Research Article

Compatibility of Selected Insecticides Against Sucking Insect Pests of Cotton Under Field Conditions

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Abstract | Cotton is an important cash and fiber crop of Pakistan. Cotton sucking insect pests cause major losses in yield of this crop. Chemical insecticides due to their quick mode of action are considered as the most effective way among the farmers for controlling these insect pests. Present study was designed to evaluate the compatibility of different insecticide mixtures against sucking insect pests *i.e.*, whitefly and jassid. Compatibility of four insecticides combinations i.e., buprofezin + flonicamid, buprofezin + nitenpyram at recommended and half dose of recommended for two years. In separate experiment two combinations of pyriproxyfen + imidacloprid and pyriproxyfen + matrine applied at recommended doses (RD) and 1/2 of recommended doses (HD) were applied on cotton crop against whitefly and jassid in consecutive two years. Randomized complete block design (RCBD) was used for each experiment with three replications each year. Data were recorded 1 DBS (day before spray) and 3 DAS (days after spray) and 7 DAS of insecticides. The results revealed that buprofezin @ 500 ml + flonicamid @ 60 g (RD) was the most effective (79.24%) insecticide mixture against whitefly up to seven days followed by pyriproxyfen + matrine @ 250 and 500 ml (RD) with 74.13% reduction. While mixture of buprofezin + nitenpyram at recommended dose was effective against jassid and whitefly (76.47%) followed by pyriproxyfen + imidacloprid (71.03%). Therefore, application of insecticide mixtures reduced population of spiders, green lacewing and pirate bugs population as compared with control (untreated plot). Almost all combinations were effective as compared to control treatments even at half doses. So, these insecticides could be applied in rotation with each other to reduce insecticides resistance and combined attack of whitefly and jassid. However, it is recommended that integrated pest management approach using different control tactics for conservation of natural enemies, use of yellow sticky traps, botanicals, use of selective insecticides when needed could be the best strategy to overcome insecticides resistance problems.

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Introduction

Cotton is mainly grown in different humid and hot areas of country. In these areas there is high pressure of many insect pests which disturb the quality and quantity of cotton yield. Other factors involved in low yield of cotton per hectare include less availability of financial resources, improper market access and lack of farmers training (Hassan, 1991). Also, less availability of water for irrigation purpose, less adoption of advance technology, the impurity of different pesticides products are the major factors contribute to the low cotton crop yield (Abdullah, 2010). With the introduction Bt (*Bacillus thuringiensis*) cotton in Pakistan loss in the yield due to bollworms attack has been minimized resulted in reduction of pesticide consumption against bollworms but it is not effective for controlling various other insect pests (whitefly, thrips, jassid) (Abdullah, 2009; Majeed *et al*., 2016) of cotton. In Bt crop less consideration was given towards sucking insect pest's population due to which they become more important pests and caused major damages to the crop. Sucking insect pests (jassid and whitefly) damage crop quality and ultimately reduce yield by sucking cell sap and secreting honeydew (Shahid *et al*., 2012). As a cotton pests whitefly was also observed first time in Greece in year 1889. Gangwar and Charu (2018). Whitefly assists as a vector of various viral disease known as (CLCV) cotton leaf curl virus (Malik *et al*.,1999). It serves as a vector of 100 diseases of the plants (Horowitz *et al*., 1998). These pests become more destructive during different plant stages like seedling as well as vegetative growth of cotton plant due to sucking of cell sap Arshad and Suhail (2010). To control different stages of same insect or different insect pest complex, insecticides are used as tank mixture without knowing their compatibility in farmer's fields. For example, insecticides like buprofezin and pyriproxyfen are recommended against nymphs of whitefly but they are not effective against adults of whitefly or other insect pests like jassid usually present in the field at same time. Therefore, present study was considered to find out best possible combination of insecticides against insect pests complex of cotton.

Materials and Methods

Compatibility of different insecticides against whitefly and jassid in cotton, under field conditions were evaluated. Field trials were conducted at the Research Farm of MNS University of Agriculture, Multan (Lat 30.14034; Lng: 71.44427) in cotton season of 2017 and 2018. Two separate experiments were conducted for different combinations of insecticides as mentioned in Tables 3 and 4. Each experiment was conducted in Randomized Complete Block Design (RCBD), five treatments and three replications for each treatment including control. The size of each plot was 18.5 x 9.75 m^2 with treatment size 3.34 x 2.93 m^2. Distance between each replication was 1.52 meters. Five treatments with three replications were maintained in each experiment. Distance between row to row was 0.76 meters, treatment path between each treatment was 1.52 meters. Measurement of distance between plant to plant was 0.22 meters. Insecticides for whitefly and jassid were applied in combination as buprofezin + flonicamid, buprofezin + nitenpyram, pyriproxyfen + matrine and pyriproxyfen + imidacloprid at field recommended as well as half of field recommended doses were applied at economic threshold level. Each insecticide mixture was applied three times on the same plot to avoid residual effects. The scouting of pest was done on weekly basis by selecting randomly 10 plants from each individual treatment. Three leaves from each plant (upper, middle, lower) were selected

Table 1: *Detail of insecticides used in the experiment.*

Sr. No	Common name	Trade name	Dose/ acre	Target insects
1	Buprofezin	Spike 25% WP	500 g	Whitefly
2	Nitenpyram	Pyramid 10% AS	200 ml	Jassid
3	Flonicamid	Ulala 50% WG	60 g	Jassid
4	Pyriproxyfen	Lanolex10.8% EC	250 ml	Whitefly
5	Imidacloprid	Confidor20% SL	250 ml	Jassid, whitefly
6	Matrine	Legend 0.5 AS	500 ml	Whitefly

Table 2: *List of insecticide mixtures used in the experiments.*

Insecticide mixtures	Recommended dose/ acre (RD)	Half of recommended dose/ acre (HD)	No. of applications
Buprofezin+ Flonicamid	500 g + 60 g	250 g + 30 g	3
Buprofezin + Nitenpyram	500 g + 200 ml	250 g + 100 ml	3
Pyriproxyfen + Matrine	500 ml + 500 ml	250 ml + 250 ml	3
Pyriproxyfen + Imidacloprid	500 ml + 250 ml	250 ml + 125 ml	3

Table 3: *Mean (±SE) of whitefly and jassid population, 1DBS, 3 and 7 DAS of three insecticides applications in cotton during year 2017 and 2018.*

Treatments	Mean of whitefly/ leaf (After three sprays) Year (2017)			Mean of jassid/ leaf (After three sprays) Year (2017)			Mean of whitefly/ leaf (After three spray) Year (2018)			Mean of jassid/ leaf (After three sprays) Year (2018)		
	1 DBS	3 DAS	7 DAS	1 DBS	3 DAS	7 DAS	1 DBS	3 DAS	7 DAS	1 DBS	3 DAS	7 DAS
buprofezin+nitenpyram (RD)	6.06±0.44a	3.02±0.34b	3.32±0.36b	1.05±0.1b	0.67±0.07b	0.57±0.15b	8.56±0.37a	3.43±0.45b	3.03±0.44b	1.97±0.1b	0.83±0.10b	0.69±0.86b
buprofezin+flonicamid (RD)	8.55±1.13a	2.23±0.45b	2.89.2±0.56b	1.87±0.12b	0.76±0.19b	0.67±0.46b	9.35±1.13a	2.87±0.31b	3.2±0.47b	2.10±0.23b	0.86±0.15b	0.73±0.11b
buprofezin+nitenpyram (HD)	8.08±1.23a	3.65±2.76b	3.13±0.37b	1.55±0.34b	0.62 ±0.26	0.45±0.24b	8.86±1.23a	3.97±2.89b	3.47±0.48b	2.13±0.18b	0.99 ±0.24b	0.92±0.26b
buprofezin+flonicamid (HD)	7.43±0.32a	2.71±0.32b	3.01±0.21b	2.04±0.22b	0.88±0.13b	0.71±0.09b	9.15±0.62a	3.13±0.25b	3.49±0.28b	2.15±0.12b	0.67±0.06b	0.62±0.11b
Control	10.08±0.29a	8.76±0.43a	9.32±0.41a	3.06±0.35a	5.32±0.23a	4.50±0.31a	11.04±0.29a	9.16±0.26a	8.36±0.40a	5.00±0.23a	4.38±0.19a	4.39±0.28a

Means sharing same letters in each column are non-significant (Tukey's HSD, P > 0.05). DBS = Days before spray, DAS: Days after spray, RD: recommended dose, HD: Half of recommended dose.

Table 4: *Mean (±SE) of whitefly and jassid population, 1DBS, 3 and 7 DAS of three insecticides applications in cotton during year 2017 and 2018.*

Treatments	Mean of whitefly/ leaf (After three sprays) Year (2017)			Mean of jassid/ leaf (After three sprays) Year (2017)			Mean of whitefly/ leaf (After three sprays) Year (2018)			Mean of jassid/ leaf (After three sprays) Year (2018)		
	1 DBS	3 DAS	7 DAS	1 DBS	3 DAS	7 DAS	1 DBS	3 DAS	7 DAS	1 DBS	3 DAS	7 DAS
pyriproxyfen+imidacloprid (HD)	6..22±0.35a	2.82±0.51b	3.20±0.23b	1.43±0.13a	0.44± 0.28b	0.89± 0.18b	9.33±0.64a	3.14±0.70b	3.25±0.30b	1.93±0.15a	0.94±0.22b	0.79±0.15b
pyriproxyfen + matrine (RD)	8.09±0.44a	2.49±0.33b	2.66±0.28b	1.03±0.16a	1.01± 0.14b	0.34± 0.27b	9.13±0.52a	3.49±0.39b	1.43±0.29b	1.98±0.10a	1.05±0.19b	0.29±0.20b
pyriproxyfen+imidacloprid (RD)	7.37±0.87a	3.01±0.54b	2.95±0.36b	1.06±0.23a	0.08± 0.26b	0.76± 0.19b	8.32±0.84a	3.4±0.62b	2.86±0.24b	2.01±0.14a	1.08±0.24b	0.92±0.26b
pyriproxyfen + matrine (HD)	7.74±0.66a	2.11±0.21b	2.65±0.22b	1.11±0.47a	0.76± 0.29b	0.45 ±0.09b	8.74±0.56a	3.11±0.21b	1.73±0.31b	1.64±0.14a	0.67±0.24b	0.62±0.05b
Control	9.09±0.23a	8.03±076a	9.45±0.42a	2.39±0.34a	3.20±0.34a	2.78 ± 0.32a	9.56±0.36a	9.02±0.87a	8.31±0.29a	3.49±0.16a	3.16±0.23a	2.99±0.26a

Means sharing same letters in each column are non-significant (Tukey's HSD, P> 0.05). DBS: days before spray, DAS: Days after spray, RD: recommended dose, HD: Half of recommended dose.

Table 5: *Mean (±SE) of spider, green lacewing and pirate bug population, 1DBS, 3 and 7 DAS of three insecticides applications in cotton.*

Treatments	Mean of spider population/Plant (After three sprays)			Mean of green lacewing population/Plant (After three sprays)			Mean of pirate bug population/Plant (After three sprays)		
	1 DBS	3 DAS	7 DAS	1 DBS	3 DAS	7 DAS	1 DBS	3 DAS	7 DAS
buprofezin + nitenpyram (RD)	0.86±0.19a	0.37±0.09b	0.13±0.06b	3.00±0.20a	0.38±0.12b	0.17±0.09b	1.04±0.17a	0.24±0.09b	0.28±0.06b
buprofezin + flonicamid (HD)	0.82±0.17a	0.41±0.0.6b	0.22±0.09b	1.04±0.23a	0.20±0.31b	0.10±0.07b	0.86±0.21a	0.61±0.12b	0.48±0.16b
buprofezin + nitenpyram (HD)	1.26±0.11a	0.22±0.10b	0.10±0.0.6b	0.51±0.17a	0.14±0.07b	0.14±0.08b	0.82±0.11a	0.24±0.13b	0.13±0.07b
buprofezin + flonicamid (RD)	0.73±0.18a	0.22±0.05b	0.08±0.0.4b	0.93±0.19a	0.40±0.06b	0.10±0.08b	1.16±0.20a	0.63±0.20b	0.45±0.17b
Control	1.13±0.17a	0.91±0.13a	0.66±0.07a	1.22±0.13a	0.91±0.09a	0.83±0.06a	1.02±0.11a	0.88±0.12a	0.91±0.09a

Means sharing same letters in each column are non-significant (Tukey's HSD, P> 0.05). DBS: Days before spray, DAS: Days after spray, RD: recommended dose, HD: Half of recommended dose.

for observing nymph and adults of whitefly and jassid before and after the treatment of insecticides. Post-treatment data were noted after three and seven days of insecticide application. After recording data were analyzed with analysis of variance (ANOVA) by Statistical 8.1 software. Significant treatment means were separated with Tukey HSD test.

Results and Discussion

Whitefly pre-treatment and post-treatment population data were observed before and after insecticide treatment are given in Tables 3 and 4. After 3 and 7 days of insecticides treatment mean of whitefly population from different treated plots showed that whitefly population was above ETL i.e., 5 nymph/adult per leaf in untreated plot. Whitefly population was reduced significantly in all four treatments. However, reduction was higher in buprofezin + flonicamid during both cotton seasons followed by pyriproxyfen + matrine, buprofezin + nitenpyram applied in different plots were also effective and population was below ETL. The second insecticide application effect on whitefly population was observed which showed that after 3 days of insecticide treatment highest mortality of insect population was by buprofezin @ 500 g + flonicamid @ 60 g/acre which followed by pyriproxyfen + matrine, buprofezin + nitenpyram during both year of experiments *i.e.,* 2017 and 2018. Population of whitefly was below ETL in all treated plots. While buprofezin + flonicamid after seven days of second application gave maximum control of pest population and followed by insecticide mixture of buprofezin + nitenpyram.

After third insecticide application recorded data (after 3 days) showed that insecticide mixture buprofezin + flonicamid at recommended dose was more toxic against the whitefly population as compared to other insecticides applied in different plots and after seven days of treatment buprofezin + nitenpyram cause maximum reduction of pest population. In second genotype of cotton insecticide mixture pyriproxyfen @ 500ml + matrine @ 500ml at half of recommended dose gave best results against whitefly population followed by pyriproxyfen + imidacloprid. Population of jassid was recorded before and after first treatment of insecticides. Results showed that among the insecticide treatment buprofezin @ 500 g + nitenpyram @ 200 ml/acre gave best results and maximum reduction of jassid population was recorded (Table 3) and it followed by pyriproxyfen + imidacloprid, buprofezin + flonicamid and pyriproxyfen + matrine. After three and seven days of insecticide application mean of insect population in different plots revealed that population of jassid reduced significantly in all treated plots. Population of jassid was also recorded after second insecticide application. Observed data showed that maximum reduction of jassid population caused by buprofezin + nitenpyram followed by pyriproxyfen + imidacloprid, pyriproxyfen + matrine and buprofezin + flonicamid after three days and seven days of insecticide application.

Population data after three and seven days of third insecticide application showed that the maximum mortality of jassid population caused with buprofezin + nitenpyram followed by pyriproxyfen + imidacloprid, pyriproxyfen + matrine and buprofezin + flonicamid (Table 3). These insecticides mixtures have some effect on beneficial insects population shown in Table 5.

Insecticides were tested in tank mixture, for the management of sucking insect pest complex in cotton crop. Compatibility of insecticides used in these experiments was confirmed by Abbas *et al.* (2012) on insecticides like pyriproxyfen (Flyban 10.8 EC), flonicamid, chlorfenapyr (Decode 36 % SC) and he found that flonicamid gave best results against whitefly, jassid and other sucking pests. This study can be corelated with previous work done by Asif *et al.* (2016) on insecticides efficacy of imidacloprid (Confidor 200 SL), nitenpyram (Nockout 25 SP), profenofos + cypermethrin (Polytrin-C 44 EC), bifenthrin (Talstar 10 EC) he concluded that nitenpyram and imidacloprid proved best for the management of jassid. It is also supported by Sahito *et al.* (2017) who evaluated insecticides like acetamiprid, pyriproxyfen, diafenthiuron, acephate and nitenpyram against jassid and he concluded that nitenpyram gave more control of jassid population. Compatibility of insecticides used in this experiment was confirmed by Abbas *et al.* (2012) on insecticides like pyriproxyfen (Flyban 10.8 EC), flonicamid (Ulala) chlorofinapyr (Decode 36 % SC) and he found that flonicamid gave best results against whitefly, jassid and other sucking pests. This study could be corelated with previous work done by Asif *et al.* (2016) on insecticides efficacy of imidacloprid (Confidor 200 SL), nitenpyram (Nockout 25 SP), profenofos + cypermethrin (Polytrin-C 44 EC), bifenthrin (Talstar 10 EC). He concluded that nitenpyram and imidacloprid proved best for the management of jassid. It is also supported by Sahito *et al.* (2017) evaluated insecticides like acetamiprid, pyriproxyfen, difenthiuron, acephate and nitenpyram against jassid and concluded that nitenpyram gave better control of jassid population.

Insect pest management in cotton crop always remained a tricky and an interesting job for crop managers due to diversity of insect pests, ever changing behavior of insects, biotic and abiotic factors. Abiotic factors like temperature and relative humidity are very important in subcontinent which not only effect life cycle of insects but also reduce the effect of different control measures being applied against insect pests of cotton. Chemical control is among one of the important control methods to manage the insect pests of cotton all over the world. Several chemical groups have been invented with insecticidal activities since 1946 to date. Conventional insecticides included Organochlorines (OCs), Organophosphate (OPs), Carbamates and Synthetic pyrethroids (SPs), whereas new chemicals included Avermectins, Neonicotinoid. Insect growth regulators (IGRs) with novel mode actions (Sparks and Nauen, 2015; Ishtiaq and Saleem, 2011). These insecticide groups include several chemical insecticides used against sucking and chewing insect pests of different crops.

Insecticides belonged to neonicotinoid group are recommended against sucking insect pests with contact and oral mode of action. Representatives of neonicotinoids expressed high target specificity against insect pests and less toxicity against nontarget organisms. They shared almost 20 % of global agrochemical market (Gupta and Milatovic, 2014). Synthetic pyrethroids are contact insecticides, IGRs includes contact and oral insecticides used for the management of sucking insect pests. Insecticides belonged to these groups are being used on a large scale by the farmers in Pakistan for the management of these insect pests since 1970 (Ishtiaq *et al.*, 2012). Cotton crop is attacked by insect pest complex during cropping season. Due to specificity of insecticides various chemicals are applied by the farmers to control insect pest. To deal with more than two insect pests at a time different chemicals (insecticides) are being applied as a tank mix. The use of these chemicals is a technical issue without knowing their compatibility. Farmers use different insecticides against different insect pests without understanding their compatibility which results into pest control and this caused economic losses of crops. If two insecticides are not compatible than they will result into control failure of pests, crop damage and loss of money due to chemicals. Insecticides tank mixtures may have synergistic or antagonistic effects. Synergist means increase in combined effect of two substances. A study was conducted to check the compatibility of four different insecticides acetamiprid + fipronil, ivermectin + acetamiprid, fipronil + chlorfenapyr and ivermectin + chlorfenapyr separately and in mixture form against *Musca domestica*. They concluded that efficacy of fipronil, acetamiprid and ivermectin was maximum in mixture form due to synergistic effect. While chlorfenapyr showed antagonistic effect Levchenko and Silivanova (2019). Antagonistic effect of insecticides means less control in mixture form. Synergist mode of action includes blockage of metabolic system by interfering with process of insecticides detoxification, they have a role to restore insecticide susceptibility in insects. They help to reduce dose of the chemicals applied against insect pests (Zhu *et al.*, 2017). Insecticide ethion showed a potentiation effect when applied with cypermethrin and deltamethrin while triazophos, chlorpyriphos and profenofos showed antagonism when applied with deltamethrin (Ahmad, 2004). In general, insecticide tank mixing is discouraged due to lack of knowledge of the farmers and field workers. Insecticides mixtures could also induce multiple resistance in insect pests, however one or two applications of these mixtures in a season targeting two or more insect pests in the same crop could help the farmers to save their crop and money by overcoming insect pest complex situations in cotton.

Conclusions and Recommendations

At initial stage jassid (June-July) population increased with mild whitefly population, a tank mixture of buprofezin + nitenpyram @ 600 g + 200 ml/ acre respectively gave effective control against both the pests followed by 2nd spray of pyriproxyfen + imidacloprid could effectively manage whitefly and jassid. Whereas, in later stage whitefly population increased in large number in August-September, one spray of pyriproxyfen + matrine @ 250 and 500 ml/ acre could reduce it’s nymph and adults population significantly. However, integrated pest management approaches using different control tactics like promoting natural enemies, use of yellow sticky traps, botanicals, use of selective insecticides when needed could be the best strategy to overcome insecticides resistance problems.

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Novelty Statement

Insecticides are usually recommended singly against one insect pest in cotton. It is difficult to handle insect pest complex in the field as a result farmer applied insecticides as mixtures without knowing their compatibility. Present study provides the solution of the problem.

Author's Contribution

M. Tariq Mushtaq and Faisal Manzoor both executed the field trials for their M.Sc. thesis research.
M. Ishtiaq as supervisor designed experiment.
M. Ishtiaq, Mirza Abdul Qayyum, Muqarrab Ali, as supervisory committees help in designing the experiments, data analysis and review initial draft.
Saleem Riaz revised the manuscript.
All authors approved the final article after reading.

Conflict of interest
The authors have declared no conflict of interest.

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