SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)
ISSN (Print)1813-1743,ISSN (online) 2791-0547
Vol.56:02(2024).
Doi: https://doi.org/ 10.26692/surj-ss.v56i02.7312

Evaluation of Some Integrated Pest Management (IPM) tactics against *Thrips* Species in Cotton Crop

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Cite this:
Khalil Ahmed Kanhar, Fakhara Soomro, Evaluation of Some Integrated Pest Management (IPM) Tactics Against Thrips Species in Cotton Crops. Sindh Uni. Res..J. (SS) 65:02 (2024).

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ABSTRACT

Integrated pest management (IPM) tools were implemented to reduce population of *Thrips* species, specifically *Thrips tabaci* (Lind.) and *Frankliniella occidentalis* (Pergande) and to minimize insecticides usage in cotton filed. The most *Thrips* susceptible cotton variety, NIAB-878, was sown at Saeed Agricultural Farm during the 2020-21 seasons. Field experiments were conducted to evaluate different color sticky traps (yellow, blue, red, pink, green and white) to *Thrips* species. Each color experiment was assessed using a Randomized Complete Blocks Design (RCBD) with four replications. Each treatment consisted of five cards, adjusted in each replication. Data on plant extract and selective insecticides were recorded at 24, 48, 72, and 168-hour interval after each application. The results of color sticky traps showed that the *T. tabaci* was attracted with a greater number on yellow color followed by green color sticky traps. In contrast, *F. occidentalis* attracted to red and yellow traps, whereas lowest number on blue and white traps. Neem plant leaves, bark and seed extracts proved to be the most effective, reducing the *Thrips* population by above 50% after 72 h of application. However, all dosages of Neem derivative were less effective at 24, 48 and 168 hours, failing to reduce *Thrips* population by 50%. Selective insecticides including Acephate 75% WP, Imidacloprid 20% SL and *Chlorfenapyr* 3 60% SC caused over 50% mortality of *Thrips* species with all dosages, except for Acephate at 250gm and Imidacloprid at 200 and 400 ml after 168 hours. Chlorfenapyr at *100 and 200 ml* remained below 50% effective in reducing the *Thrips* population after 72 and 168 hours respectively. In conclusion, the study found that the color sticky traps and plant extracts are environment friendly Integrated Pest Management (IPM) tools that can significantly reduce pest population.

KEYWORDS: *Thrips tabaci*, *Frankliniella occidentalis*, Integrated pest management (IPM), Colored Sticky Traps, cotton crop.

INTRODUCTION

During the discoveries from the ruins of the historical city of Mohenjo-Daro in the Indus Valley of India (now Sindh, Pakistan), cotton crop was cultivated as early as 3,000 BC. The cotton *Gossypium hirsutum* (L.) crop has a wonder yarn: the peoples of Indus Valley rolled, knitted and stained it since ancient periods, and it is still widely used as a fiber for clothes (Shaheen 2018). Cotton (*Gossypium* sp.) is cultivated as a major fiber crop in around 60-111countries worldwide providing fiber and various other raw materials (Amin *et al*., 2008; Lee and Fang 2015). It has declined in yield day by day due to widespread pests and diseases (Egan and Stiller, 2022). Constable and Bange (2015) reported that China, India, the United States of America (USA), Pakistan, Uzbekistan, and Brazil are among the top producers of seed cotton in the world.

Cotton crop is cultivated in different geographical zones of Pakistan including Jhang, Raheem Yar Khan, Bahawalnagar, Bahawalpur, Vihari, Multan, Khanewal, Rajanpur, Muzaffarabad, Lodran, and Faisalabad districts of Punjab and Nawabshah, Kazi Ahmed, Naushero-feroze, Ghotki, and Khairpur districts of Sindh, Pakistan (Shuli *et al*., 2018). The cotton crop in Khairpur district, Sindh, Pakistan, was cultivated and produced seed cotton (82,781 hectors and 433,039bales), ranking third after Sanghar (119,288 hectors and 687,438 bales) and Ghotki (97,434 hectors and 566,179 bales), during 2016-17 (Husain *et al.*, 2019).

In Pakistan the cotton crop was cultivated on 2,517 thousand hectares during 2019-20, but it reduced to 2,079 thousand hectares during 2020-21(Pakistan Economic Survey, 2020-21). The main reason for the reduction in cotton crop cultivation in Pakistan is the change in the global environment, which effects seed germination, crop growth, insect pest infestation, fruiting bodies development and ultimately, crop fields (Imran *et al*., 2018). Cotton, *G. hirsutum* crop is the most favorable food source for leaf sucking and boll chewing insects compare to desi cotton, *G. arborium* (Aslam *et al*., 2004; Amjad and Aheer, 2007). A total of 145-166 insect species damages the cotton crop, out of which17-40 species are considered highly harmful pests (Wilson *et al*., 2013; Luttrell *et al*.,2015; Raza *et al*.,2019). It affects yield production and spreads viruses (Rebijith *et al*., 2012; Prema *et al*., 2018; Rageshwari *et al*., 2021). Severe damage causes cotton plant leaves to turn slivery, and then shades occur, delaying boll maturity and resulting in a 30-80% loss in lint and earliness of the crop (Williams, 2000; Abro *et al*., 2004; Cook *et al*., 2011; Cook *et al*., 2013; Knight *et al*., 2017). The damage of western flower *Thrips* is vulnerable to ornamental as well as agricultural crops. Western flower *Thrips* sucks the cell sap of different body parts of plants and deteriorates the shape of plants and nymphs feed by piercing plant tissues with their needle-shaped mandible and consumes the contents of damaged tissues (Ahmed *et al*. 2023). Moreover, *F. occidentalis* not only cause damage by sucking, but also indirectly by transmitting several viral diseases such as tomato Spotted Wilt Virus (TSWV) and impatiens necrotic spot wilt virus (TNSWV) to several crops (Elimem *et al*., 2014). The most common species of *Thrips* being the western flower *Thrips*, *F. occidentalis* (Pergande) for three main reasons. First, this pest is difficult to detect because of its small size and its matrix behavior. Second, this *Thrips* has strong productivity and even partheno-genetically. Third, this pest has developed resistance to most of the chemical control agents available on the market (Hanafy, 2015).

The incidence of *Thrips* species can be measured over large area using satellite remote sensing, different colored sticky traps and visual observations in integrated pest management programs (Fitzgerald *et al*., 2004; Boll *et al*., 2007; Ranjitha *et al*., 2014; Prema *et al*., 2018). Population monitoring using different colored sticky traps is an effective tool in integrated pest management programs for cotton crops (Gerling and Horowitz, 1984; Hill and Hopper, 1984; Gillespie and Quiring, 1987). The installation of yellow-colored sticky traps is easy to assists population growth, as well as choosing effective control measures (Prema *et al*., 2018). Blue and Yellow sticky traps are more attractive to Western flower *Thrips* (Ren *et al*., 2020; Pobozniak *et al*., 2020). The *Thrips* are more attracted to sticky traps during crop blooming stages, with fever numbers detected before bloom and even fewer after crop bloom (Allan and Jennifer, 2018). IPM tools involve implementing specific non-chemical practices to manage pest complexes in cropping system. To effectively adopt IPM (Integrated Pest Management) approaches, farmers requiring training on pest scouting, identification of beneficial insects, and other methods that can help reduce pesticide usages in cotton crops (Prudent *et al*., 2007; Haq *et al*., 2008). The use of synthetic insecticides has increased agricultural production but on the other hand it has created environmental pollution and decreased beneficial organisms (Aneja *et al*., 2016). Although biochemical extracts from several forest, wild and medicinal plants, are effective in managing insect pests, exclusive studies are needed on numerous forests, wild plants and other weeds to identify prospective plant species with insecticidal bioactive compounds (Tlak and Dar, 2021). While plant extracts are easy to prepare and safe compared to synthetic pesticides, they also exhibit broad-spectrum insecticidal properties against sucking pests (Ahmed, 2020). Plant extracts and essential oils (EOs) have broad spectrum effects on insects, these plant bioactive agents exhibit various activities, including as repellence, attraction, anti-feedant, inhibition of respiration, oviposition and disruption of host plant recognition (Tripathi *et al*., 2009; Ali *et al*., 2017). Neem based bioactive agents works as anti-feedant, biochemical and growth regulators, and have adverse effects on insect physiology (Nathan and Kalaivani, 2006; Taye and Borkataki, 2020). Rashid *et al*, (2012) stated that the applications of Neem oil at 2% and Neem seed water extract at 3% significantly reduced *Thrips* infestation up to 12 days compare to untreated plots. Malinga and Laing (2021) stated that bio pesticides Eco-Bb® and Bandit® effectively reduced *Thrips* populations in cotton crops. The forest plant *Conocorpus lancifolius* containing high concentration of alkaloids, phenols and tannin. Additionally, its plant leaf extract exhibits insecticidal properties, repellence, antifeedants and disrupts the metamorphosis of pest (Rajabpour *et al*., 2019). While several researchers have devoted time to exploring alternative and environmentally safe method for *Thrips* control in cotton crop, the present study evaluates the effectiveness of colored sticky traps as attractant, botanical insecticides and synthetic insecticides in manage *Thrips* populations below economic thresh hold level in cotton crops.

MATERIALS AND METHODS

DIFFERENT COLOR STICK TRAPS

The field experiment on different colored sticky traps was conducted to evaluate *Thrips* species attraction to colors in cotton crop ecosystem for monitoring *Thrips* population during 2020-2021. The six colors namely yellow, blue, red, green, pink and white were used to monitor *Thrips* populations. The colored sticky traps were adjusted with separate colored paper sheets, each measuring 45cm x 25cm, in field. Each colored treatment was evaluated in Randomized Complete Blocks Design (RCBD) with four replications. Each treatment consisted of five cards, which were placed in each replication. The experimental field was kept free from synthetic and botanical insecticides throughout the crop growing seasons. The height of each sticky traps was adjusted from time to time to maintain a position 1 foot above the plant canopy. The castor oil and grease were mixed at a 1:1 ratio and applied to the cards as sticking agent, following the method described by (Prema *et al*., 2018). The sticky traps were replaced every 15 days after observing *Thrips* attraction, until to first picking of cotton crop.

EVALUATION OF DIFFERENT SYNTHETIC AND BOTANICAL INSECTICIDES AGAINST *THRIPS*

The most susceptible cotton variety NIAB-878 during 2021 was grown to facilitate *Thrips* population buildup. The five treatments, including a control, were tested under field conditions. Different botanical extracts namely Neem, *Azadirachta indica* green leaves bark and seed oil, as well as *C. lancifolius* leaves and bark, were examined at various concentrations for their efficacy against cotton *Thrips* species.

NEEM, AND *C. LANCIFOLIUS* LEAVES COLLECTION AND SAMPLE PREPARATION

Healthy Neem, and *C. lancifolius* leaves were collected from healthy plants. The collected leaves were washed to remove foreign materials, then dried under shade and ground using an electric grinder. Ground leaves with different weights (0.5 kg, 1kg, 1.5kg and 2.0kg) were separately mixed with10 liters of water. The resulting leaf paste solution of different concentrations (0.5 kg, 1 kg, 1.5 kg and 2.0 kg) were applied to plants, *Thrips* mortality counts were recorded at interval of 24, 48, 72 and 168 hours.

NEEM SEED COLLECTION AND SAMPLE PERPETRATION

Dry Neem, *A. indica* seeds fallen under Neem, *A. indica* trees were collected from the university premises. The collected dry Neem seeds were brought to the laboratory, washed with fresh water to remove dust and other foreign materials, and the dried under shade for four hours. Neem seed oil was extracted from clean Neem seeds of different weights (0.5 kg, 1 kg, 1.5 kg and 2.0 kg) using a Piteba oil expeller. The extracted oil was filtered using muslin cloth. The filtered Neem seed oil from each seed weight was separately mixed with 10 liters of water to prepare solutions for spraying on plants. The *Thrips* population reduction data were collected at intervals of 24, 48, 72 and 168 hours.

NEEM AND *C. LANCIFOLIUS* BARK SAMPLE COLLECTION AND PREPARATION

The bark (epidermal layer) of Neem, *A. indica* and *C. lancifolius* branches were peeled from area 2-6 inches in length using a sharp knife. The collected barks were rinsed with fresh water, cut into small pieces, and then weighed into four different quantities 0.5 kg, 1 kg, 1.5 kg and 2.0 kg. Each quantity was boiled separately in pressure cooker at 120^0Cdegreeforone hour. The obtained extract was filtered using muslin cloth, and the filtered solution was mixed with fresh water to prepare 10 litter solutions for spraying on plants. The efficacy of the botanical pesticide on *Thrips* population was evaluated at intervals of 24, 48, 72 and 148 hours.

FORMULATED INSECTICIDES

The formulated synthetic insecticides were purchased from different insecticide distributers in Sindh. Their dosages were set as follows: Acephate 75 WP at 250, 500 and 750 gm/100 liter of water, Imidacloprid 20 SL at 200, 400 and 500 ml/100 liter of water, and Chlorfenapyr 360 SC at 100, 200 and 300 ml/100liter of water. These dosages were evaluated in a separate field experiment, which was designed using a Randomized Complete Block Design (CRBD).

POPULATION CHANGE

Population change was calculated using Abbot's formula (1925):

$$Pc = \frac{C - T}{C} \times 100$$

Where; Pc is population change, C is control, and T is treatment.

STATISTICAL ANALYSIS

The observed data were subjected to statistical analysis using the ANOVA technique and the HSD (Highest Significant Difference) test to differentiate the advantages of treatment means. The analysis was performed using Statistic (Ver. 8.1) Micro-Computer Statistical Software, following the method described by Gomez *et al*., (1984).

RESULTS

ATTRACTION OF *THRIPS* SPECIES TO DIFFERENT COLORED STICKY TRAPS

A two-year study was conducted to evaluate the attraction of *T. tabaci* to different colored sticky traps in a cotton field during 2020-2021.The results showed that *T. tabaci* was significantly (F=34.75, df=5, p= 0.0001; F=32.63, df=5, p= 0.0001) more attracted to yellow (21.186 and 15.457), followed by blue (15.014 and 6.729), red (11.243 and 6.759), white (13.321 and 7.479), pink (9.5 and 5.064) and green (7.55 and4.221) colored sticky traps, respectively (Table 1).

The results showed that *F. occidentalis* was highly attracted to red (44.371 and 8.779) and yellow (35.171 and 7.657) colored sticky traps, with significant differences (F=61.17, df=5, p= 0.0001; F=23.43, df=5, p=0.0001, respectively). The second most attractive color was pink (41.165 and 8.779), while blue (10/536 and 4.207), green (19.879 and.35) and white (14.293 and 5.157) colored traps were the least preferred during both year trial (Table 2).

Table1: Capture of *T. tabaci* on different colored sticky traps 2020-2021.

Trap Colors	2020	2021
Yellow	21.186±4.107a	**15.457±2.52a**
Blue	15.014±3.193b	**6.729±1.05bc**
Red	11.243±2.439cd	**6.757±1.05bc**
Pink	9.5±2.144de	**5.064±0.864bc**
Green	7.55±1.9e	**4.221±0.873c**
White	13.321±2.828bc	**7.479±1.146 b**

Means ± S.E followed by the same letters are not significantly different from each other (P<0.05; HSD)

Table2: Capture of *F. occidentalis* on Different Colored Sticky Traps during 2020-21

Trap Colors	2020	2021
Yellow	35.171±5.572b	**7.657±1.061ab**
Blue	10.536±1.648 d	**4.307±0.874 d**
Red	44.371±5.869a	**8.779±0.957a**
Pink	41.164±5.049ab	**7.514±0.88ab**
Green	19.879±3.7c	**6.35±0.878bc**
White	14.293±2.413cd	**5.157±0.812cd**

Means ± S.E followed by the same letters are not significantly different from each other (P<0.05; HSD).

BOTANICAL SPLANT EXTRACTS

The present study evaluated the efficacy of fresh Neem, (*A. indica*) leaves extract against *Thrips* species in cotton crop at different dosages (0.5 kg, 1.0 kg, 1.5 kg and 2.0 kg per 100 liters of water). The results (Table 3) showed significant differences (F=749.14, df=3, p= 0.0001; F=816.51, df=3, p=0.0001, F=819.09, df=3, p=0.0001; F=1055.21, df=3, p=0.0001) in mean percent reduction of *Thrips* species after 24, 48, 72, and 168 ours of application. The data in Table 3 clearly indicate that the Neem leaves extract significantly reduced the *Thrips* species population by more than 50% (52.781, 56.279, 58.484 and 62.941) at all dosages after 72 hours. Moreover, dosages of in 1.5 kg and 2.0 kg/ 100 liters of water achieved reduction of 53.645 and 59.293 respectively after 48 hours. In contrast, all dosages (0.5 kg, 1.0 kg, 1.5 kg and 2.0 kg per 100 liters of water) were less effective when applied at 24 hours (26.903, 29.929, 34.727and40.583) and 168 hours (28.26, 33.127, 38.642 and 42.007) after spraying. The data presented in Table 4 show that the four different concentrations of Neem, (*A. indica*) bark extract exhibited significant differences (F=471.68, df=3, p= 0.0001; F=618.67, df=3, p=0.0001, F=706.86, df=3, p=0.0001; F=742.08, df=3, p=0.0001) in toxicity against *Thrips* species. The highest mortality of *Thrips* species exceeding 50% (52.285 and 59.055), was observed with 02 kg Neem bark extract after 48 and 72 hours, followed by 1.5 kg (50.254) bark extract at 72 hours. In contrast, all remaining concentrations resulted in less than 50% mortality of the pest at the four observation intervals. The present results in (Table 5) indicate that the different Neem (*A. india*) seed oil concentrations exhibited significant differences (F=394.11, df=3, p= 0.0001; F=490.39, df=3, p=0.0001, F=524.24, df=3, p=0.0001; F=493.66, df=3, p=0.0001) in mortality of *Thrips* species under cotton field conditions. Mortality exceeding 50% was observed with 1.5 kg and 2.0 kg Neem seed oil concentrations (52.585and55.81) after 72 hours and with 2.0 kg (51.858) after 48 hours, against *Thrips* species. In contrast, all other dosages and time intervals resulted in below in mortality below 50%. The results presented in Table 6 show that different extract percentages of *C. lancifolius* leaves exhibited significant differences (F=211.22, df=3, p= 0.0001; F=365.13, df=3, p=0.0001, F=795.84, df=3, p=0.0001; F=533.97, df=3, p=0.0001) in reducing *Thrips* populations. At 72 hours post application, concentrations of 1.5 kg and 02 kg achieved54.177% and 59.52% pest reduction, respectively. In contrast, other concentrations remained below 50% effective at all post application intervals. population reduction percentages for different *C. lancifolius* bark extract concentrations (0.5 kg, 1.0 kg, 1.5 kg and 2.0 kg/ 100 litre of water) presented in Table 7 showed significant differences (F=1934.02, df=3, p= 0.0001; F=1561.66, df=3, p=0.0001, F=1083.21, df=3, p=0.0001;F=880.72, df=3, p=0.0001) in mortality of *Thrips* species under filed conditions. Notably, *C. lancifolius* bark extract effectively reduced *Thrips* species populations by 61.407%, 57.78%, 55.69% and 53.66% after application of all prepared concentrations at 48 hours. The highest reduction percentage (63.707%) was recorded with 2.0 kg bark extract followed by 61.36%, 57.301% and 55.493% at 72 hours after application. In contrast, all-prepared concentrations of *C. lancifolius* bark extract was found to be least effective against *Thrips* species during the 24 hours and 168 hours' intervals. The present results of synthetic insecticide Acephate 75 WP at 250 mg, 500 gm and 750 gm/ 100 liter of water separately showed significant to reduced *Thrips* species population (F=1011.59, df=3, p= 0.0001; F=1788.64, df=3,

Table 3: Evaluation of Different Neem leaf Extract Dosages for Reduction of *Thrips* Species Time Intervals (24, 48, 72 and 168 hours) after Application.

Treatments	Control	Mean Percent Reduction of *Thrips* Species			
		After24 Hours	After48 Hours	After72 Hours	After168 Hours
T_1 (0.5 Kg /100 Liter)	55.69± (0.09)	26.90± (0.403)c	44.048± (0.52)b	52.781± (0.502)a	**28.26± (0.404)c**
T_2 (1.0 Kg /100 Liter)	56.03± (0.08)	29.93± (0.523)d	49.498± (0.473)b	56.279± (0.38)a	**33.13± (0.41)c**
T_3 (1.5 Kg /100 Liter)	56.04± (0.09)	34.73± (0.51)d	53.645± (0.462)b	58.48± (0.46)a	**38.64± (0.438)c**
T_4 (2.0 Kg /100 Liter)	56.31± (0.09)	40.58± (0.4) d	59.293± (0.32)b	62.941± (0.334)a	**43.07± (0.344)c**

Means ± S.E followed by the same letters are not significantly different from each other (P<0.05; HSD)

Table 4: Evaluation of Different Neem, *A. indica* Bark Extract Dosage for Mortality of *Thrips* Species at (24, 48, 72 and 168 hours) after application

Treatments	Control	Mean Percent Reduction of *Thrips* Species			
		After 24 Hours	After 48 Hours	After 72 Hours	After 168 Hours
T_1 (0.5Kg /100 Liter)	55.86± (0.095)	24.249± (0.467)c	38.241± (0.45)b	45.069± (0.648)a	**21.958± (0.434)d**
T_2 (1.0Kg /100 Liter)	55.643± (0.11)	26.032± (0.443)c	40.084± (0.42)b	46.98± (0.42)a	**25.904± (0.425)c**
T_3 (1.5 Kg /100 Liter)	56.093± (0.103)	29.853± (0.493)c	48.108± (0.309)b	50.254± (0.386)a	**29.044± (0.515)c**
T_4 (2.0Kg /100 Liter)	55.863± (0.095)	37.045± (0.48)c	52.285± (0.493)b	59.055± 0.357)a	**31.921± (0.545)d**

Means ± S.E followed by the same letters are not significantly different from each other (P<0.05; HSD)

F=789.88, df=3, p=0.0001 respectively) at per count, 24 hours, 48 hours, 72 hours and 168 hours post spray count (Table 8).

Table 5: Evaluation of Different Neem, *A. indica* Seed Oil Dosages for Mortality of *Thrips* Species at (24, 48, 72 and 168 hours) after Application

Treatments	Control	Mean Percent Reduction of *Thrips* Species			
Neem Seed Oil Dosages		**After24 Hours**	**After48 Hours**	**After72 Hours**	**After 168 Hours**
T_1 (0.5 Kg/100 Liter)	55.90± (0.099)	28.37± (0.596)c	39.859± (0.553)b	48.113± (0.603)a	24.472± (0.386)d
T_2 (1.0 Kg/100 Liter)	56.03± (0.097)	30.197± (0.452)c	42.356± (0.561)b	49.948± (0.495)a	27.556± (0.371)d
T_3 (1.5 Kg/100 Liter)	56.26± (0.094)	31.004± (0.42)c	46.458± (0.433)b	52.585± (0.514)a	31.966± (0.516)c
T_4 (2.0 Kg/100 Liter)	56.58± (0.101)	35.425± (0.608)c	51.858± (0.388)b	55.81± (0.459)a	35.937± (0.48)c

Means ± S.E followed by the same letters are not significantly different from each other (P<0.05; HSD)

The efficacy results showed that the population of *Thrips* species decreased by 85.16% significantly at 750 gm/ 100 liter of water after 72 hours. Whereas, all dosages of Acephate 75 WP were initiated reduction in *Thrips* species population by more than 50% compare to pre application, except dose at 250 gm/ 100 liters, which recorded the lowest mortality of 46.63% after application at168 hours. The application results of Imidacloprid 20 SL at 200 ml, 400 ml and 500 ml/ 100 liters of water showed a significantly decline in *Thrips* species count (F=1196.99, df=3, p=0.0001; F=1091.84, df=3, p=0.0001; F=1754.56, df=3, p=0.0001 respectively) at 24hours after post application, and at 24,48, 72 and 168 hours after application (Table 9). The effectiveness result of Imidacloprid 20 SL revealed that the number of *Thrips* species was reduced significantly by 85.17% at 500ml/100 liters of water after 72 hours, whereas the lowest reduction was observed at 200 ml and 400 ml/ 100 liters of water after 168 hours with 37.25% and 46.27% of pest count reduction respectively. All dosages of Imidacloprid 20 SL significantly reduced the *Thrips* species population by more than 50% compares to pre application level. However, the lowest mortality rate just below 50% was recorded at 200 ml and 400 ml/ 100 liters of water after application at 168 hours.The field application effectiveness of Chlorfenapyr 360 SC at 100 ml, 200 ml and 300 ml/ 100 liters of water showed significant reduction in *Thrips* species (F=925.03, df=3, p=0.0001; F=889.98, df=3, p=0.0001; F=796.76, df=3, p=0.0001 respectively at 24 hours after spray at 24, 48, 72 and 168 hours, individually (Table 10). The toxicity results of Chlorfenapyr 360 SC revealed that *Thrips* species population was significantly reduced, with the highest reduction of 84.38% observed at 300 ml/ 100 liters of water after 48 hours. In contrast, the lowest reductions were observed at 100 and 200 ml/ 100 litres of water after 72 hours and 168 hours, with 45.96%, 32.82% and 42.37% reduction in *Thrips* species respectively. All dosage of Chlorfenapyr 360 SC significantly reduced *Thrips* species mortality by more than 50% compared to pre application levels. However, the lowest reduction, just below 50% was observed with100 ml and 200 ml/100 litres of water after application at 72- and 168-hour intervals respectively.

Table 6: Evaluation of Different *Conocarpus lancifolius* Leaf Extract Dosages for Mortality of *Thrips* Species at Various Time Intervals (24, 48, 72 and 168 hours) after Application

Treatments	Control	Mean Percent Reduction of *Thrips* Species			
		After24 Hours	**After 48 Hours**	**After72 Hours**	**After 168 Hours**
T1 (0.5 L/100 Liter)	54.08± (0.126)	18.47± (0.43)c	26.168± (0.77)b	36.858± (0.504)a	19.617± (0.559)c
T2 (1.0 L/100 Liter)	55.08± (0.105)	21.529± (0.494)d	34.966± (0.542)b	40.664± (0.464)a	23.534± (0.463)c
T3 (1.5 L/100 Liter)	55.01± (0.116)	25.533± (0.463)c	42.336± (0.528)b	54.177± (0.462)a	26.569± (0.553)c
T4 (2.0 L/100 Liter)	56.15± (0.123)	32.809± (0.676)c	45.47± (0.35)b	59.52± (0.369)a	34.297± (0.71)c

Means ± S.E followed by the same letters are not significantly different from each other (P<0.05; HSD)

DISCUSSION

The present study was conducted to evaluate some Integrated Pest Management (IPM) tactics to manage *Thrips* species using different colored sticky traps, a well-known synthetic insecticide, and laboratory prepared extracts of Neem, *A. indica* and *C. lancifolius* plant parts at various concentrations. The objective was to reduce *Thrips* species infestation to below the economic injury level in cotton crops, while, minimizing environmental pollution and residual effects of pesticide on living organisms. Sticky traps are widely used globally as strong pest population monitoring strategy to decide on proper control measures before the pest population reaches the economic injury level.

Table 7: Evaluation of Different *C. lancifolius* Bark Extract Dosage for Mortality of *Thrips* Species at Various Time Intervals (24, 48, 72 and 168 hours) after Application

Treatments	**Control**	Mean Percent Reduction of *Thrips* Species			
		After 24 Hours	**After 48 Hours**	**After 72 Hours**	**After 168 Hours**
T_1 (0.5 L/100 Liter)	55.483± (0.119)	20.72± (0.558)c	53.667± (0.367)b	55.493± (0.384)a	18.35± (0.596)d
T_2 (1.0 L/100 Liter)	54.977± (0.107)	23.56± (0.538)b	55.69± (0.39)a	57.301± (0.59)a	21.459± (0.461)c
T_3 (1.5 L/100 Liter)	55.363± (0.099)	29.07± (0.679)c	57.78± (0.385)b	61.37± (0.519)a	29.26± (0.558)c
T_4 (2.0 L/100 Liter)	52.463± (0.136)	34.076± (0.588)c	61.407± (0.452)b	63.707± (0.491)a	33.602± (0.689)c

Means ± S.E followed by the same letters are not significantly different from each other (P<0.05; HSD)

The present results showed that yellow-colored sticky traps were more attractive to *T. Tabaci* during the 1^{st} and 2^{nd} year trials. In contrast, *F. Occidentalis* was highly attracted to both yellow and red colored traps. The red, pink, blue, green and white colored traps were the least attractive to *T. tabaci*, whereas yellow, blue, green and white traps were the least attractive to *F. Occidentalis* Mainali and Llm, (2010). The present study is partially agreeing with previous findings by Demirel and Yildirim, (2008) who reported that the *T. tabaci and F. occidentalis* were more attracted to neon yellow, orange, neon orange and neon pink on brassica crops. Similarly, found that yellow color was more attractive to *F. cephalica* in mango orchards. Amutha (2023) obtained similar results, indicating the blue and yellow color traps were most attractive to *Scirtothrips dorsalis* (Hood), *T.*

Table 8: Evaluation of Different Dosages of Acephate75WP for Mortality of *Thrips* Species at Various Time Intervals (24, 48, 72, and 168 hours) After Application

Treatments		**Control**	Mean Percent Reduction of *Thrips* Species			
			After 24 Hours	**After 48 Hours**	**After 72 Hours**	**After 168 Hours**
T1	**(250gm/ 100 Liter)**	66.7± (0.132)	71.93± (0.43)c	74.27± (0.46)b	75.9± (0.41)a	46.63± (0.44)d
T2	**(500gm/ 100 Liter)**	65.97± (0.133)	76.88± (0.37)c	79.49± (0.28)b	83.09± (0.3)a	50.03± (0.45)d
T3	**(750gm/ 100 Liter)**	66.05± (0.154)	78.13± (0.33)c	82.1± (0.32)b	85.16± (0.23)a	64.05± (0.4) D

Means ± SE followed by the same letters are not significantly different from each other (P<0.05, HSD).

tabaci (Lindeman) and *T. palmi* (Karny) in cotton crops. Khatake *et al*. (2023) reported that *Thrips* were more attracted to blue colour traps in pulse crops. Demirel and Yildirim (2008) found that the yellow colour traps remained more attractive to *Thrips* species during the first-year trial, while blue color was in second year in cotton crops. Irshad *et al*. (2023) suggested that blue color traps are the best option for early *Thrips* population monitoring in orchards. Reddy *et al*. (2023) found that yellow traps caught more thrips in guava orchards. Mukhtar *et al*. (2022) reported that yellow-colored traps were highly attractive to *Thrips* in onion crop. The sicky traps are a good option for monitoring *Thrips* population and making timely decision for control to minimize crop damage. Previous research by Prema *et al*. (2018) reported that the yellow-colored sticky traps caught a greater number of *Thrips* in cotton crops. However, the present results disagree with those of Atakan and Bayram (2011) who reported that white colored traps were more attractive than blue color in cotton crops. The results of using Neem, *A. indica* plant parts extract usage against *Thrips* species showed higher efficacy at the 2.0 kg of leaves, bark and seed oil extract, resulting in59.293%,62.941%,52.285%, 59.055%, 51.858% and 55.81% reduction in pest count at 48 and 72 hours after application respectively. The present experimental results are in agreements with those of Ali

Table 9: Evaluation of Different Dosages of Imidacloprid 20 SL for Mortality of *Thrips* Species at Various Time Intervals (24, 48, 72, and 168 hours) After Application

Treatments	**Control**	Mean Percent Reduction of *Thrips* Species			
		After 24 Hours	**After 48 Hours**	**After 72 Hours**	**After 168 Hours**
T_1 (200ml /100Liter)	65.5± (0.132)	50.23± (0.39)c	63.48± (0.41)b	74.97± (0.43)a	37.25± (0.67)d
T_2 (400ml /100Liter)	67.7± (0.146)	63.04± (0.45)c	74.14± (0.47)b	78.85± (0.36)a	46.27± (0.49)d
T_3 (500ml /100Liter)	66.15± (0.127)	67.78± (0.46)c	82.05± (0.29)b	85.17± (0.22)a	51.03± (0.48)d

Means ± SE followed by the same letters are not significantly different from each other (P<0.05, HSD).

et al. (2022), who described that the application of botanical extracts substantially reduced pest population and prevented *Thrips* infestation for several days, without residual effects on living organisms and the atmosphere. Application of Neem, *A. indica* extract has been considered a prospective source for plant defense and safe for the environment (Adusei and Samuel, 2022), it is also eco-friendly and alternative strategy to pest control (Gupta and Dikshit, 2010). The present results also conform to those of Ghelani *et al*., (2014), who observed that botanical insecticides had moderate efficacy against sucking pests of cotton. The Neem oil at 2.0% was found to be more effective on *T. tabaci* in cotton crop (Khan *et al*., 2013). Similar results were observed by Mane *et al*. (2021) who described that the Azadirachtin 3000 ppm @ 4 ml/liter and neem seed extract 5% significantly controlled onion *Thrips*. However, Zanuncio *et al*., (2016) reported that the applications of Neem oil at high or low dosages caused mortality, inhibited growth and affected the survival of non-target predator.

Table10: Evaluation of Different Dosages of Chlorfenapyr 360SC for Mortality of *Thrips* Species at Various Time Intervals (24, 48, 72, and 168 hours) After Application						
Treatments		**Control**	Mean Percent Reduction of *Thrips* Species			
			After 24 Hours	**After 48 Hours**	**After 72 Hours**	**After 168 Hours**
T_1	**(100ml/ 100Liter)**	65.59± (0.126)	59.48± (0.45)b	61.31± (0.44)a	45.96± (0.41)c	32.82± (0.47)d
T_2	**(200ml/ 100Liter)**	66.34± (0.156)	63.1± (0.35)b	69.68± (0.42)a	60.34± (0.34)c	42.37± (0.47)d
T_3	**(300ml/ 100Liter)**	66.83± (0.128)	72.51± (0.32)c	84.38± (0.29)a	81.63± (0.3)b	64.27± (0.4)d
Means ± SE followed by the same letters are not significantly different from each other (P<0.05, HSD).						

In Pakistan, these trees begun to be planted in large number after 2005 due to their ability to tolerate various weather, soil and water shortage conditions. The present experiment, different quantity of solutions was prepared from *C. lancifolius* leaves (0.5, 1.0, 1.5 and 2.0 liters) and mixed with 100 liters of water. The solutions were sprayed against *Thrips* in cotton crops, and the results were observed after 24, 48, 72 and 168 hours of application. The best results were obtained after 48 hours using 1.5 and2.0 Liters of *C. lancifolius* leaf extract solutions with 42.336% and 45.47% reduction in *Thrips* species respectively. After 72 hours, the 1.0, 1.5 and 2.0 liters' leaf extract solutions resulted in 40.664%, 54.117% and 54.59.52% reduction in *Thrips* species. The best extract solution of *C. Lancifolius* was also prepared in the same quantities as the solution (0.5, 1.0, 1.5 and 2.0 liters) and mixed with 100 liters of water. The result showed more than 40% reduction in *Thrips* species 53.607%, 55.69%, 57.78% and 61.407% after 48 hours and55.493, 57.309, 61.37and 63.707%after 72 hours. Hopefully, the use of botanical extracts will successfully control *Thrips*, providing financial benefits to growers while reducing environmental pollution and residual effects of synthetic chemicals on living organisms. According to Torres and Bueno (2018), the term "conservation biological control" (CBC) refers to the practice of maintaining, defending, and improving crop health and its surrounding environment.

The studies were conducted on the above IPM (Integrated Pest Management) program tactics for management of *Thrips* populations through cost- effective plans. These strategies help reduce the spread of environmental pollution and the negative effects of pesticides on human health. Finally, if all IPM (Integrated Pest Management) methods fail, the last option for pest control is the use of synthetic chemicals. Before conducted current experiments, the selective insecticides were chosen for the pest control program, the results of selective pesticides are presented. The results of acephate 75% WP were showed the lowest reduction (46.68%) in *Thrips* species at 250 gm/ 100 liters of water after 168hours, while the highest mortality (85.18%) was found at 750 gm/ 100 Liters of water after 72hours spraying. Similarly, the reduction percentage was observed after the application of Imidacloprid 20% SL It showed the lowest mortality (37.25%) at 200 ml/100 Liters of water after 168 hours of spraying, whereas the highest mortality (85.17%) was observed at 500ml/100 Liters of water after 72h of spraying. Chlorfenapyr 360 SC, reduced *Thrips* species by 32.82% at 100 ml/ 100 Liters of water after 168 hours, whereas, the highest toxicity (84.38% mortality) was observed at 300 ml/ 100 liters of water after 48 h of spraying. Ataide *et al.* (2024) conducted an experiment in the laboratory on conventional and bio-rational insecticides. They observed that chlorfenapyr, and sulfoxide, generated the highest mortality in all life stages of *T. parvispinus* on bean plant leaves. Imidacloprid caused the maximum reduction percentage of *Scirtothrips dorsalis* population on rose plants (Sathyan, *et al.*, 2017). Similar results were observed that acephate and chlorphenapyr cause maximum mortality of *Thrips* in cotton fields. Asif *et al.* (2016) studied the effectiveness of different insecticides against the sucking complex of cotton crops. They found that applications of imidacloprid and nitenpyram caused the highest mortality of whitefly and *Thrips* in cotton crops. Yesuf *et al*. (2022) recommended imidaclopirid 20 SC for managing *Thrips* populations in cotton crops.

CONCLUSIONS

The primary aim of this study was to reduce the toxic and residual effects of insecticides in cotton crops, there by avoid environmental pollution, protecting beneficial insects through the implementation of integrated pest management (IPM) tools to control thrips species. The sticky traps examined in the experiment revealed that *Thrips*, *T. Tabaci* preferred yellow sticky traps, while *F. Occidentalis* was highly attracted to red and yellow colour traps. This finding suggests that thrips can be monitored periodically, and their population can be reduced by installing a greater number of colour sticky traps in the crops. The application of bio insecticides, including neem, *A. indica* leaves, seeds and bark, as well as *C, lancifolius* leaves and bark extract, effectively reduced *Thrips* population. In IPM (Integrated Pest Management), insecticides are used as a last resort when other methods fail to control insect populations. Therefore, in this experiment, insecticides were used to evaluate their efficacy, and the results showed significant reductions in pest populations. The present study aimed to provide a comprehensive guide for growers to implement in the field. Notably, *Conoccarpus* has been rarely explored as a bio pesticide worldwide. This study paves the way for future research on *C. lancifolius*, exploring its various aspects and potential applications.

ACKNOWLEDGEMENTS

The authors extend their sincere gratitude to all individuals who contributed directly or indirectly to this research, providing valuable support and assistance during the course of the study and data analysis.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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