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Relative toxicity of some chemicals to bihar hairy caterpillar, *Spilarctia obliqua* Walker (Arctiidae, Lepidoptera)

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ABSTRACT

The relative toxicity of six insecticides to third instar larvae of *Spilarctia obliqua* (Wlk) was studied in the laboratory condition. On the basis of LC_{50} values (% ai), the descending order of toxicity was: emamectin benzoate 5 SG (0.00005), cypermethrin 10 AF (0.00013), indoxacarb 14.5 SC (0.00053), endosulfan 35 EC (0.00323), fenvalerate 20 EC (0.00340) and fenpropathrin 30 EC (0.00513). Considering the LC_{50} value of fenpropathrin 30 EC as unity (being least toxic), fenvalerate 20 EC, endosulfan 35 EC, indoxacarb 14.5 SC, cypermethrin 10 AF and emamectin benzoate 5 SG were 1.51, 1.59, 9.68, 39.46 and 102.6 times, respectively, more toxic than fenpropathrin 30 EC.

Key words : *Spilarctia obliqua*, emamectin benzoate 5 SG and indoxacarb 14.5 SC.

Bihar hairy caterpillar, *Spilarctia obliqua* (Wlk) is a polyphagus pest, feeding on pulses, sesamum, linseed, cotton, jute, sorghum, groundnut and some vegetables. During the early instars, the caterpillars feed gregariously on the leaves and then disperse. In severe infestations, plants may be completely denuded (Srivastava, 1993). Earlier, about three dozen insecticides were evaluated by various workers against this pest. Some of these include cypermethrin, deltamethrin, fenvalerate, fenpropathrin, fluvalinate, endosulfan, parathion-methyl and monocrotophos (Nagia *et al.* 1990; Jaglan and Sircar, 1997). In the present study the relative toxicity of two new chemicals namely emamectin benzoate 5% SG and indoxacarb 14.5% SC was investigated on 3rd instar larvae of *S. obliqua* along with some common one like endosulfan, cypermethrin, fenvalerate and fenpropathrin.

MATERIALS AND METHODS

The experiment was conducted in the Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during June, 2005 – June, 2006. Bihar hairy caterpillar *Spilarctia obliqua,* taken from nucleus culture maintained in this laboratory, were reared on castor leaves. Six concentrations of each chemical were prepared for the study. Castor leaves were dipped in these chemical solutions, dried under fan and were placed into plastic containers. Thirty 3rd instar larvae of uniform size were released in each container. Each treatment was replicated thrice. For control, leaves are dipped in plain water and then dried. Observations were taken 24 hours after treatment. The percent mortality observed in different treatments was corrected by using modified Abbotts formula (Abbott, 1925). To calculate the LC_{50} values, data obtained on mortality were subjected to probit analysis (Finney, 1971). Relative toxicity of the chemicals was determined on the basis of LC_{50} values, considering the chemicals possessing the highest LC_{50} value as unity.

RESULTS AND DISCUSSION

The data presented in the Table-1, revealed that emamectin benzoate 5 SG showed lowest LC_{50} value (0.00005) and was most toxic among all the chemicals to the 3rd instar larvae of *S. obliqua* followed by cypermethrin 10 AF (0.00013), indoxacarb 14.5 SC (0.00053), endosulfan 35 EC (0.00323), fenvalerate 20 EC (0.00340) and fenpropathrin 30 EC (0.00513). Considering the LC_{50} value of fenpropathrin 30 EC as unity (being least toxic), fenvalerate 20 EC, endosulfan 35 EC, indoxacarb 14.5 SC, cypermethrin 10 AF and emamectin benzoate 5 SG were 1.51, 1.59, 9.68, 39.46 and 102.6 times, respectively, more toxic than fenpropathrin 30 EC. The results of the present studies are in conformity with that of Gupta *et al.* (2004) who reported that emamectin benzoate (proclaim) was more toxic than fenvalerate, indoxacarb, cypermethrin and endosulfan to *Spodoptera litura* (Fabr.).

Hence, it is evident that proclaim is most toxic among all the chemicals tested against larvae of Bihar hairy caterpillar and may be utilized to control this pest.

Table 1 : Relative toxicity and LC_{50} values of different chemicals on 3rd instar larvae of *Spilarctia obliqua*

Chemicals	d.f.	Heterogeneity (χ^2)	Regression equation	LC_{50} (% a.i.)	Fiducial limit	Relative toxicity
Fenpropathrin 30 EC	4	5.261	Y= 4.24032 + 1.85190X	0.00513	0.00442 0.00597	1
Fenvalerate 20 EC	4	6.994	Y= 3.03090 + 1.22770X	0.00340	0.00218 0.00525	1.51
Endosulfan 35 EC	4	14.591	Y= 5.50439 + 2.20970X	0.00323	0.00222 0.00481	1.59
Indoxacarb 14.5 SC	4	12.482	Y= 9.16748 + 2.80099X	0.00053	0.00040 0.00072	9.68
Cypermetrin 10 AF	4	2.807	Y= 5.13157 + 1.32068	0.00013	0.00011 0.00016	39.46
Emamectin benzoate 5 SG	4	11.381	Y= 10.30624 + 2.39476X	0.00005	0.00004 0.00007	102.6

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Persistence of herbicides and its impact on soil micro flora in rice-rice system

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ABSTRACT

Experiments were carried out in the field and laboratory during 2001-02 to study the persistence of three herbicides, namely butachlor, pretilachlor (Rifit) and 2,4-D in a rice – rice system and the effect of their residues on soil micro flora. Irrespective of the seasons and treatments, all the three herbicides dissipated quickly from soil and no residues were detected at the time of harvest. Even in the plots where butachlor was sprayed continuously for the four crop seasons without addition of organic matter, more than 96.20 per cent of the applied herbicide disappeared from the soil by 30 days after spraying. Therefore, alternate application of butachlor or pretilachlor between years or seasons could not exert any influence on their persistence in soil. The results also indicated that considerable variation in the microbial population would result from the application of herbicides. However, the change was observed only for a short period. Drastic decline in the population of soil bacteria noticed at one day after the application of herbicides extended up to 30 to 45 days in the first crop and 15 to 30 days in the second crop. In all the treatments, microorganisms attained the initial (normal) level of population by the time of harvest. Inhibitory effect of the herbicides was more on soil bacteria than soil fungi or actinomycetes and the extent of inhibition was more manifested by the application of butachlor than pretilachlor. The treatments with farmyard manure had higher population of micro flora at all the sampling intervals and they registered higher rate of degradation of butachlor, pretilachlor and 2,4-D in the soil.

***Key words* :** Herbicide persistence, soil micro flora, rice-rice system, influence of organic matter

An understanding of the persistence of herbicides used in a cropping system is important for assessing their pollution potential. Several experiments conducted in different parts of India with single application of herbicides in rice crop showed that at recommended rates of application of 0.75 to 2.00 kg ha^{-1}, butachlor, pretilachlor and 2,4-D did not persist in the soil beyond the time of harvest (Kulshrestha *et al*., 1981, Jayakumar and Sreeramulu, 1993., Deka and Gogoi, 1993., Devi *et al*. 1997 and Devi, 2002. Microbial degradation is one of the major processes responsible for dissipation of herbicides in soil. Application of organic matter enhanced the microbial activity and reduced the inhibitory effects of herbicides on microbes (Bolan and Baskaran, 1996). However, there are only limited reports on the cumulative effect of pre and post emergence herbicides on the soil micro flora when these chemicals are used continuously for more than one year. The present study was programmed to evaluate the persistence and degradation of common rice herbicides in the cropping system, to study the effect of organic matter on herbicide residue build up in soil and to compare the status of the soil micro flora and herbicide residues in soil under single and repeated application of the same herbicide.

MATERIALS AND METHODS

Trials were conducted in the first and second crop seasons of 2001 and 2002 with six treatments (Table 1). Rate of application of each herbicide was kept uniform in all the crop seasons. (Butachlor @ 1.25 kg ha^{-1}: Pretilachlor @ 0.75 kg ha^{-1} : 2,4-D @ 1.0 kg ha^{-1}). Fertilizers were applied as per the Package of Practices- Recommendations of Kerala Agricultural University and the recommended rate of 70: 35:35 kg ha^{-1} through fertilizer was taken as 100% NPK. In the two treatments viz., T4 and T6, 25 % N, P and K (17.5 kg N, 8.75 kg P_2O_5 and K_2O) were replaced through FYM. Both butachlor and pretilachlor were applied as pre emergence spray at 8 days after sowing (since phytotoxicity was more when applied before 8 days especially under flooded situation in the rainy season) and 2,4-D was applied at three weeks after sowing. Herbicides residues in the soil were estimated from the soil samples taken at first and second crop seasons of 2002 by taking soil samples from the plots at 1 and 30 days after spraying and at the time of harvest. Gas chromatographic methods suggested by Sankaran *et al*. (1993) were used for the analysis of the residues.

For studying the effect of herbicide application on the total population of bacteria and fungi, soil samples were taken from the plots at 0,1,7,15,30 and 45 days after spraying. Each soil sample was introduced into soil dilutions of 10^{-4} and 10^{-6} for fungi and bacteria respectively and plated on to the respective enrichment media. (Martin's rose bengal streptomycin agar and soil extract agar respectively for fungi and bacteria, Rangaswami, 1988). Observations on the total number of bacteria per 10^{-6} g soil and fungal colonies per 10^{-4} g soil were recorded. In order to see variations in the population of soil bacteria and fungi due to various weed control treatments in the rice-rice cropping system, their percentage variation over the normal population at varying intervals were worked out. Population before spraying (0 DAS) was taken as normal population (100 %) for each treatment. By subtracting the percentage change from normal, their population at different sampling intervals were worked out and those values were taken on the (y) axis for plotting the graphs. Sampling intervals were plotted on the X axis.

RESULTS AND DISCUSSION

Persistence of butachlor

The results indicated that the initial residues (at 1 DAS) remain more or less same in both the crop seasons and about 89 to 95% of the applied herbicide (the change in concentration ranged from -89.47% to -94.95 % for the first crop and -94.16 % (only one treatment) for the second crop) had been dissipated from the soil within 30 days after spraying (Table 2.). Greater losses were observed in the FYM applied plots (94.95%). Since soil microorganisms are involved in the degradation of butachlor (Pionke and Chesters (1973), Beestman and Deming (1974), Chen and Wu (1978)) added organic matter would have enhanced their activity. Disappearance of the residue from the plot which received continuous application of butachlor without FYM (T_2) was faster in the second crop season.

Persistence of pretilachlor

About 86.81% to 96.00% of the applied pretilachlor had disappeared from the soil by 30 days after spraying (Table 3). Higher losses of pretilachlor were observed in the plots which received FYM (93.52% to 96.00%). As in the case of butachlor, higher degree of dissipation was noticed in the second crop season. The results of the present investigation indicated similarities in the pattern of dissipation of butachlor and pretilachlor in the paddy field under a particular agro climatic condition.

Table 1 : Treatments applied for two years in the rice-rice system

Treatments	2001		2002	
	First crop	Second crop	First crop	Second crop
T_1	HW (Farmer's practice)	HW (Farmer's practice)	HW (Farmer's practice)	HW (Farmer's practice)
T_2	Butachlor + 2,4-D (100% NPK)	Butachlor + 2,4-D (100% NPK)	Butachlor + 2,4-D (100% NPK)	Butachlor + 2,4-D (100% NPK)
T_3	Butachlor + 2,4-D (100% NPK)	Pretilachlor + 2,4-D (100% NPK)	Butachlor + 2,4-D (100% NPK)	Pretilachlor + 2,4-D (100% NPK)
T_4	Butachlor + 2,4-D (75% NPK + 25% FYM through)	Pretilachlor + 2,4-D (100% NPK)	Butachlor + 2,4-D (75% NPK+25% FYM through)	Pretilachlor + 2,4-D (100% NPK)
T_5	Butachlor + 2,4-D (100% NPK)	Butachlor + 2,4-D (100% NPK)	Pretilachlor, + 2,4-D (100% NPK)	Pretilachlor +2,4-D (100% NPK)
T_6	Butachlor + 2,4-D (75% NPK + 25% FYM)	Butachlor) + 2,4-D (100% NPK)	Pretilachlor, + 2,4-D (75% NPK+25% FYM)	Pretilachlor + 2,4-D (100% NPK)

Table 2 : Butachlor residues in the soil (µg g^{-1}) during the first and second crop seasons of 2002

Treatments	First crop			Second crop		
	1 DAS	30 DAS	Harvest	1 DAS	30 DAS	Harvest
T_1	NA	NA	NA	NA	NA	NA
T_2	0.3310	0.0240 (-92.75)	BDL	0.3430	0.020 (-94.16)	BDL
T_3	0.3895	0.0410 (-89.47)	BDL	NA	NA	NA
T_4	0.3960	0.0200 (-94.95)	BDL	NA	NA	NA
T_5	NA	NA	NA	NA	NA	NA
T_6	NA	NA	NA	NA	NA	NA

Table 3 : Pretilachlor residues in the soil (µg g^{-1}) during the first and second crop seasons of 2002

Treatments	First crop			Second crop		
	1 DAS	30 DAS	Harvest	1 DAS	30 DAS	Harvest
T_1	NA	NA	NA	NA	NA	NA
T_2	NA	NA	NA	NA	NA	NA
T_3	NA	NA	NA	0.2275	0.030 (-86.81)	BDL
T_4	NA	NA	NA	0.1990	0.010 (-94.97)	BDL
T_5	0.2150	0.0205 (-90.70)	BDL	0.2310	0.025 (-89.18)	BDL
T_6	0.2005	0.0130 (-93.52)	BDL	0.2500	0.010 (-96.00)	BDL

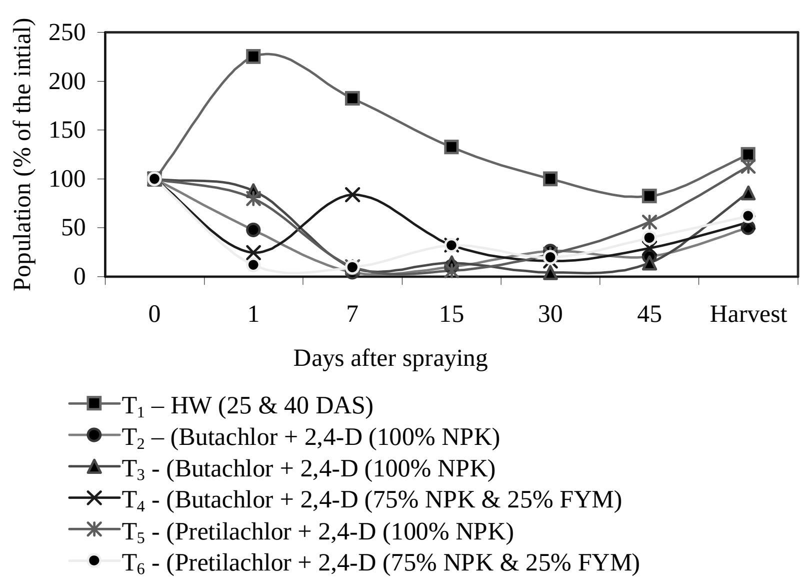
DAS – Days after spraying : NA - Not analysed when the particular herbicide was not applied (the treatment consists either butachlor or pretilachlor) : BDL – Below detectable level.
Figures in parentheses indicate the percentage change from one day after spraying.

Table 4 : 2,4-D residues in the soil (µg g^{-1}) during the first and second crop seasons of 2002

Treatments	First crop			Second crop		
	1 DAS	30 DAS	Harvest	1 DAS	30 DAS	Harvest
T_1	NA	NA	NA	NA	NA	NA
T_2	0.385	0.020 (-94.80)	BDL	0.480	0.016 (-96.67)	BDL
T_3	0.310	0.035 (-88.70)	BDL	0.420	0.01 (-96.43)	BDL
T_4	0.502	0.015 (-97.01)	BDL	0.400	0.005 (-98.75)	BDL
T_5	0.390	0.015 (-98.15)	BDL	0.470	0.010 (-97.87)	BDL
T_6	0.400	0.010 (-97.5)	BDL	0.395	0.005 (-98.73)	BDL

DAS – Days after spraying : NA - Not analysed (No 2,4-D treatment) BDL – Below detectable level.
Figures in parentheses indicate the percentage change from one day after spraying

First crop



Second crop

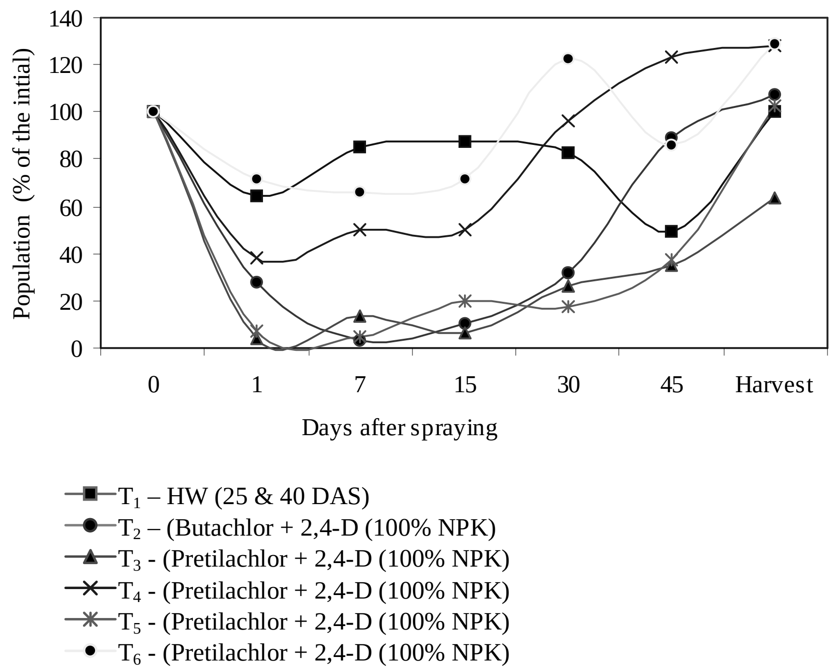
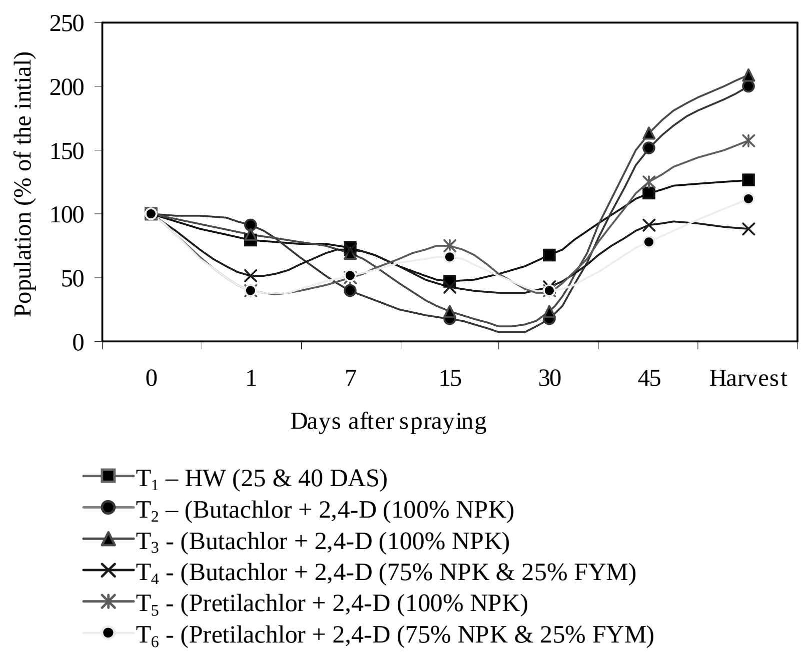


Fig. 1 : Changes in the population of soil bacteria in the first and second crop seasons due to application of herbicides

First crop



Second crop

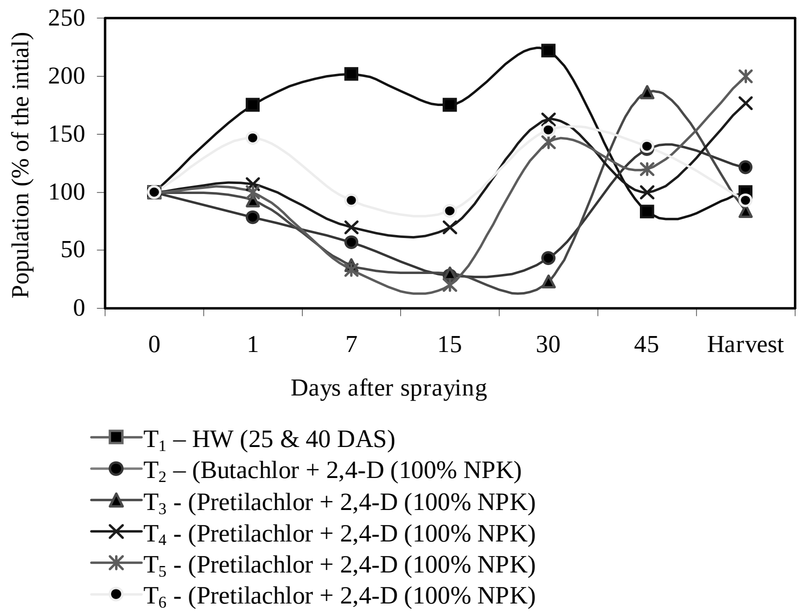


Fig. 2 : Changes in the population of soil fungi in the first and second crop seasons due to application of herbicides to wet land paddy

Persistence of 2,4-D

Residues of 2,4-D also dissipated quickly from the soil. About 88.70% to 98.75% of the applied herbicide had been dissipated from the soil by 30 DAS, which received FYM (Table 4). Devi (2002) reported that degradation of 2,4-D in the rice soils of Kerala followed first order rate equation with half-lives ranging from 3.44-10.76 days.

EFFECT ON SOIL MICROFLORA

Effect on soil bacteria

The population of bacteria changed over varying time intervals in a crop season. There was an increase in the population of soil bacteria from 0 to 15 DAS in the hand weeded plot. The population came down and attained initial level by the time of harvest. In the herbicide treatments, population of soil bacteria was lower during 15 and 30 days after spraying in the first and second crop seasons respectively. Maximum reduction was noticed at 7 DAS in both the crop seasons, except in the pretilachlor + FYM treatment. Farm yard manure application would have reduced the toxicity of pretilachlor and hence the population of bacteria was higher at 7 DAS than that of 1 DAS.

In the plot where butachlor was followed by 2,4-D during the first and second crop seasons (T_2) percentage reduction in soil bacteria was 95.20 % in the first crop and 96.8 % during the second crop season. In both the seasons maximum percent reduction was noticed at 7 DAS. The treatment T_3 (butachlor fb 2,4-D with 100 % NPK in first crop and pretilachlor fb 2,4-D with 100 % NPK in second crop) also recorded about 96.00 % reduction in population during both the seasons. In the first crop, maximum reduction was noticed at 30 DAS while in the second crop season drastic reduction was observed immediately after spraying (1 DAS) which prolonged up to 15 DAS only. The result indicated that the effect of pretilachlor on the soil bacteria was comparatively lesser than that of butachlor.

In the FYM applied plot (T_4) when butachlor fb 2,4-D was alternated with pretilachlor fb 2,4-D in the second crop season, the percentage reduction was less (61.70% to 84.10%).

In the plot where pretilachlor fb 2,4-D was applied during the two crop seasons without FYM application, percent inhibition of bacterial growth during the first crop at 15 DAS was 96.0 % while in the second crop season percentage inhibition was 80.5 %. When pretilachlor was sprayed in the FYM treated plots the negative effect of herbicide was less compared to the plot which received no FYM. Here also maximum reduction was noticed in the first crop season (90.4%).

Effect on soil fungi

The results revealed that population of fungi in the soil also varied with time. In all the treatments percentage inhibition was comparatively less for soil fungi than for soil bacteria (Fig.1& 2). When butachlor fb 2,4-D was continuously applied during first and second crop seasons, maximum reduction in population of fungi was observed at 15 DAS (81.9 and 71.8 per cent for the first and second crop seasons respectively). It was also noticed that both butachlor and pretilachlor (T_3) inhibited the fungal population to the same magnitude (76.8 %) in both the seasons. So, pretilachlor was equally harmful to soil fungi as butachlor, while in the case of bacteria the inhibitory effect of pretilachlor was less compared to that of butachlor.

In the plots which received FYM when sprayed with butachlor during the first crop season and pretilachlor in the second crop season, variation in the population of fungi occurred to a lesser magnitude (56.76 and 30.30 % for butachlor and pretilachlor respectively). When pretilachlor was applied continuously in first and second crop seasons without the application of FYM, fungal population was inhibited to a greater extent during second crop season. Observations recorded from T_6 (pretilachlor fb 2,4-D with 75 % NPK and 25 % FYM) made clear that the inhibitory effect of pretilachlor on soil fungi was less when sprayed after the application of FYM.

The above results on the effect of treatments on the soil microflora can be summarized in the following manner. The reduction in the population of bacteria and fungi due to the application of herbicides is indicative of the harmful effect of these chemicals to certain species of microflora. However, their total population remained unchanged at the time of harvest due to the low persistence of residues in soil. The results revealed that inhibitory effect of butachlor or pretilachlor or 2,4-D on the soil microorganisms is only temporary. Similar effects have been reported by Ghatak *et al.* (2006) when pre emergence herbicide fluchloralin was applied to soil. Farmyard manure enhanced the population of soil bacteria and fungi and reduced the adverse effect of herbicides.

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