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Monitoring of insecticide resistance in *Bemisia tabaci* populations collected from selected regions of the Punjab, Pakistan

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Whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae), is a notorious sucking insect pest of cotton and many other crops worldwide. It acts as a vector of various diseases and responsible for causing destruction to economy by damaging major crops. In order to determine, the resistance ratio and efficacy of insecticides against whitefly, field populations of *B. tabaci* were collected from four districts (Multan, Bahawalpur, Jhang and Toba Tek Singh) of Punjab, Pakistan, during 2020 to 2022. After collection, leaf-dip bioassay method was used to measure resistance level in whitefly populations by insecticides (spirotetramat, buprofezin, pyriproxyfen, diafenthiuron, and bifenthrin). The results showed that *B. tabaci* developed high to very high resistance against buprofezin (97.26-108.41 fold), high resistance level against bifenthrin (70.65-95.30 fold), moderate to high resistance against pyriproxyfen (35.68-80.46 fold), moderate level of resistance against diafenthiuron (20.72-30.77 fold), low level of resistance against spirotetramat (11.66-18.60 fold), while comparing with susceptible population. The results of present study i.e., spirotetramat and diafenthiuron may be used as wise choices regarding the selection of insecticides against *B. tabaci* and delay insecticide resistance.
Keywords: *Bemisia tabaci*, Insecticide resistance, Cotton, Leaf-dip bioassay

INTRODUCTION

Cotton is a considerable cash crop, and Pakistan is among top ten countries in cotton production and ranked fifth largest producer of cotton. It is heat and drought resistant due to its vertical tap root system (Khalid *et al.*, 2021; Haider *et al.*, 2022) and sometimes known as "white gold," in Pakistan. Pakistan's cotton exports are the backbone of the country's economy (Haider *et al.*, 2022).

The very low to low level of resistance reported from different regions of Pakistan during 2016 to 2018 against spirotetramat, and pyriproxyfen, Modrate resistance was observed against diafenthiuron during 2017 to 2019 (Saleem *et al.*, 2021). High resistance reported from different districts in *Bemisia tabaci* field population against different insecticides groups such as pyrethroids, ketonols and thiourea. There were several reports from Asia of insecticide resistance in *Bemisia tabaci* (Saleem *et al.*, 2022; Ahmad *et al.*, 2020; Shadmany *et al.*, 2015; Ahmad *et al.*, 2002).

Whitefly, *Bemisia tabaci,* Gennadius (Hemiptera: Aleyrodidae) is polyphagous sucking insect pest of numerous horticultural and agricultural crops worldwide (Mahalanobish *et al.*, 2022; Hu *et al.,* 2020). In 1889, for the first time *B. tabaci* was identified as a pest of tobacco in Greece known as *Aleyrodes tabaci*. Currently, it is widespread throughout the world, living on all continents with the exception of Antarctica (Kanakala and Ghanim, 2019; Sain *et al.*, 2021). Over the centuries, more than one thousand plant species and sixty plant families have been reported as a host plants for this pest (Simmons *et al.,* 2008). Some of these plant families and species include cotton, brinjal, tomato, tobacco and potato (Kunjwal *et al.*, 2018; Khan and Wan, 2015). It needs 16 to 31 days to complete its life cycle, with some minor variations depending on host plants. However, its Q biotype has significantly shorter lifecycle, but the adult lifetime is significantly longer than that of the B biotype (Ismail *et al.*, 2020).

It causes destruction by directly feeding on the plant leaves, lowering seed quality by excreting honeydew, making sooty mold (Lu *et al.*, 2019; Mansour *et al.*, 2013), and spreading cotton leaf curl virus (Khalid *et al.,* 2021). Begomoviruses are known to be the main cause of 20-100% crop production losses that cost millions of dollars (Gangwar and Charu, 2018).

Whiteflies can be effectively controlled by foliar sprays of different classes of insecticides such as pyrethroids

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(bifenthrin), ketonols (spirotetramat), IGRs (buprofezin and pyriproxyfen) and thiourea group (diafenthiuron) (Viana *et al.*, 2023; Bielza *et al.*, 2019; Avery *et al.*, 2019; Shinde *et al.*, 2018; Bretschneider *et al.*, 2003). The unwise use of preventive treatments has significantly contributed to the emergence of insecticide resistance and subsequent failures in controlling whiteflies globally (Horowitz *et al.*, 2020). *B. tabaci* ranked fifth among top twelve insecticide-resistant pests species in the world (Sparks and Nauen, 2015).

It was frequently advised to avoid persistent use of insecticides and apply rotation schedules of insecticide in integrated pest management (IPM) programs to reduce resistance mechanism (Simmons *et al.*, 2008). Insecticide resistance management (IRM) initiatives have been developed by technical organizations like Insecticide Resistance Action Committee (IRAC) to monitor and guide for managment (Sparks and Nauen, 2015). The aim of current study was to monitor the insecticide resistance against *B. tabaci*.

MATERIALS AND METHODS

***Collection of whitefly*:** Whiteflies were collected from unsprayed cotton field areas from various districts of Punjab, Pakistan. To develop susceptible population of *B. tabaci* were reared upto 20 generations and maintained in the laboratory without exposure to any insecticide on cotton plants under controlled conditions at 60±5% relative humidity, 27±1°C temperature and 16:8 (L:D) hours photoperiod. This population used as a susceptible population for assessing the tolerance of field-collected population of *B. tabaci* against different insecticides as earlier pronounced by Ahmad and khan (2017) and Saleem *et al*. (2022).

For field strain, whiteflies were collected from major host crops i.e., cotton, brinjal and tomato from four districts of Punjab (Toba Tek Singh, Jhang, Multan and Bahawalpur) during 2020 to 2022. To maintain the diversity in field population, it was carefully collected from random spots in field area through a vacuum aspirator and then cautiously transferred in the glass jars to relocate in the laboratory.

***Chemicals*:** Tested insecticides were all commonly used by the farmers for the control of whitefly in the field, including: spirotetramat (Movento 240 SC, Bayer Crop Sciences France), diafenthiuron (Polo ® 500 SC, Sygenta, Pakistan), pyriproxyfen (Priority 10.8 EC, Sygenta, Pakistan), buprofezin (WP 25%, Syngenta, Pakistan) and bifenthrin (Talstar 10 EC, FMC).

***Bioassay*:** Leaf-disc bioassay method was used to monitor toxic effects of selected insecticides on *B. tabaci* population performed in controlled laboratory conditions. Six serial dilution of each insecticide in distilled water along with control group were prepared. Serial dilution of each insecticides were prepared in distilled water based on active ingredients percentage in formulated insecticide. Cotton leaf discs (54mm width) were dipped for 10 second in insecticide solution, left for air drying for 20 min on tissue paper. Agar-agar (7g /liter of distilled water) was prepared and added in the petri dishes to keep the leaf moist (Saleem *et al.*, 2022). Whitefly adults remained at -20°C for 60 sec slightly inactive to get transferred on petri plates and maintained in controlled conditions at 27 ± 1°C temperature, 60 ± 5% RH and photoperiod of 16:8 (L:D) hours.

Table 1. Location, years of study, host crops, stage of *B. tabaci* and GPS Coordinates

Location	Years	GPS Coordinates	Host	Stage
Bahawalpur	2020	29.39˚N, 71.6836˚E	Cotton	Adult
Bahawalpur	2021	29.39˚N, 71.6836˚E	Cotton	Adult
Bahawalpur	*2022*	29.39˚N, 71.6836˚E	Cotton	Adult
Toba Tek Singh	2020	30.96˚N, 72.4613˚E	Tomato	Adult
Toba Tek Singh	2021	30.96˚N, 72.4613˚E	Cotton	Adult
Toba Tek Singh	2022	30.96˚N, 72.4613˚E	Cotton	Adult
Multan	2020	30.15˚N, 71.5249˚E	Cotton	Adult
Multan	2021	30.15˚N, 71.5249˚E	Cotton	Adult
Multan	2022	30.15˚N, 71.5249˚E	Cotton	Adult
Jhang	2020	31.27˚N, 72.3317˚E	Cotton	Adult
Jhang	2021	31.27˚N, 72.3317˚E	Tomato	Adult
Jhang	2022	31.27˚N, 72.3317˚E	Brinjal	Adult

For each insecticide five treatments were prepared along with one control group in distilled water. Each treatment had 5 replications. Twenty-five adults of whitefly were released per treatment along with one control group (5 adults per petri plate) with total of 150 adults in one treatment of each insecticide. After 24, 48 and 72 hours of exposure to insecticide mortality data were recorded.

Table 2. Response of laboratory susceptible *population of *B. tabaci* to insecticides

Insecticides	n[a]	LC_{50} (mgL^{-1}) 95% FL)[b]	Calculated values by Probit Analysis			
			Slope±SE[c]	X^{2} [d]	df [e]	P
pyriproxyfen	150	9.14 (12.1-27.8)	1.68±0.22	0.54	4	0.72
buprofezin	150	3.24 (1.10-4.26)	1.72±0.36	1.09	4	0.86
diafenthiuron	150	3.01 (2.12-3.81)	1.23±0.15	1.13	4	0.55
bifenthrin	150	2.78 (1.29-4.12)	0.54±0.11	0.96	4	0.49
spirotetramat	150	0.15 (0.08-0.29)	0.91±0.08	1.10	4	0.43

*Twenty (20) generations; a: Total number of whitefly adults used in experiment; b: LC_{50} values of each insecticides with 95% fiducial limits; c: Slope and standard error; d: Chi-square value; e: Degree of freedom

***Data Analysis*:** For data analysis, Probit analysis (Finney, 1971) Polo Plus software (LeOra, 2003) was used and classified following (Robertson *et al.*, 2017). The lethal medium concentration (LC_{50}) of each insecticide was calculated with the help of Probit analysis, along with slopes±SE and 95% fiducial limits (FL) and for corrected mortality Abbott's formula (1925) was used. For the comparison any two values were considered significantly different if their 95% fiducial limits (FL) did not overlap (Wolfe and Hanley, 2002). Resistance Ratio was calculated according to following values: RR > 100 very high, RR = 51–100 high, RR = 21–50 moderate, RR =11–20 low, RR = 2–10 very low and RR ≤ 1 none.

RESULTS

***Buprofezin*:** All field populations of *B. tabaci* demonstrated high to very high level of resistance against buprofezin during the observed years with no change in response from 2020 to 2022 and overlapped with each other while the resistance ratio of Bahawalpur and Multan populations were significantly higher during 2020-2022 than all others. Resistance ratio (RR) for Multan, Bahawalpur, Jhang and Toba Tek Singh populations were ranged from 101.61 to 107.06-fold, 103.34 to 108.41-fold, 99.48 to 103.53-fold, and 97.26 to 101.58-fold, respectively as shown (Table 3).

***Pyriproxyfen*:** The field populations of *B. tabaci* showed moderate to high resistance level against pyriproxyfen during the observed years with no significant change in response of whitefly frrom 2020 to 2022 and showed significant overlapping with each other and the resistance ratio was significantly higher in Bahawalpur and Multan populations. However, Jhang and Toba Tek Singh populations developed moderate resistance level. Resistance ratio (RR) of Multan population was ranged from 75.24 to 78.69-fold, for Bahawalpur population was ranged from 78.78 to 80.14-fold, for Jhang population was ranged from 45.41 to 49.09-fold, and for Toba Tek Singh population was ranged from 35.68 to 48.41-fold in all three years as shown (Table 3).

***Diafenthiuron*:** All the field populations of *B. tabaci* exhibited moderate resistance level to diafenthiuron. There was no significant difference showed in response during the observed years from 2020 to 2022 and the resistance ratio of all the districts (Multan, Bahawalpur, Jhang and Toba Tek Singh) were overlapping. Resistance ratio for Multan, Bahawalpur, Jhang and Toba Tek Singh populations were ranged from 20.72 to 28.57-fold, 21.35 to 30.77-fold, 22.16 to 26.97-fold and 22.53 to 28.33-fold, respectively as shown (Table 3).

***Spirotetramat*:** All the populations of *B. tabaci* showed low level of resistance against spirotetramat during the observed years with no significant change in response of whitefly frrom 2020 to 2022 and showed significant overlapping with each other while the resistance ratio of Bahawalpur and Multan populations were comparatively higher during 2020-2022 than all others. The resistance ratio measured of spirotetramat for Multan population was ranged from 14.73 to 17.73-fold during 2020 to 2022, for Bahawalpur population was ranged from 13.93 to 18.60-fold, for Jhang population was ranged from 11.66 to 14.60-fold and Toba Tek Singh population was ranged from 12.20 to 14.60-fold during all three years 2020 to 2022 as shown (Table 3).

***Bifenthrin*:** All the populations of *B. tabaci* showed high level of resistance against bifenthrin during 2020 to 2022 with no significant change in response of whitefly and showed significant overlapping with each other while the resistance ratio of Multan population were comparatively higher during 2020-2022 than all others followed by Bahawalpur, Jhang and Toba Tek Singh. The resistance ratio for bifenthrin in Multan, Bahawalpur, Jhang and Toba Tek Singh populations were ranged from 89.63 to 95.30-fold, 84.31 to 88.53-fold, 74.47 to 78.93-fold and 70.65 to 76.16-fold, respectively as shown (Table 3).

DISCUSSION

For over a decade, continuous monitoring of insecticide resistance in *B. tabaci* has been conducted in Pakistan (Ahmad *et al.*, 2010; Basit, 2019). The results reported that whiteflies in Pakistan have developed resistance to a number of formerly effective insecticides (Mushtaq *et al.*, 2000; Ahmad and Khan, 2017) underscores the importance of ongoing monitoring to effectively manage resistance and ensure the long-term effectiveness of chemical control methods. In 1990s in Pakistan, the failure to control *B. tabaci* using traditional insecticides became evident, primarily due to the development of resistance against organophosphates, carbamates, and pyrethroids. Consequently, new classes of insecticides were introduced to address the issue of resistance and improve management strategies (Basit el al., 2013; Ahmad and Khan, 2017). IGRs and neonicotinoids are widely employed in Pakistan for controlling phloem-feeding insect pests that infest cotton, vegetable crops, as well as ornamental plants (Basit *et al.*, 2011).

Field populations of *B. tabaci* collected from four districts (Multan, Bahawalpur, Jhang, and Toba Tek Singh) of Punjab, Pakistan demonstrated resistance against various insecticides. In the current study, *B. tabaci* developed very high to moderate resistance against buprofezin, pyriproxyfen, diafenthiuron, spirotetramat and bifenthrin during 2020-2022. Our results showed high level of resistance against bifenthrin in all the selected districts of Punjab. Ahmed et al. (2010) and Saleem et al. (2022) recorded the similar results and showed the moderate to high resistance to bifenthrin. Moreover, the conventional insecticide bifenthrin did not demonstrate any effective control over *Bemisia tabaci*.

Table 3. Toxicity of insecticides against adult of *B. tabaci* collected from four districts of Punjab, Pakistan from 2020 to 2022.

Years	Insecticides	Locations	LC_{50} (mgL^{-1}) (95% FL)	Fit of Probit Analysis				
				Slope ± SE	X^2	Df	P	RR
2020	buprofezin	Multan	329(212-348)	5.41±0.29	5.25	4	0.71	101
		Bahawalpur	334(278-462)	5.18±0.41	4.12	4	0.44	103
		Jhang	322(212-390)	4.29±0.28	6.79	4	0.93	99.4
		Toba Tek Singh	315(210-381)	4.42±0.88	5.33	4	0.84	97.2
2021	buprofezin	Multan	335 (211-362)	4.10±0.92	4.98	4	0.89	103
		Bahawalpur	345(280-461)	4.17±0.54	3.37	4	0.65	106
		Jhang	330(221-398)	3.38±0.49	4.17	4	0.77	101
		Toba Tek Singh	322(215-390)	4.29±0.43	3.28	4	0.92	99.6
2022	buprofezin	Multan	346(234-356)	3.28±0.79	2.94	4	0.43	107
		Bahawalpur	351(289-465)	3.12±0.59	3.12	4	0.57	108
		Jhang	335(218-391)	2.82±0.64	4.82	4	0.66	103
		Toba Tek Singh	329(210-401)	3.01±0.25	4.64	4	0.94	101
2020	pyriproxyfen	Multan	687(562-831)	4.92±0.81	3.11	4	0.92	75.2
		Bahawalpur	720 (614-819)	3.78±0.92	4.28	4	0.89	78.7
		Jhang	415(390-489.49)	4.68±0.32	5.73	4	0.46	45.4
		Toba Tek Singh	326(302-428)	4.61±0.48	6.21	4	0.78	35.6
2021	pyriproxyfen	Multan	706(667-845)	3.82±0.37	3.78	4	0.51	77.3
		Bahawalpur	735 (607-831)	4.28±0.93	4.93	4	0.72	80.4
		Jhang	423(392-503)	3.43±0.73	4.04	4	0.23	46.3
		Toba Tek Singh	339(316-541)	4.31±0.17	5.49	4	0.44	37.1
2022	pyriproxyfen	Multan	719(612-851)	3.29±0.82	4.14	4	0.63	78.6
		Bahawalpur	732(590-831)	2.87±0.64	6.02	4	0.49	80.1
		Jhang	436(394-512)	2.11±0.89	3.89	4	0.84	47.7
		Toba Tek Singh	442(328-554)	3.21±0.74	4.15	4	0.68	48.4
2020	diafenthiuron	Multan	62.3(52.1-69.3)	4.82±0.13	6.01	4	0.65	20.7
		Bahawalpur	64.2(48.1-73.2)	3.14±0.98	5.82	4	0.51	21.3
		Jhang	66.7(50.2-74.8)	3.09±0.55	3.77	4	0.64	22.1
		Toba Tek Singh	67.8(62.2-79.2)	2.89±0.19	4.08	4	0.19	22.5
2021	diafenthiuron	Multan	73.1(54.3-78.4)	4.93±0.64	5.92	4	0.81	24.1
		Bahawalpur	75.4(60.3-80.1)	3.93±0.83	4.89	4	0.62	25.0
		Jhang	72.9(53.8-75.1)	3.01±0.42	7.10	4	0.51	24.2
		Toba Tek Singh	76.7(63.8-80.9)	3.20±0.11	3.32	4	0.43	25.5
2022	diafenthiuron	Multan	86.0(59.14-91.23)	5.88±0.99	3.18	4	0.87	28.5
		Bahawalpur	92.6(65.1-96.5)	2.89±0.93	4.39	4	0.64	30.7
		Jhang	31.19(55.-85.3)	3.93±0.39	2.16	4	0.57	26.9
		Toba Tek Singh	85.2(64.2-81.3)	3.55±0.90	4.29	4	0.60	28.3
2020	spirotetramat	Multan	2.21(0.74-4.82)	3.11±0.89	3.87	4	0.21	14.7
		Bahawalpur	2.09(0.01-4.29)	3.34±0.18	4.77	4	0.59	13.9
		Jhang	1.75(0.13-3.18)	2.87±0.77	4.91	4	0.76	11.6
		Toba Tek Singh	1.83(0.33-2.73)	3.15±0.68	5.80	4	0.93	12.2
2021	spirotetramat	Multan	2.43(0.75-4.08)	4.19±0.17	7.20	4	0.49	16.2
		Bahawalpur	2.56(0.81-3.54)	3.05±0.12	5.49	4	0.58	17.1
		Jhang	1.92(0.35-3.21)	2.97±0.62	3.17	4	0.69	12.8
		Toba Tek Singh	1.96(0.43-2.82)	3.29±0.38	4.89	4	0.16	13.0
2022	spirotetramat	Multan	2.66(0.84-3.98)	2.74±0.93	4.10	4	0.51	17.7
		Bahawalpur	2.79(0.83-3.57)	4.02±0.78	2.82	4	0.71	18.6
		Jhang	2.32(0.21-2.93)	3.40±0.84	2.91	4	0.83	15.4
		Toba Tek Singh	2.19(0.41-2.98)	2.19±0.33	3.04	4	0.39	14.6
2020	bifenthrin	Multan	249(190-339)	3.84±0.49	6.24	4	0.98	89.6
		Bahawalpur	234(183-279)	4.79±0.68	5.76	4	0.67	84.3
		Jhang	207(172-222)	2.97±0.59	4.29	4	0.83	74.4
		Toba Tek Singh	196(151-248)	3.72±0.63	7.24	4	0.57	70.6
2021	bifenthrin	Multan	256(189-340)	4.15±0.68	3.97	4	0.92	92.4
		Bahawalpur	240(180-280)	4.98±0.79	4.80	4	0.73	86.3
		Jhang	211(175-235)	5.48±0.94	7.29	4	0.69	76.0
		Toba Tek Singh	203(149-251)	6.34±0.57	6.98	4	0.47	73.1
2022	bifenthrin	Multan	264(184-335)	5.24±0.82	3.39	4	0.82	95.3
		Bahawalpur	246(182-274)	3.25±0.75	4.45	4	0.78	88.5
		Jhang	219(170-240)	2.64±0.59	6.86	4	0.28	78.9
		Toba Tek Singh	211(152-254)	3.01±0.24	2.76	4	0.59	76.1

Its ineffectiveness has been observed in whitefly populations collected from cotton crops in West Africa (Houndété *et al.*, 2010), China (Islam *et al.*, 2010), Cyprus (Vassiliou *et al.*, 2011) and India (Naveen *et al.*, 2017). A high level resistance to bifenthrin has been reported in various horticultural regions of Australia (Subramaniam, 2010). During 2002–2005, bifenthrin resistance was discovered in Emerald, where resistance ratios were reported of up to 300-fold (Gunning, 2005). Ahmad et al. (2002) conducted a study on whitefly from 1992 to 2000 and concluded that less reliance on conventional insecticides in the past to control whitefly due to the introduction of new chemistry insecticides for management have reduced resistance level (1997-2000) in whiteflies because of this potential application gap. So, it could be suggested that for managing insecticide resistance should be prioritizing the rotation of insecticides from different chemical classes. This strategy should be accompanied by the utilization of novel chemicals and the integration of various pest management tactics. Guo et al. (2020) also studied that conventional insecticide that were tested exhibited low toxicity as indicated by LC_{50} values. Bifenthrin had LC_{50} values ranging from 16.9 to 296.6 mg/L. The results suggested that the newly introduced insecticides can be considered as valuable and effective alternatives for managing insecticide resistance in *Bemisia tabaci* populations in China.

In contrast to Saleeem et al. (2022), our results indicated that *Bemisia tabaci* showed moderate to high resistance to pyriproxyfen and buprofezin also showed high level of resistance in all four populations of selected districts, it might be because both the insecticides are IGR and used against immature stages and have minimum effect on adult *B. tabaci*, however, it was observed that the toxicity of both insecticides is negligible against whitefly adults with minimum mortality and showed high resistance ratio.

Ahmad and Khan (2017) reported low to very high level of resistance to diafenthiuron. Our study showed that resistance to diafenthiuron is moderate in the different selected zones of Punjab, Pakistan. Basit et al. (2013) reported a negligible level of resistance to diafenthiuron in *Bemisia tabaci* populations in Pakistan during the period of 2008-2009. A low to very high resistance to diafenthiuron was reported in *B. tabaci* from Malaysia (*Shadmany et al. 2015)*. Saleem et al. (2022) also recorded that field populations of *Bemisia tabaci* collected from five districts of Pakistan exhibited low to moderate level of resistance against diafenthiuron and the resistance ratios for diafenthiuron ranged from 16.37 to 26.07-fold during 2017-2019. Moderate to high level of resistance to diafenthiuron was also recorded in *B. tabaci* from China (Zhang *et al.,* 2016, 2017). Diafenthiuron, a derivative of thiourea, is considered a suitable insecticide choice for effectively controlling *Bemisia tabaci* populations (Zhang *et al.,* 2017).

Spirotetramat is an innovative insecticide derived from tetramic acid, possessing a distinct mode of action for the control of sucking insect in their juvenile and immature stages including scale insects, aphids and whitefly (Salazar-López *et al.,* 2016). Saleem et al. (2022) studied that spirotetramat was also highly toxic to the *B. tabaci*. A very low level of resistance was detected in *B. tabaci* populations from Pakistan, which agree with Salazar-López et al. (2016) and Bielza et al. (2019) detecting that resistance to spirotetramat did not develop.

Among tested insecticides, spirotetramat proved less resistant and best to control *B. tabaci* in all four districts of Punjab. Ahmed et al. (2020) showed similar results and reported low level of resistance to spirotetramat. Saleem et al. (2022) recorded similar results of spirotetramat with 3.62 to 13.75-folds resistance level. Among all, spirotetramat with the lowest resistance ratio is recommended.

***Conclusion*:** This study showed that whitefly have developed low to very high resistance to spirotetramat, diafenthiuron, pyriproxyfen, bifenthrin and buprofezin from the selected regions of the Punjab, Pakistan. Spirotetramat with low resistance level is suggested for the control strategies of whitefly in field area. Diafenthurion with moderate resistance was found to be effective against whitefly. The cautious use of tested insecticides enhances the effectiveness of control measures and ensures successful management of whitefly populations within an IPM/IRM framework.

***Author's Contribution*:** Sabeen Asghar conducted the trial and prepared the manuscript. Muhammad Asrar supervised the whole study. Farhat Jabeen and Dilbar Hussain analyzed and checked the samples and statistical analysis.

***Declaration of Competing Interest*:** The authors declare that they do not have any known competing financial interests or personal ties that could appear to have influenced the work disclosed in this study.

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