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Residual Toxicity of Synthetic and Bio-Insecticides Sprayed on Okra against Whitefly (*Bemisia Tabaci* [Genn.])

M. IQBAL[++], A. R. KHAN*, M. PANHWAR**, M. RAFIQUE*, K. MAHMOOD*, M. QASIM, N. I. JAJJA

Department of Entomology, University of Poonch, Rawalakot, AJK,

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Abstract: In order to compare residual toxicity of synthetic and bio-insecticides sprayed on okra against whitefly (*Bemisia tabaci* Genn.), the experiment was conducted at the experimental site, Poonch University of Agriculture Rawalakot (AJK) during 2016. The crop was sprayed with five synthetic pesticides including Tracer (Spinosad), Runner (Methoxyfenozide), Radiant (Spinetoram), Belt (Flubendiamide) and Coragen (Chlorantraniliprole) as well as eight botanical pesticides based on Neem (*Azadirachta indica*), Tobacco (*Nicotiana tabacum*), Tooh (*Citrullus colocynthus* (L.) Schrad), Datura (*Datura stramonium*), Garlic (*Allium sativum* L.), Eucalyptus (*Eucalyptus obliqua*, *E. occidentalis*) and Ginger (*Zingiber officinale*). The determined dissipation response of these synthetic and botanical pesticides their toxic residual effects on edible okra pods were recorded upto 2 weeks of spray. The toxic residues of Tracer (EU-MRLs = 0.015 mg/kg^{-1}); Runner (EU-MRLs=0.05 mg/kg^{-1}), Belt (EU-MRLs= 0.01 mg/kg^{-1}) persisted upto 7 days after spray; while Radiant (EU-MRLs=0.025 mg/kg^{-1}) showed strong persistence of high residual toxicity upto 14 days of spray. However, Coragen showed toxic residues below EU-MRLs (0.60 mg/kg^{-1}) after 3 days of spray. Extracts of neem, tobacco and tooh/tumma were more effective against whitefly compared to Datura, Garlic, Eucalyptus and Ginger extracts. The neem based bio-insecticides were more effective to inhibit whitefly population; while tobacco, tooh/tumma and ginger extracts also suppressed whitefly population considerably. Although chemical control was most effective to combat whitefly population, but for a crop that is harvested for its edible pods almost daily or at alternate day, the use of these poisons is extremely harmful for human health. The botanical extracts suppressed whitefly population appreciably and pods from the sprayed plots were free of any toxic effects on the next day of spray.

Keywords: Whitefly, Okra, Synthetic Pesticides, Botanical Extracts, Residual Effects

1. INTRODUCTION

Among vegetables, okra (*Abelmoschus esculentus* Monech.), a member of Malvaceae family is ravaged by many insect pests. There are some 145 insect pest species ravage okra plant including sucking complex and bollworms. Whitefly, Thrips, Jassid, Aphid, Mites, Termite, leaf-roller and cutworm are considered as key insect pests of okra (Dhaka and Pareek, 2007). These insect pests cause great economic losses in okra crop (Mahal *et al.*, 1994). Apart from a variety of insect pests whitefly causes serious crop damages throughout the crop season (Atwal and Singh, 1990; Mani *et al.*, 2005; Gupta and Misra, 2007).

Whitefly is a major sucking insect pest of okra that causes great losses in quantitative and qualitative terms. White fly is a poly phagous insect which feed on 53 host plants including okra, cotton, brinjal, sunflower, cowpeas and tomatoes. (Metha and Saxena, 1998; Silva *et al.*, 1974; Bianchini and Corbetta, 1976; Adediran *et al.*, 1976; Suman *et al.*, 1984; Govindachari, 1992; Saini and Singh, 1999; Lohar, 2001; Tipping *et al.*, 2002; Ahmed *et al.*, 2009; Dhaka and Pareek, 2007; Gafar *et al.*, 2012). The body of whitefly is covered with a white waxy powder (Ullah *et al.*, 2010). Peak population period is August-September in Sindh on cotton and other crops of Malvaceae family (Bhatti *et al.*, 1996). Both the adults and nymphs damage the plants by sucking the cell sap (Gosalwad and Kawathekar, 2009; and Khan *et al.* 2011; *Ramesh* and Chandrasekharan, 2010). The nymphs of white fly secrete honey dew which causes the growth of sooty mould. White fly transmits 23 pathogens in plants in Pakistan (Mahmood *et al.*, 2014).

Although, the toxicc chemicals produce effective control of insect pests, but spraying these chemicals on vegetables that are harvested frequently at short intervals has become a threat to human health. The toxic chemicals as pesticides are also developing pesticides resistance in targeted insect pests (Ahmad *et al.*, 2010). However, use of botanical extracts to combat insect pests particularly on fruits and vegetables is gaining popularity under the organic farming system (Zobayer and Hasan, 2013). (Mahmood *et al.* 2014) showed that tobacco extract reduced population of *B. tabaci* upto 92.62%, followed by Neem powder (91.50%), Heeng (50.93%), Tooh (86.17%), akk (81.19%) and Dhatura (70.94%). These results clearly indicate that botanical extracts can be an effective alternate of toxic chemicals.

Approximately 27% pesticides are used for controlling the pests of fruits and vegetables and it is

[++]Corresponding author: Mazhar Iqbal, Email: flourist6@gmail.com
*Institute of Plant Sciences, University of Sindh, Jamshoro

increasing 25% every year (Hussain *et al.* 2002; USAID, 2009). A large number of chemical pesticides related to organochlorine, organophosphate, pyrithroide and carbamates are used for managing okra pests. Usually systemic granular pesticides are applied through the soil to cause minimum lethal losses to the defenders (Prabhaker and Toscano, 2002). Residual studies showed that Carbofuran was the best with minimum residual persistence of 0.142µg/kg followed by chloropyrifos 0.24 µg/kg, cypermethrin 1.79µg/kg and malathion 7.49 µg/kg one day after treatment, which reduced to 0.091µg/kg, 0.074 µg/kg, 0.25 µg/kg and 3.24 µg/kg, respectively after one week. The residual persistence of the tested pesticides after one month was observed 0.047µg/kg, 0.008µg/kg, 0.0155µg/kg and 0.19µg/kg respectively. The present study was carried out to determine residual toxicity of synthetic and bio-insecticides sprayed on okra against whitefly (*Bemisia tabaci* [Genn.]),

2. MATERIALS AND METHODS

This experiment was laid out at the experimental site, Poonch University of Agriculture Rawalakot (AJK) during 2016. The experiment was laid out in a three replicated Randomized Complete Block Design in a sub-plot size of 3m x 3m ($9m^2$). In all 45 plots were prepared to develop 15 treatments with three replicates. The land was prepared in off-season initially by removing the hard pan of the soil with disc plow and left for 15 days. After 15 days, clods were crushed with tractor drawn clod crusher followed by leveling. After soaking dose, when the land came in condition, the plots were finally prepared by separation strips and forming feeding channels. The row to row distance was maintained at 60 cm and plants were spaced at 30 cm.

The crop was sprayed with five synthetic pesticides including Tracer (Spinosad), Runner (Methoxyfenozide), Radiant (Spinetoram), Belt (Flubendiamide) and Coragen (Chlorantraniliprole) as well as eight botanical pesticides based on Neem (*Azadirachta indica*), Tobacco (*Nicotiana tabacum*), Tooh (*Citrullus colocynthus* (L.) Schrad), Datura (*Datura stramonium*), Garlic (*Allium sativum* L.), Eucalyptus (*Eucalyptus obliqua*, *E. occidentalis*) and Ginger (*Zingiber officinale*). The recommended doses of insecticides, usi ng 100 liter of water was sprayed against whitefly. On appearance of whitefly, the botanical and synthetic pesticides were applied in all the plots with the exception of control were recorded after one and 2 weeks of spray**.** The determined dissipation response of these synthetic and botanical pesticides their toxic residual effects on edible okra pods.

Determination of residues of pesticides:

The chemicals including sodium chloride, Methanol, petroleum ether, ethyl acetate, potassium permanganate (GR 99%) and acetonitrile were the basic elements for determination of pesticide residues. These chemicals (HPLC grade) were procured from Merck International. Millipore Milli-Q water purifier was used for further purification of distilled water. Dr. Ehrenstorfer Ltd (Germany) analytical standards for pesticides were acquired; and by dissolving the standard in acetonitrile, the ACCU. stock standard solution (1mg/mL) was prepared and placed in the dark room at 4°C.

Procedure:

The sample okra pods obtained from the pesticide treated plants were crushed and weighed. The sample was added in 200ml acetonitrile (CH_3CN) plus 500ml water. This material was homogenized for 5 min by blender at high speed. Using suction pump, the material was filtered through Buckner funnel by filter paper (Whatman No. 6) and evaporated using rotary evaporator (at 55°C). In order to concentrate elute just before its dryness nitrogen gas was used. Elute was re-dissolved into acetonitrile to make it 500µl for determination. The petroleum ether (100ml) was added to separating funnel containing filtrate. After shaking well for about 2 min, it was added to saturated sodium chloride (10ml) and water (1000ml). The separator was horizontally positioned to separate the layers discarding the lower aqueous layer. The solvent layer was washed using H_2O portions of 100ml discarding aqueous layer. In the vacuum concentrator, organic layer was evaporated, completely dried and dried organic layer re-dissolved for cleanup procedure in one ml hexane.

Clean up of extracted sample:

The cleanup procedure is termed as "column chromatography" and for this purpose the sample was mixed in 15g anhydrous $Na2SO_4$ and shaken well. For cleanup, the organic elute was passed through a glass column with 1gm florisil. The glasss column was wetted before further process using 50 ml petroleum ether. The glass column was eluted with 200ml of ethyl ether (6%) in petroleum ether and later 200ml ethyl ether (15%) was added in petroleum ether. Thereafter, acquired substance was concentrated on a rotary evaporator up to 100ml for loading on GC for analysis.

3. RESULTS AND DISCUSSION

The study was carried out to determine comparative residual toxicity of synthetic and bio-insecticides sprayed on okra against whitefly (*Bemisia tabaci* Genn.). The experimental crop was sown during 2016. After field evaluation of efficacies of synthetic and bio-insecticides against whitefly, the okra fruit samples from each plot were secured and sent to laboratory for determination of residual effects. The results for insecticide efficacies against whitefly and residual effects are presented as follows:

Comparative insecticidal efficacies

The bio-insecticides showed encouraging results and managed *Bemisia tabaci* effectively. The 1st spray results (Table 1) indicate that crop sprayed with neem oil killed 70.7 and 69.6% whitefly population when monitored after one week and 2 weeks of spray; while whitefly mortality on crop sprayed with neem, tobacco and tooh extracts was 62.1, 61.1 and 60.6% after one week of spray and 60.7, 59.8 and 60.1% after 2 weeks of spray, respectively. The insect mortality was relatively lower in plots sprayed with Ginger, Eucalyptus, Garlic and Dhatura extracts. The 1st spray chemical control results showed that Runner proved to be most effective to control whiteflies on okra showing 97.0 and 96.7% efficacies after one and 2 weeks of spray, respectively. Whitefly was also effectively controlled by Radiant (81.3 and 79.7%), Coragen (80.4 and 80.2%), Tracer (77.5 and 75.5%) and Belt (73.6 and 73.1%), respectively.

The 2nd spray data show that the okra plantation treated with neem oil resulted in 56.8 and 54.9% whitefly mortality after one week and 2 weeks of spray, respectively; while whitefly mortality on crop sprayed with neem, ginger and tobacco extracts was 53.8, 47.6 and 47.0% after one week of spray, respectively. However, after 2 weeks of 2nd spray, the efficacy was higher in plots sprayed with neem extract (51.8%), tobacco extract (45.6%) and akk extract (44.4%). The efficacies against whitefly were relatively lower in plots sprayed with Eucalyptus (35.6%), Dhatura (37.6%), Garlic (40.3%), tooh (41.9%) and ginger extracts (42.9%). The second spray chemical control data show that Runner was most effective against whitefly on okra showing 87.8 and 86.2% efficacies after one and 2 weeks of spray, respectively. Effective whitefly control was also witnessed in plots sprayed Tracer (74.2 and 71.9%), Radiant (70.1 and 67.2%), Coragen (67.3 and 66.6%), Belt (66.5 and 66.1%), respectively.

The results suggested that neem based bio-insecticides were more effective to inhibit whitefly population that was not injurious to okra crop economically. Similarly, tobacco, tooh and ginger extracts also suppressed whitefly population considerably. Although chemical control was most effective to combat whitefly population, but for a crop that is picked for its edible pods almost daily, the use of these poisons is extremely harmful for human health.

Residual Effects of Synthetic Pesticides

Tracer (Spinosad)

Tracer (Spinosad) was determined at the level of 0.65679 mg/kg^{-1} in okra pod on day-1 of spray; while after 3, 7 and 14 days of spray the determined levels were 0.02662, 0.01922 and 0.00570 mg/kg^{-1}, respectively (Table 2). The toxic residues in Tracer sprayed plants persisted upto 7 days after treatment (EU-MRLs = 0.015 mg/kg^{-1}). Generally the okra pods for marketing are picked at alternate day; obviously the pods are picked with toxic residual effects that are harmful for human health.

Runner (Methoxyfenozide)

The residual toxicity of Runner (Methoxyfenozide) in okra pod samples was found at the level of 1.8123 mg/kg^{-1} on day-1 of spray; while after 3, 7 and 14 days of spray the residual toxicity in pods was 0.74301, 0.16042 and 0.01757 mg/kg^{-1}, respectively (Table 3). The toxic residues in Runner sprayed plants persisted upto 7 days after treatment (EU-MRLs = 0.05 mg/kg^{-1}). The overall picture from the determined pesticide residues revealed that okra crop treated with Methoxyfenozide cannot be consumed even after seven days of treatment as suggested by the EU-MRLs 0.05 ppm.

Table 1: Comparative mortality (%) of whitefly (*Bemesia tabaci*) on okra sprayed with synthetic and bio-insecticides

Treatments	Pre-treat	1st spray				Pre-treat	2nd spray			
		1 WAS		2 WAS			1 WAS		2 WAS	
		Mortality	%	Mortality	%		Mortality	%	Mortality	%
Neem extract	3.67	2.28	62.1E	2.23	60.7E	2.49	1.34	53.8D	1.29	51.8D
Neem Oil	3.62	2.56	70.7D	2.52	69.6D	2.71	1.54	56.8D	1.49	54.9D
Tobacco extract	2.96	1.81	61.1E	1.77	59.8E	2.17	1.02	47.0E	0.99	45.6E
Akk extract	3.46	1.89	54.6F	1.87	54.0F	2.59	1.17	45.1E	1.15	44.4E
Tooh/Tuma extract	3.76	2.28	60.6E	2.26	60.1E	2.81	1.20	42.7F	1.18	41.9E
Datura extract	2.76	1.35	48.9G	1.25	45.2G	2.07	0.87	42.0F	0.78	37.6F
Garlic extract	3.94	2.31	58.6E	2.17	55.0F	2.95	1.34	45.4E	1.19	40.3E
Eucalyptus extract	3.96	2.14	54.0F	2.01	50.7F	2.97	1.19	40.0G	1.06	35.6G
Ginger extract	3.42	1.99	58.1E	1.86	54.3F	2.56	1.22	47.6E	1.10	42.9E
Tracer 480 EC	3.48	2.70	77.5C	2.63	75.5C	2.60	1.93	74.2B	1.87	71.9B
Runner	3.39	3.29	97.0A	3.28	96.7A	2.54	2.23	87.8A	2.19	86.2A
Radiant SC	3.75	3.05	81.3B	2.99	79.7B	2.81	1.97	70.1C	1.89	67.2C
Coragen	4.05	3.26	80.4B	3.25	80.2B	3.03	2.04	67.3C	2.02	66.6C
Belt	3.72	2.74	73.6D	2.72	73.1C	2.78	1.85	66.5C	1.84	66.1C
Control	4.03	0.16	3.9H	0.02	0.5H	2.49	-0.03	-1.2H	-0.05	-2.0H
LSD 0.05			***3.74***		***5.33***			***3.96***		***4.01***

Radiant (Spinetoram)

The analyzed values for residual effects of Radiant (Spinetoram) sprayed on okra were 7.7966 mg/kg^{-1} on day-1 of spray; and there was simultaneous reduction in residual toxicity level i.e. 3.14305, 1.33044 and 0.25571 mg/kg^{-1}, respectively after 3, 7 and 14 days of spray (Table 2). Spinetoram showed strong persistence of high residual toxicity in fruit samples from the Spinetoram sprayed okra crop even after 14 days of spray (EU-MRLs = 0.025 mg/kg^{-1}). The determined pesticide residues revealed that the okra pods of Spinetoram sprayed plants cannot be consumed even after two weeks of treatment as suggested by the EU-MRLs 0.025 ppm. Moreover, Spinetoram was highly toxic pesticide and its spray on vegetable crops is not justifiable.

Table 2: Residues and degradation kinetics in okra samples of edible pods sprayed with different synthetic pesticides (mg/kg^{-1})

Time(Days)	Tracer (Spinosad)	Runner (Methoxyfenozide)	Radiant (Spinetoram)
1	0.65679±0.0351	1.81230±0.1365	7.79660±0.8774
3	0.02663±0.0054	0.74301±0.0954	3.14305±0.1665
7	0.01922±0.0012	0.16042±0.0344	1.33044±0.0456
14	0.00570±0.0004	0.01757±0.0054	0.25571±0.0245
EU-MRLs	**0.015**	**0.05**	**0.025**

Belt (Flubendiamide)

Belt (Flubendiamide) was determined at the level of 4.31291 mg/kg^{-1} in okra pod on day-1 of spray; while after 3, 7 and 14 days of spray the determined levels were 0.73307, 0.06022 and 0.01070 mg/kg^{-1}, respectively (Table 3). The toxic residues in Belt sprayed plants persisted upto 7 days of spray (EU-MRLs = 0.01 mg/kg^{-1}). The toxic residues in Belt sprayed okra pods were higher than EU-MRLs upto seven days of spray and the values of residual effects were at par with the EU-MRLs (0.01 mg/kg^{-1}) when determined after 14 days of spray. The okra plants sprayed with Flubendiamide cannot be consumed upto 7 days of spray as suggested by the EU-MRLs 0.01 mg kg^{-1} and this product is not safe for controlling insect pests on vegetables.

Coragen (Chlorantraniliprole)

The residual effects of Coragen (Chlorantraniliprole) sprayed on okra were determined as 2.55419 mg/kg^{-1} on day-1 of spray; while after 3, 7 and 14 days of spray the residual toxicity in pods was 0.57438, 0.26012 and 0.16329 mg/kg^{-1}, respectively (Table 3). The toxic residues in Coragen sprayed okra pods were higher than EU-MRLs only on day-1 of spray and the values of residual effects decreased below the permissible limits (EU-MRLs = 0.60 mg/kg^{-1}) after 3 days of spray. The okra plants sprayed with Chlorantraniliprole can be consumed after 3 days of spray as suggested by the EU-MRLs 0.60 ppm.

Table 3: Residues and degradation kinetics in okra samples of edible pods sprayed different synthetic pesticides (mg/kg^{-1})

Time(Days)	Coragen (Chlorantraniliprole)	Belt (Flubendiamide)
1	2.55419±0.0722	4.31291±0.1265
3	0.57438±0.0166	0.73307±0.0463
7	0.26012±0.0065	0.06022±0.0052
14	0.16329±0.0074	0.01070±0.0010
EU-MRLs	**0.60**	**0.01**

Residual Effects of Botanical Insecticides

The residual effects of different botanical pesticides based on extracts of Neem (*Azadirachta indica*), Tobacco (*Nicotiana tabacum*), Akk (*Calotropis procera* Alton. F.), Tooh (*Citrullus colocynthus* (L.) Schrad), Datura (*Datura stramonium*), Garlic extract (*Allium sativum* L.), Eucalyptus (*Eucalyptus obliqua*, *Eucalyptus occidentalis*) and Ginger (*Zingiber officinale*) sprayed on okra were also determined and the results showed that the residual effects of neem oil, neem extract and tobacco extract at day-1 of spray were 0.4052, 0.79211 and 1.09421 mg/kg^{-1} against EU-MRLs 1.00, 1.00 and 0.75 mg/kg^{-1}, respectively. At day-1 of spray only tobacco extract sprayed pods showed a slightly higher residual effect than EU-MRLs (0.75 mg/kg^{-1}); while toxic effects in pods of okra sprayed with neem based biopesticides were below the EU-MRLs (1.00 mg/kg^{-1}) at day-1 of spray (Table 4). Neem and tobacco based biopesticides effectively controlled the whitefly population and the vegetable was quite safe for human health.

Table 4: Residues and degradation kinetics in okra samples of edible pods sprayed with neem and tobacco based bio-pesticides (mg/kg^{-1})

Time(D ays)	Neem oil	Neem extract	Tobacco extract
1	0.4052±0.0198	0.79211±0.1003	1.09421±0.0195
3	0.20064±0.0088	0.10890±0.0085	0.50516±0.0098
7	0.011129±0.0021	Not detected	0.00163±0.0001
14	Not detected	Not detected	Not detected
EU-MRLs	**1.00**	**1.00**	**0.75**

The determined residual values of Akk (*Calotropis procera* Alton. F.), Tooh (*Citrullus colocynthus* (L.) Schrad) and Datura (*Datura stramonium*) extracts at day-1 of spray were 1.27265, 2.30120 and 1.98223 mg/kg^{-1} against EU-MRLs 2.00 mg/kg^{-1}, respectively. At day-1 of spray only *C. colocynthus* extract sprayed pods showed a slightly higher residual effect than EU-MRLs (2.00 mg/kg^{-1}); while toxic effects in pods of okra sprayed with *C. procera* and *D. stramonium* extracts were below the EU-MRLs (2.00 mg/kg^{-1}) at day-1 of spray (Table 5). *C. colocynthus*, *C. procera* and *D. stramonium* extracts used to control whitefly on okra, not only suppressed the insect infestation to a reasonable level, but okra as vegetable was also safe for human consumption from residual toxicity.

Table 5: Residues and degradation kinetics in okra samples of edible pods sprayed with extracts of various medicinal plants (mg/kg^{-1})

Time(Days)	Akk extract	Tooh/Tuma extract	Dhatura extract
1	1.27265±0.0254	2.30120±0.0095	1.98223±0.0105
3	0.20511±0.0094	0.40178±0.0045	0.35172±0.0041
7	Not detected	0.10327±0.0011	0.21329±0.0012
14	Not detected	Not detected	Not detected
EU-MRLs	**2.00**	**2.00**	**2.00**

The edible pods of okra crop sprayed with Eucalyptus (E. obliqua, E. occidentalis), Garlic (*A. sativum* L.) and Ginger (*Z. officinale*) extracts were also subjected to determine residual effects and at day-1 of spray, the residual effects of E. obliqua, *A. sativum* and *Z. officinale* were 1.23199, 0.01423 and 2.76319 mg/kg^{-1} against EU-MRLs 2.00 mg/kg^{-1}, respectively. At day-1 of spray only *Z. officinale* extract sprayed pods showed residual effect higher than EU-MRLs (2.00 mg/kg^{-1}); while toxic effects in pods of okra sprayed with E. obliqua and *A. sativum* extracts were below or at par with the EU-MRLs (2.00 mg/kg^{-1}) at day-1 of spray **(Table 6).** This indicates that the application of E. obliqua, *A. sativum* and *Z. officinale* extracts for control of whitefly on okra is safe so far the human health is concerned.

Table 6: Residues and degradation kinetics in okra samples of edible pods sprayed with extracts of various medicinal plants (mg/kg^{-1})

Time Days	Eucalyptus extract	Garlic extract	Ginger extract
1	1.23199±0.0597	2.01423±0.2367	2.76319±0.1004
3	0.33377±0.0065	1.05183±0.0645	1.56872±0.0955
7	0.27221±0.0041	0.76329±0.0098	0.46709±0.0088
14	Not detected	Not detected	Not detected
EU-MRLs	**2.00**	**2.00**	**2.00**

4. DISCUSSION

The determined residual effects of pesticides on edible okra pods were recorded upto 2 weeks of spray. The toxic residues were critically higher for Spinosad, Methoxyfenozide, Spinetoram and Flubendiamide; while Chlorantraniliprole group was relatively safe so far the human health is concerned. Tracer (EU-MRLs = 0.015 mg/kg^{-1}); Runner (EU-MRLs=0.05 mg/kg^{-1}), Belt (EU-MRLs= 0.01 mg/kg^{-1}) persisted upto 7 days after spray; while Radiant (EU-MRLs=0.025 mg/kg^{-1}) showed strong persistence of high residual toxicity upto 14 days of spray. However, Coragen showed toxic residues below EU-MRLs (0.60 mg/kg^{-1}) after 3 days of spray. Although chemical control was most effective to combat whitefly population, but for a crop that is harvested for its edible pods almost daily or at alternate day, the use of these poisons is extremely harmful for human health. The botanical extracts suppressed whitefly population appreciably and pods from the sprayed plots were free of any toxic effects on the next day of spray. Similar results have been reported by Sharma *et al*., (2008) who determined that sprayed cabbage could not be consumed upto 10 days of spray of spinosad. Tracer (Spinosad) is biodegradable and its degradation is associated with the environmental variability. Saunders and Brett (1997) Spinosad controlled insect pest upto 86% with lowest initial deposits (0.142565µg/kg) but residues on fruits or pods are not busted like leaves. Dhas and Srivastava (2006) reported that residual effects on Malathion persistence upto 3days of spray and upto 90 days in soil samples. Abo-El-Seoud *et al* (1995) reported that Malathion persisted for residual effects above permissible limits for 12 days on outer layer of cabbage. Mahmoud Shalby (2011) reported that Malathion was effective against *Helicoverpa armigera* on okra with residual effects upto 16.453 ppm at day-1 and decreased to 0.002 ppm 15 DAT. Baig *et al* (2009) reported that chlorpyrifos were detected in 33.0% of the tested vegetables and exceeded the MRLs in 8% of the tested vegetable samples. The toxic residues of Tracer, Runner Belt were higher than the respective MRLs and pods from the okra crop spayed with these pesticides cannot be consumed upto 7 days of spray; while the okra pods from Radiant sprayed crop cannot be consumed even upto 2 weeks of spray. Toxic residues of Coragen were below the MRLs and pods of Coragen sprayed crop can be consumed after 2-3 days of spray. Coragen was not only effective to control whitefly but was also safe for human health. The botanical extracts suppressed whitefly population appreciably and pods from the sprayed plots were free of any toxic effects on the next day of spray.

5. CONCLUSIONS

- The determined dissipation response of Spinosad (Tracer), Methoxyfenozide (Runner), Spinetoram (Radiant), Flubendiamide (Belt) and Chlorantraniliprole (Coragen) recorded and toxic residual effects on edible okra pods were determined upto 2 weeks of spray.
- The toxic residues of Tracer, Runner Belt were higher than the respective MRLs and pods from the okra crop spayed with these pesticides cannot be consumed upto 7 days of spray; while the okra pods from Radiant sprayed crop cannot be consumed even upto 2 weeks of spray.
- Toxic residues of Coragen were below the MRLs and pods of Coragen sprayed crop can be consumed after 2-3 days of spray. Coragen was not only

effective to control whitefly but was also safe for human health.

- The botanical extracts suppressed whitefly population appreciably and pods from the sprayed plots were fre[illegible]y toxic effects on the next day of spray.

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Botanical extracts may be frequently sprayed on okra crop to suppress and keep the whitefly population below ETL, preferably the neem based bio-insecticides, tobacco extract and tooh/tumma extract; that were more effective to inhibit whitefly population on okra. In case the whitefly population persists beyond ETL, Coragen (Chlorantraniliprole) may be sprayed. However, picking of fruits in Coragen sprayed plots may be done atleast after 2-3 days of spray.

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