

A comparative study on the persistence of pre-mix formulation of endosulfan and cypermethrin in tomato, *Solanum lycopersicum*

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ABSTRACT

The present study was done to compare the persistence of endosulfan and cypermethrin in pre-mix formulation Endohyper 40 EC (endosulfan 35% + cypermethrin 5%) with individual insecticide endosulfan (Endocel 35 EC) and cypermethrin (Challenger 25 EC). Endosulfan and cypermethrin were applied at recommended rate of 350 g and 50 g ai/ha and at double the recommended rate 700 g and 100 g ai/ha on tomato crop. The fruits and soil samples were collected at different intervals and analyzed after second spray. Residues of both insecticides were determined by using gas chromatograph Agilent 6890N having electron capture detector. In fruits the endosulfan and cypermethrin residues reached below detectable limit in 15 and 7 days when applied at recommended rate and in 20 and 10 days when applied at double recommended rate. Endosulfan deposits reduced to half in 2.01-2.47 days and cypermethrin deposits required 1.20-1.40 days to reduce to half as combi-product but when applied individually endosulfan initial deposits were reduced to their half in 1.21-1.59 days and cypermethrin deposits became half in 1.57-2.08 days. In soil residues of endosulfan persisted for 0-20 days whereas residues of cypermethrin persisted for 0 day only.

Keywords: Endosulfan; cypermethrin; tomato; residues; persistence

INTRODUCTION

Tomato (*Solanum lycopersicum* L) forms the main dietary component in our food. It is a crop known for its special nutritive value and is attacked by many insect pests including tomato fruit borer, mites, leaf miner, aphids, whiteflies etc which affect quantity and quality of fruits. In order to

prevent the damage to the crop the farmers rely heavily on the usage of many pesticides viz quinalphos, phosalone, fenvalerate, cypermethrin, deltamethrin etc (Singh et al 1980, Singh et al 1989, Awasthi 1986, Anon 2010). In addition to the increasing residues of these pesticides on the crops as well as in the environment development of pest resistance to existing pesticides is

a major problem leading to the losses to the crops. As the insects are becoming resistance to more and more insecticides so in order to combat this menace usage of insecticide mixtures is being advocated. In India a large number of ready-mix insecticide formulations have been registered for use on various crops (Regupathy et al 2004). Endohyper 40 EC a combination of endosulfan 35% + cypermethrin 5% is one such ready-mix formulation. Endosulfan has been banned in India after 2010 and this study relates to before it. Ready-mix insecticide formulations have been found effective against insect pests of many vegetables (Dharne and Kabre 2009, Kumar and Shivaraju 2009). It not only reduces the cost of application but also results in lesser number of sprays as compared to individual chemical. The information in respect of the residues of these two insecticides from the combi-product and their comparison with the residues when these two chemicals are applied individually on tomato in the mid-hill regions is not available. Therefore the present studies were contemplated in order to study the persistence behavior of the combi-product and its comparison with the residue status when applied individually.

MATERIAL and METHODS

Chemicals: Analytical grade reagents viz acetone, hexane, toluene, dichloromethane, acetonitrile, sodium chloride, anhydrous sodium sulphate, Florisil and Celite 545 were obtained from M/S Merck Specialties

Private Limited, Mumbai, India. Pesticide residue grade charcoal was procured from M/S Fluka Analytical, Sigma-Aldrich Schweiz, Industrie straÙe 25, CH-9470 Buchs SG, Schweiz. Endosulfan formulation (Endocel 35 EC) and the ready-mix formulation Endohyper 40 EC containing 35 per cent endosulfan and 5 per cent cypermethrin were obtained from M/S Excel Crop Care Ltd and cypermethrin (Challenger 25 EC) from M/S Tropical Agrosystem Ltd.

Design of experiment: Experiments on the persistence behaviour of endosulfan and cypermethrin individually or as ready-mix were conducted in two years during 2009 and 2010 at the experimental farm of the Department of Entomology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP. Trials were laid out in a randomized block design and each treatment was replicated thrice.

Application of insecticides: Tomato (var Him Sohna) was sprayed at fruit formation stage with individual insecticides endosulfan (Endocel 35 EC), cypermethrin (Challenger 25 EC) and the ready-mix formulation Endohyper 40 EC (containing 35% endosulfan and 5% cypermethrin) at the recommended rate (RR) 350 g and 50 g ai/ha and at double recommended rate (DRR) 700 g and 100 g ai/ha respectively. Two sprays were given at 15 days interval. Control plots with only water spray were maintained simultaneously for comparison.

Collection of samples: After the second spray fruit samples (1 kg) from each replication were collected randomly at 0 (2 hours after spray), 1, 3, 5, 7, 10 and 15 days intervals. Soil samples (1 kg) from each replication were collected on 0, 10 and 20 days after application. The tomato fruits were homogenized and analysed for respective insecticides. Soil samples were shade dried and sieved.

Extraction and clean up: Fruit samples were analysed according to Sharma (2007). Homogenized sample (100 g) was extracted with 200 ml of acetone, filtered through Buchner funnel under low suction and rinsed with 50 ml acetone. From total extract an aliquot of 60 ml (30 g equivalent of sample) was transferred to 1 litre separatory flask and extracted with 200 ml mixture of hexane and dichloromethane (1:1 v/v). The separatory flask was shaken vigorously for 1 min and then allowed the phases to separate into organic and aqueous phases. The lower aqueous phase was transferred to another 1 litre separatory flask and remaining organic phase was retained in the same separatory flask. Ten ml saturated sodium chloride solution was added to the left amount of aqueous phase and again partitioned twice with 100 ml dichloromethane. Lower aqueous phase was discarded and upper organic phase was transferred to the 1st separatory flask. Pooled organic phase was passed through anhydrous sodium sulfate and evaporated to dryness by using vacuum rotary

evaporator at 40°C. Finally the residues were taken up in 3 ml (1+2) acetone for cleanup.

One ml sample extract was diluted with 10 ml of acetone:hexane (1:9) mixture, loaded on 4 g Florisil column (22 mm id), overlaid with 2 g layer of sodium sulphate and eluted with 50 ml solvent mixture (50% dichloromethane: 48.5% hexane: 1.5% acetonitrile). Another fraction 2 ml of sample was loaded on a charcoal column which was prepared by placing one inch layer of Celite 545, 6 g absorbent mixture (1:4 w/w Charcoal: Celite 545) and then overlaid with 2 g sodium sulfate. The sample extract was loaded on to the column and eluted with 200 ml of 2:1 acetone:dichloromethane mixture. Eluate from both the column fractions were pooled and evaporated to dryness in vacuum rotary evaporator at 50°C. The residues were redissolved in 3 ml toluene and one µl injected into gas chromatograph for residue estimation.

Soil samples were analyzed according to the method given by Brar (2003). A dried and sieved representative soil sample of 20 g was mixed with 0.5 g activated charcoal + 0.5 g Florisil and packed in 2 × 40 cm glass column containing about 5 cm layer of anhydrous sodium sulphate over a plug of cotton at the bottom. the column with 50 ml mixture of acetone and hexane (1:4) was eluted. The eluate was evaporated to dryness and residues were taken in 1 ml toluene. Finally

one µl was injected into gas chromatograph for residue estimation.

Residue estimation: Residues were estimated by using Gas Chromatograph (Agilent 6890N) having ECD detector and DB-5 Ultra Performance Capillary column (Cross-linked Methyl Silicon, length 30 m, 0.250 mm internal diameter with 0.25 µm film thickness).

Instrument conditions: Column temperature was programmed as 100°C for 1 min, 30°C/min up to 150°C (hold time 2 min), 3°C/min up to 205°C and finally temperature raised up to 260°C at the rate of 10°C/min (hold time 10 min). Temperature of injection port and ECD (detector) were kept at 250°C and 300°C respectively. Flow rate of carrier gas nitrogen was 1 ml/min and make up gas flow rate was 60 ml/min. Under these gas chromatographic parameters retention time of alpha-endosulfan, beta-endosulfan, endosulfan sulfate and cypermethrin was 19.333, 22.461, 24.590 and 30.771 min respectively. Total of alpha-endosulfan, beta-endosulfan and endosulfan sulfate residues were reported as endosulfan residues.

Method validation: The analytical method employed to estimate residues was validated by spiking the control fruit and soil samples at five different concentrations viz 0.01, 0.05, 0.10, 0.5 and 1.0 mg/kg for alpha-endosulfan, beta-endosulfan and endosulfan

sulfate respectively. Whereas in case of cypermethrin, samples were spiked at 0.05, 0.10 0.20, 0.50 and 1.0 mg/kg concentrations. The limit of determination (LOD) of alpha-endosulfan, beta-endosulfan and endosulfan sulfate was 0.01 mg/kg and for cypermethrin LOD was 0.05 mg/kg. The residue data were subjected to statistical analysis (Hoskins 1961).

RESULTS and DISCUSSION

The Table 1 depicts reliability of analytical method tested by spiking of untreated tomato fruits and soil samples at different concentrations. Recovery of endosulfan was between 80.00-91.40 per cent with relative standard deviation (RSD) of 0.040-1.005 per cent in fruits and 80.00-91.00 per cent with 0.017-0.996 per cent RSD in soil fortified samples. Recovery of cypermethrin was between 88.00-90.00 per cent with relative standard deviation (RSD) of 0.034-0.738 per cent in fruits and 86.80-90.00 per cent recovery with 0.062-0.753 per cent RSD in soil fortified samples. The results are in agreement with Pal (2011) who has observed recovery of 85.00-91.70 per cent for endosulfan and 86.60-92.31 per cent for cypermethrin in capsicum fruits.

The persistence and degradation of endosulfan and cypermethrin in the combi-mix formulation and individual insecticides formulation were studied on tomato crop at the recommended rate (RR) 350 g and 50 g ai/ha and at double recommended rate

Table 1. Recovery of endosulfan and cypermethrin from spiked tomato fruits and soil samples

Insecticide	Fruits			Soil	
	Fortification level (mg/kg)	Mean recovery (%)	Relative standard deviation (% RSD)	Mean recovery (%)	Relative standard deviation (% RSD)
<i>alpha</i> -endosulfan	0.01	80.00	1.005	90.00	0.839
	0.05	86.00	0.815	86.00	0.481
	0.10	87.00	0.350	85.00	0.234
	0.50	86.20	0.070	87.00	0.058
	1.00	88.00	0.040	88.00	0.017
<i>beta</i> -endosulfan	0.01	80.00	0.987	80.00	0.996
	0.05	84.00	0.638	84.00	0.771
	0.10	86.00	0.526	84.00	0.699
	0.50	84.00	0.095	85.00	0.249
	1.00	87.00	0.070	87.00	0.087
Endosulfan sulfate	0.01	80.00	0.976	80.00	0.964
	0.05	82.00	0.765	82.00	0.661
	0.10	89.00	0.505	89.00	0.406
	0.50	88.20	0.057	88.20	0.082
	1.00	91.40	0.444	91.00	0.089
Cypermethrin	0.05	88.00	0.738	88.00	0.728
	0.10	88.00	0.286	88.00	0.301
	0.20	89.00	0.202	87.50	0.753
	0.50	89.00	0.147	86.80	0.401
	1.00	90.00	0.034	90.00	0.062

(DRR) 700 g and 100 g ai/ha respectively. The decrease in level of residues in individual and combi-insecticide treatments at different days interval are presented in Tables 2 and 3.

Endosulfan initial deposits on tomato fruits from mixture (Endohyper 40 EC) and individual insecticide formulation (Endocel 35 EC) were 3.514-3.597 mg/kg which dissipated to 0.115-0.112 mg/kg on 10th day and 3.446-3.497 mg/kg to 0.068-0.084 mg/kg on 7th day respectively at recommended rate. In double the

recommended rate initial deposits of endosulfan from mixture were 6.225-6.283 mg/kg which dissipated to 0.120-0.099 mg/kg in 15 days whereas deposits 5.895-6.036 mg/kg declined to 0.096-0.095 mg/kg from endosulfan alone in 10 days. The comparison of initial deposits obtained in the present study suggests that the persistence of combi-formulation was higher than its individual formulation. This could be due to additive effect and the other adjuvants present in combi-mix formulation which is supported by Sharma et al (2011) who observed a slightly higher level of initial

Table 2. Persistence of endosulfan (350 g ai/ha) and cypermethrin (50 g ai/ha) on tomato fruits applied in combi-mix and as individual insecticide

Interval (days)	Combination		Individual		
	Endosulfan		Endosulfan		Cypermethrin
	Isomer/ metabolite	Residues±SD (mg/kg)	Total±SD (mg/kg)	Residues±SD (mg/kg)	residues±SD (mg/kg)
0	alpha beta	2.415±0.232 1.099±0.080	3.514±0.308	2.340±0.176 1.105±0.005	0.291±0.004
					2009
1	alpha beta	1.646±0.102 0.739±0.068	2.385±0.094	1.470±0.018 0.720±0.007	0.236±0.004
3	alpha beta ES	0.553±0.111 0.294±0.047 0.074±0.014	0.921±0.151	0.486±0.005 0.192±0.005 0.067±0.005	0.178±0.005
5	alpha beta ES	0.228±0.062 0.200±0.043 0.114±0.011	0.542±0.099	0.092±0.006 0.077±0.008 0.102±0.003	0.051±0.001
7	alpha beta ES	0.070±0.053 0.084±0.005 0.110±0.008	0.264±0.056	0.024±0.009 0.016±0.002 0.028±0.002	BDL
10	alpha beta ES	0.030±0.010 0.021±0.008 0.063±0.009	0.115±0.004	BDL BDL BDL	-
15	alpha beta ES	BDL BDL BDL	-		

Persistence of endosulfan and cypermethrin

				2010				
0	alpha beta	2.477±0.155 1.120±0.030	3.597±0.181	1.004±0.003	2.371±0.108 1.126±0.003	3.497±0.109	0.488±0.006	
1	alpha beta	1.671±0.084 0.761±0.040	2.432±0.076	0.791±0.004	1.510±0.005 0.741±0.006	2.251±0.010	0.398±0.002	
3	alpha beta ES	0.589±0.056 0.301±0.041 0.074±0.010	0.964±0.062	0.366±0.003	0.520±0.013 0.196±0.001 0.068±0.002	0.783±0.014	0.245±0.011	
5	alpha beta ES	0.241±0.040 0.202±0.017 0.116±0.007	0.559±0.058	0.055±0.014	0.094±0.002 0.081±0.006 0.104±0.002	0.279±0.005	0.050±0.009	
7	alpha beta ES	0.091±0.001 0.094±0.003 0.108±0.006	0.293±0.008	BDL	0.025±0.006 0.019±0.004 0.041±0.006	0.084±0.004	BDL	
10	alpha beta ES	0.033±0.010 0.023±0.007 0.056±0.009	0.112±0.016		BDL BDL BDL	-		
15	alpha beta ES	BDL BDL BDL	-					

BDL = Below determination limit

Table 3. Persistence of endosulfan (700 g ai/ha) and cypermethrin (100 g ai/ha) on tomato fruits applied in combi-mix and as individual insecticide

Interval (days)	Combination			Individual		
	Isomer/ metabolite	Endosulfan		Endosulfan		Cypermethrin residues±SD (mg/kg)
		Residues±SD (mg/kg)	Total±SD (mg/kg)	Residues±SD (mg/kg)	Total±SD (mg/kg)	
0	alpha beta	4.119±0.101 2.106±0.008	6.225±0.102	4.168±0.191 1.727±0.516	5.895±0.696	0.994±0.004
						2009
1	alpha beta	2.577±0.181 1.188±0.060	3.765±0.197	2.281±0.065 1.144±0.057	3.425±0.013	0.635±0.041
3	alpha beta ES	0.963±0.030 0.491±0.046 0.948±0.003	2.401±0.073	0.733±0.066 0.368±0.011 0.134±0.003	1.236±0.059	0.383±0.054
5	alpha beta ES	0.488±0.052 0.401±0.077 0.141±0.012	1.029±0.128	0.110±0.008 0.093±0.005 0.123±0.004	0.326±0.009	0.212±0.010
7	alpha beta ES	0.092±0.006 0.105±0.003 0.149±0.015	0.346±0.014	0.053±0.016 0.053±0.003 0.054±0.008	0.160±0.025	0.051±0.001
10	alpha beta ES	0.055±0.006 0.060±0.002 0.067±0.003	0.183±0.007	0.035±0.002 0.017±0.002 0.044±0.002	0.096±0.006	BDL
15	alpha beta ES	0.032±0.010 0.023±0.008 0.065±0.012	0.120±0.008	BDL BDL BDL		

Persistence of endosulfan and cypermethrin

20	alpha beta ES	BDL BDL BDL							
0	alpha beta	4.175±0.051 2.108±0.003	6.283±0.049	2010 2.051±0.053	4.216±0.142 1.820±0.010	6.036±0.153	1.074±0.005		
1	alpha beta	2.580±0.008 1.304±0.003	3.884±0.010	1.441±0.204	2.302±0.007 1.165±0.043	3.467±0.039	0.750±0.015		
3	alpha beta ES	0.981±0.004 0.505±0.005 0.964±0.010	2.450±0.007	0.889±0.006	0.764±0.006 0.400±0.005 0.138±0.003	1.301±0.005	0.431±0.034		
5	alpha beta ES	0.490±0.051 0.430±0.033 0.149±0.010	1.069±0.072	0.348±0.007	0.134±0.004 0.095±0.004 0.128±0.002	0.357±0.004	0.229±0.016		
7	alpha beta ES	0.099±0.002 0.120±0.011 0.151±0.005	0.370±0.017	0.052±0.002	0.052±0.013 0.052±0.002 0.053±0.002	0.156±0.012	0.052±0.019		
10	alpha beta ES	0.056±0.003 0.064±0.005 0.069±0.004	0.189±0.008	BDL	0.031±0.008 0.019±0.004 0.046±0.012	0.095±0.007	BDL		
15	alpha beta ES	0.030±0.014 0.021±0.005 0.048±0.013	0.099±0.011		BDL BDL BDL				
20	alpha beta ES	BDL BDL BDL							

BDL= Below determination limit

deposits of flubendiamide in combination with thiacloprid (0.499-0.992 mg/kg) than individual insecticide (0.467-0.824 mg/kg) at 60 and 120 g ai/ha doses in chilli crop. Reddy et al (2007) observed 4.62 mg/kg initial deposits of endosulfan on green chillies sprayed with endosulfan alone @ 350 g ai/ha. Shah et al (1999) reported 7.555 mg/kg endosulfan initial deposits on okra fruits sprayed with 0.05 per cent Decidan 32.8 EC (endosulfan 32% + deltamethrin 0.8%).

Initial deposits of cypermethrin on tomato fruits from mixture with endosulfan applied @ 50 g ai/ha were 1.002-1.004 mg/kg whereas at double dose the initial deposits were 2.038-2.051 mg/kg. When applied individually cypermethrin initial deposits were 0.291-0.488 mg/kg at recommended rate and 0.994-1.074 mg/kg at double recommended rate. Singh and Udeaan (1989) reported 0.65 mg/kg and 1.43 mg/kg initial deposits at 50 g ai/ha and 100 g ai/ha doses of cypermethrin respectively in okra fruits. There was decline in residues with the time lapse at both the levels of application (Table 4).

The persistence of insecticides is generally expressed in terms of RL_{50} ie time for disappearance of insecticide initial deposits to 50 per cent. The RL_{50} values are often obtained by fitting first order kinetics to observed degradation pattern.

Insecticides were not directly applied to soil but their residues were

detected in the soil on the day of application. Endosulfan residues 0.209-0.236 and 0.373-0.431 mg/kg were detected at the respective dosage of 350 and 700 g ai/ha in combi-mix formulation which became non-detectable on 20th day in single as well as in double recommended rate. When endosulfan was applied individually on the crop then residues in soil also persisted for 20 days (Tables 5 and 6). Kanjana and Kannathan (2007) reported 0.392, 0.421 and 0.505 mg/kg residues of endosulfan in soil when applied at 0.035, 0.070 and 0.140 per cent concentrations respectively on tomato crop.

Cypermethrin residues were not detected on 0 day in soil at recommended rate (50 g ai/ha) but in double recommended rate (100 g ai/ha) residues were observed 0.091-0.099 mg/kg in combi-mix formulation treatment. However in individually applied cypermethrin its residues were detected in soil on 0 day and became below detection limit in 10 days. Gupta et al (2011) observed cypermethrin residues below detection limit in soil samples after the application of Roket 44 EC @ 1 and 2 l/ha on tomato crop.

In an effort to compare the persistence of endosulfan and cypermethrin in pre-mix formulation Endohyper 40 EC (endosulfan 35% + cypermethrin 5%) and in individual insecticides endosulfan formulation (Endocel 35 EC) and cypermethrin (Challenger 25 EC) when

Table 4. Degradation kinetics of endosulfan and cypermethrin on tomato

Year/ insecticide	Dosage	Endosulfan			Cypermethrin		
		Regression equation (y=—)	r	RL50	Regression equation (y=—)	r	RL50
2009 Combination	RR	0.496-0.149X	-0.995	2.02	0.411-0.217X	-0.970	1.38
	DRR	0.662-0.122X	-0.963	2.47	-0.477-0.144X	-0.943	2.08
Individual	RR	0.574-0.241X	-0.998	1.25	0.030-0.171X	-0.976	1.76
	DRR	0.667-0.189X	-0.977	1.59	0.110-0.249X	-0.964	1.30
2010 Combination	RR	0.512-0.149X	-0.997	2.01	0.422-0.215X	-0.962	1.40
	DRR	0.690-0.126X	-0.975	2.38	-0.224-0.192X	-0.952	1.57
Individual	RR	0.571-0.231X	-0.999	1.21	0.088-0.177X	-0.917	1.70
	DRR	0.685-0.190X	-0.980	1.58	0.411-0.217X	-0.970	1.38

RR=Recommended rate, DRR= Double recommended rate, r= Correlation, RL50= Residue half-life

Table 5. Residues of endosulfan (350 g ai/ha) and cypermethrin (50 g ai/ha) in tomato cropped soil

Interval (days)	Combination			Individual		
	Endosulfan		Cypermethrin residues±SD (mg/kg)	Endosulfan		Cypermethrin residues±SD (mg/kg)
	Isomer/ Metabolite	Residues±SD (mg/kg)		Total±SD (mg/kg)	Total±SD (mg/kg)	
0	alpha	0.136±0.009	0.209±0.010	0.292±0.016	0.408±0.019	0.081±0.002
	beta	0.073±0.002		0.116±0.002		
	alpha	0.021±0.003	0.049±0.006	0.085±0.002	0.408±0.019	BDL
10	beta	0.011±0.001		0.039±0.006		
	ES	0.017±0.005		0.050±0.003		
	alpha	BDL		0.017±0.006	0.042±0.008	
20	beta	BDL		0.011±0.001		
	ES	BDL		0.014±0.002		
	alpha			BDL	-	
30	beta			BDL		
	ES			BDL		
	alpha			BDL		
0	alpha	0.159±0.011	0.236±0.014	0.325±0.004	0.455±0.006	0.089±0.001
	beta	0.077±0.005		0.130±0.004		
	alpha	0.029±0.009	0.069±0.018	0.092±0.005	0.225±0.004	BDL
10	beta	0.017±0.002		0.047±0.009		
	ES	0.024±0.010		0.085±0.002		
	alpha	BDL		0.020±0.002	0.049±0.005	
20	beta	BDL		0.012±0.002		
	ES	BDL		0.017±0.002		
	alpha			BDL		
30	beta			BDL		
	ES			BDL		
	alpha			BDL		

BDL = Below determination limit

Table 6. Residues of endosulfan (700 g ai/ha) and cypermethrin (100 g ai/ha) in tomato cropped soil

Interval (days)	Combination			Individual		
	Endosulfan		Cypermethrin residues±SD (mg/kg)	Endosulfan		Cypermethrin residues±SD (mg/kg)
	Isomer/ metabolite	residues±SD (mg/kg)		Residues±SD (mg/kg)	Total±SD (mg/kg)	
0	alpha	0.254±0.005	2009	0.512±0.009	0.795±0.011	0.108±0.003
	beta	0.119±0.007		0.284±0.005		
10	alpha	0.024±0.003		0.102±0.003	0.225±0.003	BDL
	beta	0.014±0.002		0.045±0.004		
	ES	0.021±0.001		0.078±0.006		
20	alpha	BDL		0.019±0.002	0.045±0.004	
	beta	BDL		0.011±0.001		
	ES			0.015±0.003		
30	alpha			BDL		
	beta			BDL		
	ES			BDL		
0	alpha	0.298±0.003	2010	0.605±0.003	0.821±0.007	0.131±0.004
	beta	0.133±0.002		0.215±0.004		
10	alpha	0.042±0.003		0.137±0.007	0.358±0.007	BDL
	beta	0.020±0.003		0.099±0.009		
	ES	0.032±0.001		0.123±0.005		
20	alpha	BDL		0.022±0.006	0.054±0.006	
	beta	BDL		0.014±0.003		
	ES	BDL		0.018±0.002		
30	alpha			BDL		
	beta			BDL		
	ES			BDL		

BDL= Below determination limit

applied at recommended rate and at double recommended rate in tomato fruits and soil it was observed that the pre-mix formulation showed slightly higher persistence than from its individual insecticides formulation which was supported by Dharumarajan et al (2009).

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