1589 Compatibility of Lambda-Cyhalothrin 5 CS with Nutrients and Biocontrol Agents in Cotton

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The compatibility of tank mix of lambda-cyhalothrin (LCH) (Karate Zeon® 5 CS), with foliar nutrients urea and magnesium sulphate and fungicide carbendazim (Bavistin®) was evaluated by assessing the emulsion stability and phytotoxicity. Biological effects of LCH on biocontrol agents *viz.,* , egg parasitoid, *Trichogramma chilonis* Ishii and green lacewing *Chrysoperla carnea* (Stephens) under *invitro* and impact as foliar application on field populations of natural enemies viz spiders and coccinellids in cotton ecosystem were also assessed. The optimum and effective dose of LCH 5 CS 25 g a.i ha^{-1} was physically and biologically compatible with fertilizer urea 2 per cent, micronutrient $MgSO_4$ 5 per cent and fungicide carbendazim 50 WP 0.1 per cent . The impact of LCH on biocontrol agents was only marginal. LCH caused *C. carnea* grub mortality of 52.0 - 80.3 and 57.0 - 84.0 per cent in larval feeding and dry film method respectively and hatchability was reduced by 18.5 - 28.3 per cent only when compared to 17.5 per cent in standard check endosulfan. The adult longevity was reduced to 7.5 to 11.8 from 15.3 days. The fecundity was reduced to 145.3 to 213.0 from 369.3 eggs. Immediately after application (1 DAT) spider (6.7-9.0 %) and coccinellid populations (5.7-7.0) were reduced marginally. However, their populations recovered with time.

Key words: Lambda cyhalothrin, compatibility

Introduction

Though IPM tactics with reduced pesticide use is contemplated, pesticide is the major component for the management of early season sucking pests and bollworm complex in cotton.. To avoid risk under storage condition (flammability) and load in the environment , new colloidal suspension formulations are developed to replace most of the sprayable formulations (emulsion concentrates) having organic solvents. Karate Zeon 5 CS is an ecofriendly microcapsule formulation containing lambda-cyhalothrin (LCH) in a polymer in an aqueous medium. The increase in cotton yield as a consequence of effective control of pests by LCH had been observed by Srivastava (1991) and Kalaiselvi et.al. (2006). Foliar application of urea is used due to low cost and quick plant response resulting in increased yield (Kesawapitak et al., 1995; El-Fouly and Shaaban, 1998). Cotton varieties in general need 170- 357 g of magnesium sulphate ($MgSO_4$) to produce one quintal of kapas (Gridhara Krishna *et al* 1990). In Tamil Nadu cotton is cultivated intensively both during winter (August- January)and summer(February- July)seasons. The continuous use of chemical fertilizers and limited use of organic manures resulted in the deficiencies of micronutrients and decrease in productivity (Chhabra et. al., 2004.) Soil application of $MgSO_4$@ 10 kg ha^{-1} significantly reduced reddening and increased the recovery upto 40 per cent in cotton (Chitdeshwari *et al.*1997). In Tamil Nadu, magnesium deficiency is reported in intensive cropping areas. Hence MgSO4 and urea as foliar spray are recommended by the State Department of Agriculture and Tamil Nadu Agricultural University (Crop Production Guide, 2005) on 50th and 80th day to correct this malady.

Spiders constitute an essential portion of the predaceous arthropods inhabitating the cotton ecosystem. In cotton ecosystem 21 species of spiders under 16 genera belonging to 8 families were observed throughout Tamil Nadu irrespective of situations *viz.*, main crop, main crop + inter crop and field bund (Mathirajan et. al. 2001).

The IPM package includes inundative release of egg parasitoid, *Trichogramma chilonis* Ishii at 6.25 cc/ha at 15 days interval three times from 45 DAS and the predator *Chrysoperla carnea* (Stephens)1,00,000/ha at 6th, 13th and 14th week after sowing (Dhandapani et al. 1992). Carbendazim (Bavistin ®) spray is recommended against grey mildew (0.5 %) and boll rot (1 %) respectively, along with an insecticide recommended for bollworm from 45th day at fortnightly interval by the State Department of Agriculture and Tamil Nadu Agricultural University (Crop Production Guide, 2005)

Application of nutrients and pesticides as tank mix reduced the cost of cultivation (Thukkaiyannan et al., 2004.). Hence the compatibility of LCH with nutrients urea and Mg SO_4 and fungicide, carbendazim as tank mix and the extent of the safety of LCH 5 CS on bio control agents used and the existing spider and coccinellid populations prevalent in the cotton ecosystem were assessed for effective and economic use of LCH 5CS on cotton..

Materials and Methods

Biological effects of LCH 5 CS on biocontrol agents

Biological effects of LCH in terms of parasitism, hatchability, adult emergence, longevity, oviposition and mortality on biocontrol agents *viz*., *T. chilonis* (Jalali and Singh, 1993) and *C. carnea* (Krishnamoorthy,1985; McCutchen and Plapp,1988) were assessed. Laboratory bioassay was conducted with five treatments and each treatment was replicated four times .Test concentrations for spray were reckoned from dose of LCH 5 CS @ 20, 25, and 30 and the standards endosulfan 35 EC @ 350 g a.i, chlorpyriphos 250 g a.i. and spray fluid of 500 litre ha^{-1} water spray was maintained as check unless specified.

T. chilonis

T. chilonis parasitized *Corcyra cephalonica* Stainton egg cards were obtained from the BASARAS BIOCON (INDIA) Ltd, Pennadam, Tamil Nadu. A rectangular plastic container was modified into a testing unit. Windows were cut one each on four sides and covered with muslin cloth to provide aeration. Calculated quantity of spray fluid (1.8 ml) based on the area of the testing unit (168 cm^2) was applied using an atomizer. Egg cards were also treated and shade dried .Fine streaks of concentrated honey were provided as food and 20 female parasitoids were introduced in each unit. Adult mortality was recorded 24hrs after constant exposure. Subsequently, observations on percentage parasitism, emergence, mortality and fecundity of parasitoids emerging from various treatments were recorded. Each treatment was replicated four times and compared with untreated check (water spray) (Jalali and Singh, 1993).

Fresh eggs were provided to these parasitoids at 6:1 ratio and the number of parasitized eggs (eggs appearing black and plumpy) was recorded 24 and 48 hrs after treatment and per cent parasitization was worked out.

C. carnea

Egg hatchability : The eggs along with stalk collected on brown paper strips were sprayed with various dilutions using an atomizer. Each treatment was replicated five times with 200 eggs per treatment. The number of grubs that hatched from each treatment was recorded and per cent hatchability was worked out (Krishnamoorthy, 1985).

Grub mortality: Effect of LCH on grub mortality was assessed by oral feeding and dry film methods.

Oral feeding method : Eggs of *C. cephalonica* were exposed to UV radiation of 15 W capacity for 15 minutes to kill the embryos and then sprayed with different concentrations of the insecticides with an atomizer. The treated eggs were shade dried for 15 minutes and then transferred to test tubes (1cc / test tube) of size 15 x 2 cm. Second instar grubs of *C. carnea* were transferred to these test tubes @ ten per test tube. After complete feeding of the treated eggs, the grubs were provided with untreated C*orcyra* eggs until pupation. Observations were made on the grub mortality 12, 24 and 48 hrs after treatment.

Dry film method : The test dilutions were prepared in acetone instead of water. Glass scintillation vials of 20 ml capacity with 1 mm thickness were evenly coated with 1 ml of acetone solution containing insecticide formulations and dried by rolling for few seconds. Second instars grubs were released into the vial at ten per vial and covered with muslin cloth and secured with a rubber band. After 24 hrs exposure of the grubs, 1 cc of *C. cephalonica* eggs were provided as food to the grubs. Mortality observations were taken 12, 24 and 48 hrs after treatment.

Longevity and fecundity of *C. carnea* : The adults were fed with 10 per cent sucrose solution containing different concentrations of lambda-cyhalothrin formulation in water . Chlorpyriphos was maintained as standard check. Five pairs of freshly emerged *C. carnea* adults were allowed in separate plastic containers per replication. In the untreated check, the adults were fed with 10 per cent sucrose solution alone. The eggs laid in each treatment were collected daily by keeping a brown paper sheet of size of 21 x 6 cm along the inner side of the plastic container. Observations were made on the longevity and fecundity of the adults.

Compatibility

Compatibility of tank mix was assessed bysupension stability test in the laboratory and phytotoxicity test in field. Eight different combibnations of LCH @ 25 g a.i ha^{-1} , $MgSO_4$ 5%, urea 2 % and carbendazim 0.1% *viz*., LCH alone, LCH + Urea, LCH + $MgSO_4$, LCH + Carbendazim, LCH + Urea + $MgSO_4$, LCH + Urea + Carbendazim, LCH + $MgSO_4$ + Carbendazim, LCH +Urea + $MgSO_4$ + Carbendazim were evaluated by assessing the stability and phytotoxicity.

Stability Test

Suspension stability test was carried out using standard hard water having hardness of 302 ppm calculated as calcium carbonate by Indian Standard Specification (ISI, 1973).

Field experiments

One field experiment was conducted with variety MCU-7 during 2004 at Thevarayapuram, Coimbatore to assess compatibility of tank mix for assessing the phytotoxicity. Two field experiments were conducted to evaluate the impact of LCH on field populations of spiders and coccinellid predators in cotton ecosystem. The first experiment was conducted during winter (November 2003 – February 2004) at Agricultural Research Station, Bhavanisagar with variety MCU-7 and the second experiment was conducted during summer (March – June 2004) at Agricultural Research Station, Vaigaidam with hybrid Supriya.

Phytotoxicity

Plot size of 20 m^2 was maintained with the spacing of 60 x 30 cm in a randomized block design. The treatments evaluated were same as that of tested for stability. In the field, phytotoxicity was observed in each plot from ten randomly tagged plants at 1, 3, 7 and 14 days after each application. The phytotoxic symptoms like injury to leaf tip and leaf surface, wilting, vein clearing, necrosis, epinasty and hyponasty were observed and visual rating was done on a 10 point scale.

Field populations of spiders and coccinellid predators.

The experiments were laid out in randomized block design with seven treatments replicated thrice. The plot size was 5x4 m with the spacing of 60x30 cm in the first season and 8x3 m with the spacing of 75x45 cm in the second season. Delinted seeds were used for sowing. LCH was applied @ 20, 25 and 30 g a.i ha^{-1} and the standard checks fenvalerate 20 EC @ 75, cypermethrin 25 EC @ 62.5 and chlorpyriphos 20 EC @ 250 g a.i ha^{-1}. Untreated check was also maintained.

Three rounds of sprayings in the first and second field trials commenced when the pest population reached Economic Threshold Level (ETL) of 2 numbers per leaf for sucking pests and 10 per cent for bollworm complex with pneumatic hand sprayer using 500 litres of spray fluid per hectare. Ten randomly selected plants per plot were thoroughly observed for grubs, pupae and adults of coccinellids and spiders. The observations were taken before and 1, 3, 7 and 14 days after each spraying.

Results and Discussion

LCH on *T. chilonis* : Emergence of *T.chilonis* from the untreated *C.cephalonica* eggs was 92.0 per cent. The parasitization was to the extent of 88.3 per cent. Emergence was reduced to 55.8 – 71.8 per cent in LCH treated eggs and to 88.0 per cent in endosulfan standard. LCH reduced the parasitization to 60.3, 58.8 and 50.3 at 20, 25 and 30 g a.i ha^{-1}, respectively when compared to 80.5 per cent in standard check endosulfan (Table. 1).

LCH *C. carnea* : The hatchability of *C. carnea* egg was 91.3 per cent and the mortality of hatched out grubs was 9.1 percent in untreated check . The hatchability was reduced; the mean hatchability being 79.8, 74.3 and 56.5 per cent at 20, 25 and 30 g a.i ha^{-1}, respectively 48 HAT. Mortality increased by 21.0-34.0 per cent due to LCH when compared to 19.5 per cent in endosulfan standard (Table 1). The survival of *C. carnea* grub when not exposed to insecticides was 92.7 per cent .LCH caused mortality of 54.3-80.3 and 71.0-84.0 per cent per cent by larval feeding and dry film method when compared to 52.0 - 57.0per cent in standard check endosulfan 48 HAT. (Table 2).

The mean adult longevity was 15.3 days. The longevity was reduced to 7.5-11.8, days by LCH and to 11.5 days by standard check endosulfan. The fecundity of *C. carnea* was 369.3 eggs. The egg laying was reduced by 42.3- 60.7 by LCH and 43.4 per cent by standard check endosulfan (Table 3).

Coccinellids and spiders: Before commencement of insecticide application coccinellid population was 8.0-8.6 and 6.7- 9.7 (Tables 4,5)and spiders population was 5.7- 7.7 and 6.0- 7.7during winter 2003-04 and summer 2004 respectively (Tables 6,7). The population decreased slightly in treated plots and subsequently increased gradually.

Reduction of coccinellid and spider populations was observed to an extent of 6.6- 8.0; 7.9-9.0 and 5.7-7.0; 6.0-7.7 immediately after application (1 DAT) during winter and summer season, respectively.(Tables 4-7). However, these populations recovered with time. The resumption of spider population in treated plots had been observed in cotton ecosystem (Mathirajan et. al., 2001) and coffee ecosystem (Senthil Kumar and Regupathy 2003). Mortality of spiders due to residual toxicity of insecticides was less when compared to that of contact toxicity. The population nearly reached levels to that of recorded in untreated check at 14 DAT (Tables 4-7). The toxic effect of LCH was less on *T. chilonis* as the adult emergence was to a maximum 55.8 per cent and parasitization of lambda-cyhalothrin at 25 g a.i ha^{-1} was found comparatively safe to *T. chilonis* which was in confirmity with the findings of Dhawan, (2000).

Compatibility with nutrients and fungicide: No creaming matter and / or sediment formation at bottom was observed in any of the combinations of LCH at different doses with urea 2 per cent, magnesium sulphate 5 per cent and carbendazim 50 WP 0.1 per cent. None of the combination treatments caused any phytotoxic effect and were not different symptomatically from untreated check. That LCH at the optimum and effective dose was compatible with nutrients and carbendazim and could be used as tank mix.

The impact of application on biocontrol agents *T. chilonis and* . *C carnea* was marginal as observed from the extent of parasitization, adult longevity, fecundity. The effect was dose dependent. LCH at 20, 25 g a.i ha^{-1} was less harmful and 30 g a.i ha^{-1} was moderately harmful which was in line as reported earlier by Dhawan (2000) in cotton ecosystem Though application of LCH reduced the spider and coccinellid field populations initials, recovery of these populations was observed 14 days after treatment. Reduction in spider population not exceeding 50 per cent is considered to be safe as reported by Dhawan (2000). Van den Berg *et al.* (1998) observed that the first application of LCH had no effect. However repeated applications reduced the population of natural enemies.

Avoiding repeated application effective utilization of LCH could be effectively used for the management of pests on cotton without affecting much the inundative release of *T. chilonis* and *C .carnea* and for sustaining naturally occurring spider and coccinellid populations.The optimum and effective dose of lambda-cyhalothrin 5 CS 25 g a.i ha^{-1} was physically and biologically compatible with fertilizer urea 2 per cent, micronutrient magnesium sulphate 5 per cent and fungicide carbendazim 50 WP 0.1 per cent.

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References

Chitdeshwari, B., K. Sankaran and D.Krishnadass. 1997. Role of magnesium sulphate in controlling reddening of leaves in cotton. Madras Agric. J.84 (7):386-387

Chhabra , K.L., L.K.Bishnoi, and M.S.Bhattoo. 2004. Effect of macro and micro-nutrients on the productivity of cotton genotypes. p. 161-168 *In Khadi et.al.,* International symp. on " Strategies for sustainable production –A global vision" Crop Protection 23-25, Nov. USA, Dharwad, Karnataka (India),.

Crop Production Guide. 2005. Commissioner of Agriculture, Chepauk. Chennai. pp.148-172.

Dhandapani,N.,M. Kalyanasundaram, M. Swamiappan, P.C. Sundarababu, and S. Jayaraj. 1992. Experiments on management of major pests of cotton with biocontrol agents in India. J. of Appl. Ent., 114: 52-56

Dhawan, A.K. 2000. Impact of some new insecticides on natural enemy complex of cotton ecosystem. Pestology*,* **24**(5): 8-14.

El-Fouly , M.M. and M.M. Shaaban. 1998. Foliar fertilization in cotton. p 413-416. *In* New-frontiers in Cotton Research"- Proc. of World Cotton Res. Conf. Sep. 6-12 1998, Athens, Greece.

Gridhara Krishna,T., K.Chandrasekar Reddy and P.V. Krishna Reddy. 1990. Major and secondary nutrients in bolls of different cotton genotypes Madras Agric. J. 77(2): 113-116.

ISI. 1973. Indian Standard Methods of Tests for Pesticides and their Formulations. *IS***:** 6940-1973.

Jalali, S.K and S.P. Singh. 1993. Susceptibility of various stages of *Trichogrammatoidae armigera* Nagaraja to some pesticides and effect of residues on survival and parasitizing ability. Biocont. Sci. Tech., **3**: 21-27.

Kalaiselvi,R. and **A. Regupathy*** and S.V.Krishnamoorthy. 2006. Bioefficacy of lambda –cyhalothrin 5 CS against bollworm complex in cotton. Pestology, XXX (7): 28-30.

Kesawapita K P., Boonyong, B., Somnus, P. Sanglia, S. And Jongruasyup . 1994. Foliar fertilizer application for yield and quality of cotton grown on Kampang Saen soil in Thailand. p.129-132 *In* Constable, G.A. and Forrester, N.W. (ed.) Challenging the Future: Proc. World Cotton Res. Conf. I*,* Brisbane, Australia, Feb. 14-17, 1994, CSIRO, Melbourne

Krishnamoorthy, A. 1985. Effects of several pesticides on the eggs, larvae and adults of green lace wing, *Chrysopa scelestes* (Banks). Entomon*,* **10**(1): 21-28.

Mathirajan, V.G., **A. Regupathy** and S. Chandrasekaran. 2001. Effect of thiamethoxam on spiders in cotton ecosystem. p 176-177. *In* International Conf. on Pesticides, Environment, Food security. 19-23, November, 2001. Society of Pesticide Science India, IARI, New Delhi.

McCutchen, B.F and F.W. Plapp. 1988. Monitoring procedure for resistance to synthetic pyrethroids in tobacco bollworm larvae. (2):356-358. *In* Proc. Beltwide Cotton Production Res. Conf., New Orleans, Jan.3-8, Mat.Cotton Council of America, Memphis Tenn., Senthil Kumar, C.M. and A. Regupathy. 2003. Effect of insecticides on richness and evenness of selected foliage dwelling spiders of coffee ecosystem. p. 154-155 *In* National symposium on biodiversity management for 21st century June 28-30..

Srivastava, K.P., V.T. Gabhiye and N.P. Agnihotri. 1991. Bioefficacy of new synthetic pyrethroids against cotton bollworms. Pestology, **15**(1): 4-5.

Thukkaiyannan , P. V. Chellamuthu and S. Nandini. Compatibility of foliar fertilizers with insecticides and their effect on yield of irrigated cotton (MCU 5). 2004. p. 156-158 *In* International symp. on " Strategies for sustainable production –A global vision" Crop Protection 23-25, Nov. USA, Dharward, Karnataka (India),

Van den Berg, H., K. Hassan and M. Marzuki. (1998). Evaluation of pesticide effects on arthropod predator populations in soybean in farmers fields. Biocont. Sci. Tech., **8**: 125-137.

Tab le 1. Effect of lambda-cyhalothrin 5 CS on *T. chilonis* Ishii and *C. carnea* eggs

(Means of four observations)

S.No.	Treatments	Dose (g a.i. ha^{-1})	*T. chilonis*		*C. carnea* eggs			
					24 HAT		48 HAT	
			Adult emergence (%)	Parasitization (%)	Hatchability (%)	Mortality (%)	Hatchability (%)	Mortality (%)
1.	Lambda-cyhalothrin 5 CS	20	71.8^{c}	60.3^{c}	77.3^{b}	18.5^{bc}	79.8^{c}	21.0^{bc}
2.	Lambda-cyhalothrin 5 CS	25	70.0^{c}	58.8^{c}	71.5^{c}	19.5^{c}	74.3^{d}	23.0^{c}
3.	Lambda-cyhalothrin 5 CS	30	55.8^{d}	50.3^{d}	55.8^{d}	28.3^{d}	56.5^{e}	34.0^{d}
4.	Endosulfan 35 EC	350	88.0^{b}	80.5^{b}	75.3^{b}	17.5^{b}	82.8^{b}	19.5^{b}
5.	Untreated check	-	92.0^{a}	88.3^{a}	90.0^{a}	5.0^{a}	91.3^{a}	9.3^{a}

HAT - Hours after treatment;

Means followed by same letter (s) in a column are not significantly different by DMRT (P=0.05)

Table 2. Effect of lambda-cyhalothrin 5 CS on the grubs of *C. carnea*

(Means of four observations)

S. No.	Treatments	Dose (g a.i. ha^{-1})	Larval feeding method Mortality (%)			Dry film method Mortality (%)		
			12 HAT	24 HAT	48 HAT	12 HAT	24 HAT	48 HAT
1.	Lambda-cyhalothrin 5 CS	20	35.3 ^{b}	46.8 ^{b}	54.3 ^{b}	51.0 ^{b}	61.5 ^{c}	71.0 ^{c}
2.	Lambda-cyhalothrin 5 CS	25	37.5 ^{b}	52.0 ^{b}	56.0 ^{b}	50.8 ^{b}	63.8 ^{c}	72.3 ^{c}
3.	Lambda-cyhalothrin 5 CS	30	55.5 ^{c}	65.8 ^{c}	80.3 ^{c}	73.8 ^{c}	80.0 ^{d}	84.0 ^{d}
4.	Endosulfan 35 EC	350	34.8 ^{b}	51.3 ^{b}	52.0 ^{b}	47.0 ^{b}	51.8 ^{b}	57.0 ^{b}
5.	Untreated check	-	5.5 ^{a}	7.5^{a}	7.3 ^{a}	7.3 ^{a}	7.8 ^{a}	10.5 ^{a}

HAT - Hours after treatment;

Means followed by same letter (s) in a column are not significantly different by DMRT (P=0.05)

Table 3. Effect of lambda-cyhalothrin 5 CS on the adults of *C. carnea*

(Means of four observations)

S.No.	Treatments	Dose (g a.i. ha^{-1})	Adult longevity (days)	No. of eggs laid per five female
1.	Lambda-cyhalothrin 5 CS	20	11.8 ^{b}	213.0 ^{b}
2.	Lambda-cyhalothrin 5 CS	25	10.8 ^{b}	197.3^{c}
3.	Lambda-cyhalothrin 5 CS	30	7.5 ^{c}	145.3^{d}
4.	Endosulfan 35 EC	350	11.5 ^{b}	209.0^{bc}
5.	Untreated check	-	15.3 ^{a}	369.3^{a}

HAT - Hours after treatment;

Means followed by same letter (s) in a column are not significantly different by DMRT (P=0.05)

Table 4. Effect of lambda-cyhalothrin 5 CS on coccinellids in cotton eco system (Winter 2003 - 04)

Treatments	Dose	PTC	Ist Spraying*				2nd Spraying*				3rd Spraying*			
	ml ha^{-1}		1DAT	3DAT	7DAT	14DAT	1DAT	3DAT	7DAT	14DAT	1DAT	3DAT	7DAT	14DAT
Lambda-cyhalothrin 5 CS	400	8.3	8.0^{b}	9.0^{b}	11.3^{b}	13.3^{ab}	12.3^{b}	13.6^{b}	14.6^{b}	15.6^{b}	14.3^{b}	15.3^{b}	16.6^{b}	19.6^{a}
Lambda-cyhalothrin 5 CS	500	8.6	7.6^{b}	8.0^{b}	10.6^{b}	12.6^{bc}	11.6^{b}	13.3^{b}	14.3^{b}	15.3^{bc}	13.3^{bc}	14.3^{b}	15.6^{c}	18.3^{b}
Lambda-cyhalothrin 5 CS	600	8.3	6.6^{bc}	6.3^{c}	10.3^{bc}	11.6^{cd}	9.6^{c}	11.3^{c}	12.6^{c}	14.6^{bcd}	13.3^{bc}	14.3^{b}	15.6^{c}	17.6^{bc}
Chlorpyriphos 20 EC	1250	8.0	6.0^{c}	5.6^{cd}	10.3^{bc}	11.6^{cd}	10.0^{c}	10.6^{c}	12.0^{c}	14.0^{d}	11.6^{d}	12.6^{c}	14.6^{d}	17.6^{bc}
Fenvalerate 20 EC	375	8.3	5.6^{c}	4.7^{d}	9.3^{d}	10.6^{d}	9.3^{c}	10.6^{c}	12.3^{c}	14.3^{cd}	11.6^{d}	12.6^{c}	14.6^{d}	17.3^{cd}
Cypermethrin 25 EC	250	8.0	5.3^{c}	5.0^{cd}	9.6^{cd}	10.6^{d}	9.6^{c}	10.3^{c}	12.3^{c}	14.3^{cd}	12.3^{cd}	12.6^{c}	14.3^{d}	16.6^{d}
Untreated check	-	8.3	10.0^{a}	11.6^{a}	12.6^{a}	14.3^{a}	14.6^{a}	15.3^{a}	16.3^{a}	17.3^{a}	17.3^{a}	18.3^{a}	19.3^{a}	20.3^{a}

* - Number of coccinellids per plants

Means followed by same letter (s) in a column are not significantly different by DMRT (P=0.05)

DAT – Days after treatment; PTC- Pretreatment count.

Table 5. Effect of lambda-cyhalothrin 5 CS on coccinellids in cotton ecosystem (summer 2004)

Treatments	Dose ml ha^{-1}	PTC	Ist Spraying*				2nd Spraying*				3rd Spraying*			
			1DAT	3DAT	7DAT	14DAT	1DAT	3DAT	7DAT	14DAT	1DAT	3DAT	7DAT	14DAT
Lambda-cyhalothrin 5 CS	400	9.0	9.0^{ab}	9.3^{b}	12.0^{ab}	13.0^{a}	9.0^{ab}	13.3^{ab}	14.3^{b}	15.3^{b}	14.7^{b}	15.7^{b}	17.7^{ab}	19.3^{b}
Lambda-cyhalothrin 5 CS	500	9.3	8.7^{b}	8.3^{b}	12.0^{ab}	13.3^{a}	8.7^{b}	12.3^{b}	14.3^{b}	14.7^{bc}	13.7^{c}	14.7^{bc}	17.7^{ab}	18.7^{b}
Lambda-cyhalothrin 5 CS	600	8.7	7.7^{bc}	6.7^{c}	11.3^{bc}	11.7^{b}	7.7^{bc}	9.7^{c}	12.7^{c}	14.0^{cd}	13.7^{c}	14.3^{cd}	16.7^{b}	18.3^{bc}
Chlorpyrifos 20 EC	1250	8.0	7.0^{cd}	6.0^{c}	11.7^{abc}	11.7^{b}	7.0^{cd}	9.7^{c}	11.7^{c}	14.0^{cd}	12.3^{d}	13.3^{de}	15.0^{c}	17.7^{cd}
Fenvalerate 20 EC	375	7.3	6.7^{cd}	5.7^{c}	10.7^{c}	10.7^{c}	6.7^{cd}	9.0^{c}	12.3^{c}	14.0^{cd}	11.7^{d}	13.0^{e}	15.0^{c}	17.7^{cd}
Cypermethrin 25 EC	250	6.7	6.3^{d}	6.0^{c}	10.7^{c}	10.7^{c}	6.3^{d}	9.3^{c}	12.3^{c}	13.3^{d}	12.3^{d}	13.0^{e}	14.7^{c}	17.0^{d}
Untreated check	-	9.7	10.3^{a}	11.7^{a}	12.7^{a}	13.7^{a}	10.3^{a}	14.3^{a}	15.7^{a}	16.7^{a}	16.3^{a}	17.7^{a}	18.7^{a}	20.3^{a}

* - Number of coccinellids per plants

Means followed by same letter (s) in a column are not significantly different by DMRT (P=0.05)

DAT – Days after treatment; PTC- Pretreatment count.

Table 6. **Effect of lambda-cyhalothrin 5 CS on spiders in cotton ecosystem (Winter 2003 - 04)**

Treatments	Dose	PTC	Ist Spraying *				2nd Spraying *				3rd Spraying *			
	ml ha^{-1}		1DAT	3DAT	7DAT	14DAT	1DAT	3DAT	7DAT	14DAT	1DAT	3DAT	7DAT	14DAT
Lambda-cyhalothrin 5 CS	400	7.7	6.7^{b}	7.7^{b}	8.7^{b}	11.3^{ab}	9.7^{b}	10.3^{b}	12.0^{ab}	13.7^{ab}	12.7^{b}	12.3^{b}	13.3^{b}	14.3^{b}
Lambda-cyhalothrin 5 CS	500	7.7	6.7^{b}	7.7^{b}	8.7^{b}	10.7^{bc}	9.0^{bc}	9.3^{bc}	11.7^{abc}	13.3^{bc}	12.3^{bc}	11.3^{b}	12.3^{c}	13.3^{c}
Lambda-cyhalothrin 5 CS	600	6.7	5.7^{c}	6.7^{bc}	7.7^{c}	10.3^{bcd}	8.3^{cd}	8.3^{cd}	10.7^{bcd}	12.3^{cd}	11.3^{cd}	10.3^{c}	11.3^{d}	12.3^{d}
Chlorpyrifos 20 EC	1250	6.7	5.7^{c}	6.0^{cd}	7.3^{c}	10.3^{bcd}	7.7^{d}	7.3^{d}	10.3^{cd}	11.7^{d}	10.7^{d}	9.7^{cd}	10.7^{de}	11.7^{de}
Fenvalerate 20 EC	375	5.7	4.7^{d}	5.3^{d}	6.3^{d}	9.3^{d}	7.7^{d}	7.3^{d}	9.7^{d}	11.3^{d}	10.3^{d}	9.3^{d}	10.3^{e}	11.3^{e}
Cypermethrin 25 EC	250	5.7	4.7^{d}	5.3^{d}	6.3^{d}	9.7^{cd}	7.7^{d}	7.3^{d}	9.7^{d}	11.3^{d}	10.3^{d}	9.3^{d}	10.3^{e}	11.3^{e}
Untreated check	-	7.7	8.7^{a}	9.7^{a}	10.3^{a}	12.7^{a}	12.3^{a}	12.7^{a}	13.7^{a}	14.7^{a}	14.7^{a}	15.7^{a}	15.3^{a}	15.7^{a}

* - Number of spiders per plants

Means followed by same letter (s) in a column are not significantly different by DMRT (P=0.05)

DAT – Days after treatment; PTC- Pretreatment count.

Table 7. Effect of lambda-cyhalothrin 5 CS on spiders in cotton ecosystem (summer 2004)

Treatments	Dose	PTC	Ist Spraying*				2nd Spraying*				3rd Spraying*			
	ml ha^{-1}		1DAT	3DAT	7DAT	14DAT	1DAT	3DAT	7DAT	14DAT	1DAT	3DAT	7DAT	14DAT
Lambda-cyhalothrin 5 CS	400	7.7	7.0^{b}	8.0^{b}	9.0^{b}	11.3^{b}	10.3^{b}	10.7^{b}	12.7^{ab}	14.3^{ab}	13.3^{b}	12.3^{b}	14.7^{b}	15.3^{b}
Lambda-cyhalothrin 5 CS	500	7.7	7.0^{b}	8.0^{b}	9.0^{b}	11.0^{bc}	9.7^{b}	9.7^{bc}	12.3^{ab}	13.7^{b}	12.7^{b}	11.7^{b}	13.7^{c}	14.7^{bc}
Lambda-cyhalothrin 5 CS	600	6.7	6.0^{bc}	7.0^{bc}	8.0^{c}	10.7^{bc}	8.7^{cd}	8.7^{cd}	11.3^{bc}	12.7^{c}	11.7^{c}	10.7^{c}	14.7^{d}	14.0^{cd}
Chlorpyrifos 20 EC	1250	6.7	6.0^{bc}	6.3^{cd}	7.7^{c}	10.7^{bc}	8.3^{cd}	8.0^{cd}	11.0^{c}	12.3^{cd}	11.3^{cd}	10.3^{c}	12.3^{de}	13.7^{d}
Fenvalerate 20 EC	375	6.0	5.3^{c}	5.7^{d}	6.7^{d}	9.7^{d}	8.0^{cd}	7.7^{d}	10.3^{c}	11.7^{d}	10.7^{d}	10.3^{c}	11.6^{e}	13.3^{d}
Cypermethrin 25 EC	250	6.3	5.3^{c}	5.7^{d}	6.7^{d}	10.0^{cd}	7.7^{d}	7.7^{d}	10.3^{c}	12.0^{cd}	11.0^{cd}	10.7^{c}	12.0^{de}	13.3^{d}
Untreated check	-	7.7	8.7^{a}	9.7^{a}	10.3^{a}	12.7^{a}	12.3^{a}	13.3^{a}	13.7^{a}	15.0^{a}	14.7^{a}	14.7^{a}	15.6^{a}	16.3^{a}

* - Number of spiders per plants

Means followed by same letter (s) in a column are not significantly different by DMRT (P=0.05)

DAT – Days after treatment; PTC- Pretreatment count.