the individual components with regard to their persistence and dispersion (Srinivasulu *et. al.* 2010).Most of the eco-toxicity data come from laboratory studies under controlled conditions. Therefore, the present study was initiated to understand the effect of different insecticides either alone in repeated dose or in sequential combination on soil microbial properties under eggplant cultivation in alluvial soil vis-a-vis field conditions to give a realistic approach towards effect on soil microorganisms.

MATERIALS AND METHODS

The experiment was conducted at Agricultural Experimental Farm, University of Calcutta, Baruipur, ($22^0$22’44.20” N $86^0$26’08.55” E) South 24 Parganas (West Bengal) for three consecutive years (2015-2018) in both *Kharif* and *Rabi* seasons in a randomized block design with four replications. The treatments were: Triazophos 40% EC (300 g.a.i/ha or 1ml/L per ha), Cypermethrin10% EC (60 g.a.i/ha or 1ml/L per ha), Carbaryl50% WDP (1875 g.a.i/ha or 2.5 g/L per ha) and Azadiractin 10000 ppm (5g.a.i/ha or 1ml/L per ha).Insecticide sprays were applied using a pressurized knapsack sprayer fitted with a single-cone nozzle at the rate of 500 L/ha. First sprays of the insecticides were given 35-45 days after transplanting and thereafter insecticidal applications were done at an interval of 15 days till harvest. In repeated applications, the same insecticides were sprayed repeatedly at an interval of 15 days. Sequential application of insecticides were also performed where each of the four insecticides were sprayed one after the other at an interval of 15 days. The two sequential application patterns were chosen on the basis of toxicity of these insecticides. They were Organophosphate-Carbamate-Synthetic Pyrethoids-Botanical (S1) (i.e.Triazophos, Carbaryl, Cypermetrin, Azadiractin) and Botanical pesticide- Synthetic Pyrethoids-Carbamate- Organophosphate (S2) (i.e. Azadiractin, Cypermethrin, Carbaryl, Triazophos).Soil samples from treated and untreated plots were collected at the time of transplanting, before insecticide application (BIA), Two days after application of all the insecticide (AAIA), and at harvest in all the season respectively. The physico-chemical parameters of the air dried soil sample like pH (1: 2 H_2O), organic carbon, total nitrogen, phosphorus and potassium contents were determined following standard methods (Jackson,1967).The soil is having pH of 6.8, Organic carbon 1.3 %, Available Phosphorus content 29.2 $Kgha^{-1}$, Available potassium content 250 $Kgha^{-1}$, Total Nitrogen content 1.11 gkg^{-1}respectively. The microbial biomass-carbon of soil samples was determined by fumigation extraction method (Joergensen1995) followed by determination of K_2SO_4 extractable Carbon (Vance *et al.*, 1987).Biomass C was estimated as: Biomass C = 2.64 Ec, where Ec is the difference between K_2SO_4 extractable C from the fumigated and unfumigated soils. Basal, substrate and induced soil respiration of the soil samples were determined by the methods described by Alef (1995).Fluorescein diacetate hydrolyzing activities (FDHA) of the soil samples were determined following the method of Schnürer and Rosswall (1982).

Treatments were replicated three times in a completely randomized design. Analysis of variance (ANOVA) followed by post-hoc Duncan's Multiple Range Test (DMRT) were applied to evaluate homogeneity or differences between the treatments using SPSS (Version 21.0) statistical software package. Differences obtained at a level of ($p<0.05$) were considered significant.

RESULT AND DISCUSSION

The Soil microbial biomass carbon (SMBC) at different time interval of the cropping seasons (*Kharif* and *Rabi)* represented in Table 1 The results showed that samples collected at the time of transplanting in both the seasons showed non-significant variation in SMBC as determined by Duncan's multiple range test (DMRT). Samples collected 36 days after transplanting i.e. before insecticide application (BIA) showed non-significant increase or decrease among different treatments in both the seasons. In *Kharif* seasons, two days after application of all insecticide showed significant inhibition in soil microbial biomass in Triazophos and Carbaryl treated plots in 2015, Triazophos treated plots in 2016 andTriazophos, Carbaryl and Cypermethrin treated plots in comparison to the control Minimum inhibition was seen in azadiractin plots which was statistically at par with control.In *Rabi*seasons, non-significant variation in SMBC was observed during transplanting and beforeinsecticide application (BIA) among the treatments. However, two days after application of all insecticides significant inhibition in soil microbial biomass in Triazophos treated plots were found in comparison to control.Kalyani*et. al.* (2015) reported that triazophos caused significant reduction in the bacterial and fungal populations in paddy soils.Sequential treatment, S1 showed lesser inhibition than all the other treatments except the azadiractin plots. In another set of sequential treatment i.e.S2 the inhibition was found to be more than cypermethrin and azadiractin treatment in both the seasons. At the time of harvest all the soil microbial biomass in the treated fields was statistically par with control fields in both the seasons respectively.The result therefore indicates that modifications are made in soil microbiological biomass by applying different insecticides in eggplant fields either repeatedly or sequentially has short term transient effects on soil microbiological biomassand the effect are nullified during the end of the season. Pesticide application may also inhibit or kill certain group of microorganisms and outnumber other groups by releasing them from the competition (Hussain *et al.*, 2009).The same was probably observed here.

Table 1: Effect of different insecticidal treatments on Soil Microbial Biomass Carbon (µg g-1 oven dry soil)

Treatments	*Kharif* 2015				*Kharif* 2016				*Kharif* 2017			
	Trans	BIA	AAIA	Harvest	Trans	BIA	AAIA	Harvest	Trans	BIA	AAIA	Harvest
Azadiractin 10000ppm	340^{a*}	347^{a}	342^{a}	352^{a}	364^{a}	365^{a}	351^{a}	369^{a}	341^{a}	343^{a}	336^{a}	344^{a}
Sequentia Treatment (S1)	341^{a}	347^{a}	338^{a}	352^{a}	364^{a}	364^{a}	348^{a}	367^{a}	342^{a}	343^{a}	335^{a}	344^{a}
SequentialTreatment (S2)	339^{a}	347a	327^{ab}	352^{a}	364^{a}	365^{a}	344^{ab}	364^{a}	342^{a}	343^{a}	333^{ab}	342^{a}
Cypermethrin 10% E.C	339^{a}	349^{a}	330^{ab}	352^{a}	365^{a}	365^{a}	345^{ab}	366^{a}	342^{a}	343^{a}	330^{b}	345^{a}
Triazophos 40% E.C	342^{a}	346^{a}	325^{b}	351^{a}	365^{a}	365^{a}	335^{b}	365^{a}	341^{a}	342^{a}	330^{b}	342^{a}
Carbaryl 50% W.D.P	342^{a}	348^{a}	326^{b}	348^{a}	365^{a}	360^{a}	343^{ab}	363^{a}	341^{a}	343^{a}	331^{b}	343^{a}
Control	340^{a}	348^{a}	346^{a}	348^{a}	363^{a}	365^{a}	360^{a}	362^{a}	342^{a}	343^{a}	344^{a}	345^{a}
	Rabi 2015-16				*Rabi* 2016-17				*Rabi* 2017-18			
Azadiractin 10000ppm	302^{a*}	304^{a}	287^{a}	300^{a}	298^{a}	300^{a}	285^{a}	295^{a}	318^{a}	319^{a}	313^{a}	322^{a}
Sequentia Treatment (S1)	303^{a}	304^{a}	287^{a}	296^{a}	300^{a}	300^{a}	284^{a}	291^{a}	318^{a}	319^{a}	311^{a}	320^{a}
SequentialTreatment (S2)	303^{a}	304^{a}	286^{a}	295^{a}	298^{a}	300^{a}	282^{a}	291^{a}	317^{a}	319^{a}	311^{a}	318^{a}
Cypermethrin 10% E.C	303^{a}	305^{a}	287^{a}	296^{a}	299^{a}	300^{a}	283^{a}	292^{a}	318^{a}	318^{a}	311^{a}	317^{a}
Triazophos 40% E.C	304^{a}	305^{a}	280^{b}	294^{ab}	298^{a}	300^{a}	278^{ab}	290^{a}	316^{a}	319^{a}	309^{ab}	314^{a}
Carbaryl 50% W.D.P	305^{a}	304^{a}	284^{ab}	295^{a}	298^{a}	301^{a}	279^{ab}	291^{a}	318^{a}	319^{a}	310^{a}	315^{a}
Control	303^{a}	303^{a}	298^{a}	299^{a}	299^{a}	302^{a}	291^{a}	293^{a}	318^{a}	319^{a}	317^{a}	319^{a}

[*]Means within a column followed same alphabetical letters are not significantly different at p ≤ 0.05 by DMRT
Trans: Transplanting, BIA: Before insecticide application, AAIA: After application of all insecticides

The Basal Soil Respiration (BSR) at different time interval of the cropping seasons of *Kharif* and *Rabi* seasons are represented in Table 2. The results shows that non-significant variation in BSR at transplanting and before insecticide application (BIA) among the treatments at 0.05 P as determined by Duncan's multiple range test (DMRT).The BSR were also found to be reduced in the insecticide treated plots two days after application of all the insecticides but the reduction was found to be non-significant in all the insecticide treatment except triazophos plot where a significant ($p<0.05$) inhibition was found in comparison to the control plots in both the seasons respectively. At the time of harvest all the basal soil respiration in the treated fields was statistically par with control in both the seasons respectively. The study therefore corroborates with the findings of (Whang *et.al.*,2018)who reported negative effect of azoxystrobin on soil respiration. The increase respiration activity during the later part of the study after inhibition of basal soil respiration two days after treatment of all the insecticides might be in accordance with coupling of microbial respiration to the size of increasing population belonging to fast growing r-strategic microorganisms with high respiration activity (Cycon and Seget-Piorowska, 2009).

Table 2: Effect of different insecticidal treatments on Basal Soil Respiration (µg CO_2 –C g^{-1} oven dried soil h^{-1})

Treatments	*Kharif* 2015				*Kharif* 2016				*Kharif* 2017			
	Trans	BIA	AAIA	Harvest	Trans	BIA	AAIA	Harvest	Trans	BIA	AAIA	Harvest
Azadiractin 10000ppm	0.8^{a*}	0.82^{a}	0.77^{a}	0.85^{a}	0.85^{a}	0.84a	0.81^{a}	0.85^{a}	0.75^{a}	0.74^{a}	0.71^{a}	0.77^{a}
Sequentia Treatment (S1)	0.8^{a}	0.82^{a}	0.75^{a}	0.85^{a}	0.85^{a}	0.84^{a}	0.77^{a}	0.85^{a}	0.75^{a}	0.75^{a}	0.69^{a}	0.73^{ab}
Sequential Treatment (S2)	0.81^{a}	0.83^{a}	0.76^{a}	0.81^{a}	0.84^{a}	0.85^{a}	0.75^{a}	0.81^{ab}	0.75^{a}	0.75^{a}	0.68^{a}	0.72^{b}
Cypermethrin 10% E.C	0.8^{a}	0.81^{a}	0.77^{a}	0.84^{a}	0.84^{a}	0.83^{a}	0.77^{a}	0.84^{a}	0.74^{a}	0.76^{a}	0.69^{a}	0.72^{b}
Triazophos 40% E.C	0.8^{a}	0.81^{a}	0.73^{b}	0.82^{a}	0.85^{a}	0.84^{a}	0.73^{b}	0.78^{b}	0.75^{a}	0.75^{a}	0.66^{b}	0.69^{b}
Carbaryl 50% W.D.P	0.8^{a}	0.83^{a}	0.75^{a}	0.81^{a}	0.85^{a}	0.84^{a}	0.74^{b}	0.81^{ab}	0.76^{a}	0.74^{a}	0.68^{a}	0.71^{b}
Control	0.8^{a}	0.81^{a}	0.8^{a}	0.85^{a}	0.85^{a}	0.84^{a}	0.82^{a}	0.86^{a}	0.75^{a}	0.75^{a}	0.73^{a}	0.76^{a}
	Rabi 2015-16				*Rabi* 2016-17				*Rabi* 2017-18			
Azadiractin 10000ppm	0.79^{a*}	0.78^{a}	0.75^{a}	0.79^{a}	0.79^{a}	0.78^{a}	0.72^{a}	0.75^{a}	0.8^{a}	0.81^{a}	0.78^{a}	0.81^{a}
Sequentia Treatment (S1)	0.76^{a}	0.77^{a}	0.74^{a}	0.78^{a}	0.79^{a}	0.78^{a}	0.71^{a}	0.74^{a}	0.8^{a}	0.81^{a}	0.77^{a}	0.8^{a}
Sequential Treatment (S2)	0.78^{a}	0.76^{a}	0.71^{b}	0.78^{a}	0.77^{a}	0.78^{a}	0.7^{a}	0.76^{a}	0.8^{a}	0.8^{a}	0.75^{a}	0.8^{a}
Cypermethrin 10% E.C	0.78^{a}	0.76^{a}	0.73^{a}	0.77^{a}	0.79^{a}	0.77^{a}	0.71^{a}	0.74^{a}	0.8^{a}	0.8^{a}	0.76^{a}	0.8^{a}
Triazophos 40% E.C	0.79^{a}	0.76^{a}	0.71^{b}	0.73^{b}	0.78^{a}	0.78^{a}	0.69^{b}	0.72^{a}	0.79^{a}	0.81^{a}	0.72^{b}	0.77^{a}
Carbaryl 50% W.D.P	0.78^{a}	0.76^{a}	0.71^{b}	0.77^{a}	0.78^{a}	0.79^{a}	0.7^{a}	0.73^{a}	0.79^{a}	0.82^{a}	0.73^{b}	0.79^{a}
Control	0.79^{a}	0.77a	0.76^{a}	0.81^{a}	0.79^{a}	0.78^{a}	0.75^{a}	0.73^{a}	0.81^{a}	0.82^{a}	0.81^{a}	0.81^{a}

The Substrate induced Soil Respiration (SIR) at different time interval of the cropping seasons of *Kharif* and *Rabi* seasons are represented in Table 3. The SIR followed similar trend as SMBC and BSR at time of transplanting and before pesticide application. The SIR was significantly ($p<0.05$) reduced in triazophos treated plots comparison to the control in *Kharif* 2015, *Rabi* 2015-16 and *Rabi* 2017-18. This was in support of the study made by Vig*et al.* (2008)who reported that SIR was found to be reduced in field ten days after treatment with triazophos.The increase in SIR was much more than BSR during the later part of the study which might be due to community shift towards fast growing organisms due to availability of more substrate with less competition (Schimdt*et. al.*, 2018, Hussain *et al.*, 2009).

The Fluorescein diacetate hydrolyzing activity (FDHA) at different time interval of the cropping seasons of *Kharif* and *Rabi* seasons are represented in Table 4. Fluorescein diacetate hydrolyzing activity (FDHA) was found to be significantly reduced in only triazophos treated plots in comparison to control in *Kharif* 2015, *Rabi* 2015-16 and *Rabi* 2017-18 respectively two days after application of all insecticides. Fluorescein diacetate hydrolyzing activity (FDHA) was found to be statistically par with control among all the treatments at transplanting, before insecticide application and harvest in both the seasons. It has been reported by (Alef, 1995) that active microbial cells transport fluorescein diacetate inside the cells where it is hydrolyzed

Table 3: Effect of different insecticidal treatments on Substrate Induced Soil Respiration (µg CO_2 –C g^{-1} oven dried soil h^{-1})

Treatments	*Kharif* 2015				*Kharif* 2016				*Kharif* 2017			
	Trans	BIA	AAIA	Harvest	Trans	BIA	AAIA	Harvest	Trans	BIA	AAIA	Harvest
Azadiractin 10000ppm	2.57^{a*}	2.58^{a}	2.52^{a}	2.56^{a}	2.61^{a}	2.6^{a}	2.52^{a}	2.6^{a}	2.5^{a}	2.52^{a}	2.47^{a}	2.51^{a}
Sequentia Treatment (S1)	2.58^{a}	2.58^{a}	2.5^{ab}	2.55^{a}	2.62^{a}	2.59^{a}	2.51^{a}	2.55^{a}	2.51^{a}	2.52^{a}	2.45^{a}	2.5^{a}
Sequential Treatment (S2)	2.57^{a}	2.59^{a}	2.48^{b}	2.5^{ab}	2.62^{a}	2.61^{a}	2.49^{ab}	2.59^{a}	2.51^{a}	2.53^{a}	2.43^{ab}	2.5^{a}
Cypermethrin 10% E.C	2.57^{a}	2.58^{a}	2.49^{ab}	2.52^{a}	2.61^{a}	2.6^{a}	2.5^{a}	2.6^{a}	2.51^{a}	2.52^{a}	2.44^{a}	2.5^{a}
Triazophos 40% E.C	2.58^{a}	2.58^{a}	2.46^{b}	2.48^{b}	2.62^{a}	2.59^{a}	2.48^{ab}	2.51^{ab}	2.51^{a}	2.52^{a}	2.42^{ab}	2.49^{a}
Carbaryl 50% W.D.P	2.56^{a}	2.59^{a}	2.48^{b}	2.51^{ab}	2.61^{a}	2.62^{a}	2.49^{ab}	2.55^{a}	2.53^{a}	2.49^{a}	2.43^{ab}	2.51^{a}
Control	2.57^{a}	2.58^{a}	2.57^{a}	2.57^{a}	2.62^{a}	2.6^{a}	2.56^{a}	2.59^{a}	2.52^{a}	2.51^{a}	2.48^{a}	2.56^{a}
	Rabi 2015-16				*Rabi* 2016-17				*Rabi* 2017-18			
Azadiractin 10000ppm	2.14^{a*}	2.15^{a}	2.08^{a}	2.16^{a}	2.2^{a}	2.18^{a}	2.08^{a}	2.16^{a}	2.42^{a}	2.43^{a}	2.39^{a}	2.42^{a}
Sequentia Treatment (S1)	2.14^{a}	2.15^{a}	2.06^{ab}	2.14^{a}	2.18^{a}	2.18^{a}	2.07^{a}	2.15^{a}	2.41^{a}	2.44^{a}	2.38^{a}	2.42^{a}
Sequential Treatment (S2)	2.13^{a}	2.16^{a}	2.06^{ab}	2.13^{a}	2.21^{a}	2.17^{a}	2.06^{ab}	2.12^{ab}	2.41^{a}	2.42^{a}	2.37^{a}	2.41^{a}
Cypermethrin 10% E.C	2.14^{a}	2.15^{a}	2.07^{ab}	2.13^{a}	2.19^{a}	2.17^{a}	2.06^{ab}	2.16^{a}	2.41^{a}	2.43^{a}	2.38^{a}	2.41^{a}
Triazophos 40% E.C	2.15^{a}	2.16^{a}	2.03^{b}	2.1^{a}	2.22^{a}	2.19^{a}	2.03^{b}	2.1^{ab}	2.4^{a}	2.43^{a}	2.34^{ab}	2.38^{ab}
Carbaryl 50% W.D.P	2.15^{a}	2.16^{a}	2.05^{b}	2.1^{a}	2.2^{a}	2.17^{a}	2.05^{b}	2.13^{a}	2.41^{a}	2.45^{a}	2.35^{ab}	2.39^{a}
Control	2.16^{a}	2.15^{a}	2.17^{a}	2.18^{a}	2.2^{a}	2.18^{a}	2.16^{a}	2.19^{a}	2.42^{a}	2.43^{a}	2.44^{a}	2.45^{a}

in to polar fluorescein. Therefore the reduction in FDHA in the following seasons in triazophos treated plots could be linked to significant reduction in the microbial biomass.

Table 4: Effect of different insecticidal treatments on FDHA (µg fluorescein g^{-1} oven dry soil hr^{-1} at $24^{0}C$)

Treatments	*Kharif* 2015				*Kharif* 2016				*Kharif* 2017			
	Trans	BIA	AAIA	Harvest	Trans	BIA	AAIA	Harvest	Trans	BIA	AAIA	Harvest
Azadiractin 10000ppm	96^{a*}	98^{a}	92^{a}	98^{a}	107^{a}	106^{a}	97^{a}	106^{a}	96^{a}	95^{a}	88^{a}	95^{a}
Sequentia Treatment (S1)	96^{a}	99^{a}	92^{a}	97^{a}	106^{a}	105^{a}	96^{a}	105^{a}	96^{a}	95^{a}	88^{a}	95^{a}
Sequential Treatment (S2)	96^{a}	99^{a}	90^{a}	97^{a}	106^{a}	105^{a}	96^{a}	103^{a}	96^{a}	96^{a}	87^{a}	93^{a}
Cypermethrin 10% E.C	96^{a}	98^{a}	91^{ab}	97^{a}	106^{a}	106^{a}	96^{a}	102^{a}	96^{a}	95^{a}	88^{a}	93^{a}
Triazophos 40% E.C	96^{a}	98^{a}	88^{b}	96^{a}	106^{a}	107^{a}	94^{ab}	100^{ab}	96^{a}	95^{a}	87^{ab}	92^{a}
Carbaryl 50% W.D.P	96^{a}	98^{a}	90^{ab}	96^{a}	106^{a}	105^{a}	95^{ab}	102^{a}	96^{a}	95^{a}	87^{a}	94^{a}
Control	96^{a}	98^{a}	98^{a}	99^{a}	107^{a}	107^{a}	102^{a}	104^{a}	96^{a}	95^{a}	96^{a}	97^{a}
	Rabi 2015-16				*Rabi* 2016-17				*Rabi* 2017-18			
Azadiractin 10000ppm	80^{a*}	79^{a}	69^{a}	75^{a}	79^{a}	80^{a}	72^{a}	79^{a}	80^{a}	81a	73^{b}	80^{a}
Sequentia Treatment (S1)	80^{a}	79^{a}	69^{a}	74^{a}	80^{a}	80^{a}	72^{a}	78^{a}	80^{a}	80^{a}	70^{ab}	80^{a}
Sequential Treatment (S2)	80^{a}	79^{a}	69^{a}	73^{a}	79^{a}	80^{a}	71^{ab}	75^{a}	80^{a}	80^{a}	69^{b}	80^{a}
Cypermethrin 10% E.C	79^{a}	79^{a}	69^{a}	73	79^{a}	80^{a}	72^{a}	75a	80^{a}	80^{a}	70^{ab}	80^{a}
Triazophos 40% E.C	80^{a}	79^{a}	67^{b}	70^{ab}	79^{a}	80^{a}	70^{ab}	75^{a}	80^{a}	80^{a}	67^{b}	79^{a}
Carbaryl 50% W.D.P	80^{a}	79^{a}	69^{a}	76^{a}	80^{a}	80^{a}	70^{ab}	75^{a}	80^{a}	81^{a}	69^{b}	79^{a}
Control	79^{a}	79^{a}	75^{a}	74^{a}	79^{a}	80^{a}	77^{a}	80^{a}	80^{a}	81^{a}	80^{a}	79^{a}

In the present study, the insecticide treatments did not produce any long lasting effects on the studied microbial parameters. It was reported by Vig*et al.* (2008) that usually after an initial toxic effect, mineralization of insecticides leads to an increase in substrate for microbial growth which might be the reason for increase in their numbers after many insecticide treatments. Also it has been reported that in general normal recommend rates of field application of insecticide have short term inhibitory side effects on microbial biomass and basal respiration these effects are usually disappeared at the end of incubation (Zhang *et. al.* 2014). The yield data in different *Kharif* and *Rabi* seasons were represented in Table 5. Within the treatments in different *Kharif* and *Rabi* seasons, maximum yield is recorded in sequential treatment (S2) which is followed by Triazophos sequential treatment (S1) treatment. However, all these three treatments were statistically at par at 5 % level of significance. This was followed by Carbaryl and Cypermethrin treatment which showed a moderate yield. Azadiractin treatments recorded minimum yield with in the insecticidal treatments in all the seasons respectively.

Table5: Total yield of eggplant fruits (q ha^{-1}) in different treatments

Treatments	Kharif 2015	Kharif 2016	Kharif 2017	Rabi 2015-16	Rabi 2016-17	Rabi 2017-18
Azadiractin 10000ppm	81.1^{c*}	80.5^{b}	79.5^{c}	91.8^{c}	90.5^{b}	89.3^{bc}
Sequentia Treatment (S1)	134.8^{a}	118.7^{a}	128.9^{a}	138.2^{a}	136.3^{a}	134.4^{a}
Sequential Treatment (S2)	135.2^{a}	122.2^{a}	132.2^{a}	143.3^{a}	142.2^{a}	138.6^{a}
Cypermethrin 10% E.C	97.1^{bc}	90.1^{b}	100.9^{bc}	117.1^{b}	97.0^{b}	102.5^{b}
Triazophos 40% E.C	136.4^{a}	121.9^{a}	129.2^{a}	142.2^{a*}	141.4^{a}	137.5^{a}
Carbaryl 50% W.D.P	116.3^{b}	106.4^{ab}	113.6^{b}	120.1^{b}	106.8^{b}	109.7^{b}
Control	68.3^{d}	58.3^{c}	60.3^{d}	78.3^{d}	81.4^{c}	80.0^{c}

In conclusion, the present study revealed that there was a short term transient effect of application of different insecticides in alluvial soil either alone in repetition or in sequential combination on soil microbiological parameters.

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