The Journal of Agricultural Sciences - Sri Lanka
Vol. 20, No 1, January 2025. Pp 101-109
https://doi.org/10.4038/jas.v20i1.9455

Selected Botanicals and Sticky Traps for the Management of *Thrips tabaci* in Onions (*Allium cepa* L.) as Good Agricultural Practices

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Received: 16th August 2021 / Accepted: 06th November 2024

ABSTRACT

Purpose: *Thrips tabaci (Lindeman, 1889) is a polyphagous and severe sucking pest of onions causing huge economic losses. Although widely used, synthetic pesticides are less effective against it along with additional concerns to humans and the environment. Therefore, various good agricultural practices (GAP) were evaluated against it under field conditions.*

Research Method: *Treatments used were GAP1= Marigold (trap crop) and Blue sticky trap; GAP2= Marigold and Aloe vera (botanical pesticide); GAP3= Blue sticky trap and Aloe vera; GAP4= Marigold, Aloe vera, and Blue sticky trap and Control (conventional farmer's plot). Phulkara onion variety was used in the study. The plantation of marigolds and installation of blue sticky traps were done with the transplanting of onions. Aloe vera and synthetic pesticide i.e., Pirate 360 G/L (Chlorfenapyre) were applied depending on the threshold of T. tabaci.*

Findings: *All the GAPs used effectively managed the T. tabaci population on onions. Overall, the lowest T. tabaci population was observed in GAP4- Marigold, Aloe vera, and Blue sticky trap (12.6±0.3 thrips per plant), not significantly different from GAP3- Blue sticky trap and Aloe vera (12.9±0.4 thrips per plant) and control (13.6±0.5 thrips per plant). The GAP1- Marigold and Blue sticky trap treatment suffered the highest T. tabaci population (34.1±1.1 thrips per plant). Maximum onion yield was recorded in control (2597.6±73.8 kegs per ha) but not significantly different from GAP4 (2484.2±59.2 kegs per ha), whereas the lowest yield was recorded in GAP1 (1933.6±46.0 kegs per ha). The cost-benefit ratio of the two best treatments (GAP4 and control) was recorded as 3.05 and 2.53, respectively.*

Originality: *GAP4 should be adopted for better T. tabaci management in onions to get a higher profit margin.*

Keywords: *Crop Losses, IPM, Onion, Profitability, Thrips Management*

INTRODUCTION

Onion thrip, *Thrips tabaci* (Lindeman, 1889) (Thysanoptera: Thripidae) is a globally distributed, notorious, and polyphagous insect pest of many important crops, vegetables, fruits, and flowers including onions (Waiganjo *et al.*, 2008; Shiberu *et al.*, 2013; Woldemelak, 2020). It has been distributed in all onion-growing areas, not only in the tropics and sub-tropics but also in temperate regions of the world.

Therefore, it has gained worldwide attention due to losses associated with it in all cropping systems and onions in particular (Pourian *et al.*., 2009; Diaz-Montano *et al.*, 2011). Both adults and nymphs of *T. tabaci* cause losses to onions directly by sucking the cell sap using their rasping and sucking mouthparts not only from leaves but also from its flowers and fruiting bodies.

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Indirectly, it also serves as a vector of many plant diseases caused by viruses belonging to the *Tospovirus*, *Ilarvirus*, *Carmovirus*, *Sobemovirus*, and *Machlomovirus* genera(Birithia *Carmovirus*, 2013; Chen *Carmovirus*, 2014; Keough *Carmovirus*, 2016). The feeding of thrips leaves a distinct silvery coating on leaves, flowers, and fruits of onions as the yield losses reach up to 34 to 59%(Waiganjo *et al.*, 2008; Ibrahim and Adesiyun, 2009; Diaz-Montano *et al.*, 2011).

Generally, broad-spectrum insecticides are applied in various regions of the world to keep the population of *T. tabaci* below threshold levels on various cultivated crops, fruits, and vegetables (Ullah *et al.*, 2007; Foster *et al.*, 2010). However, these pesticides are not always considered as effective against *T. tabaci* but are associated with additional concerns of non-target impacts such as the destruction of natural enemies, and pollinators (Wabale and Kharde, 2010; Whitehorn *et al.*, 2012; Gogo *et al.*, 2014). Further, secondary pest outbreaks, pest resurgence (Li *et al.*, 2007; Gao *et al.*, 2012), and hazards to crops, environment, and human health are also great concerns (Mostafalou and Abdollahi, 2013). Therefore, in recent years, there has been an increasing demand for alternative, non-toxic, and environmentally friendly management strategies to manage pest populations below threshold levels including thrips (Visalakshy and Krishnamoorthy, 2012). Thus, the adoption of integrated pest management (IPM) practices based on Good Agricultural Practices (GAP) is getting the attention of the plant protection specialist against *T. tabaci*. The adaptation of GAP such as cultural practices, trap crops, sticky traps, varietal resistance, biological agents, and botanicals pesticides (Kennedy, 2008; Woldemelak, 2020) not only reduces the losses of thrips but also helps to get better cost-benefit ratio by reducing the cost of crop protection (Dwivedi *et al.*, 2017).

Good agricultural practices (GAP) include principles and codes of practice for farm management that can contribute to achieving sustainable agriculture and rural development (SARD) by improving food safety and quality, environmental sustainability and social welfare (FAO, 2003). The use of GAP can also result in improved yield and a better profit margin by reducing post-harvest losses (Xu *et al.*, 2022). Moreover, GAP also aimed to improve the farmers' practices to get better farm produce with increased farmer income leading to a better environment and farmers' health (Srisopaporn *et al.*, 2015). Therefore, this study was conducted to evaluate the potential of using marigold as a trap crop, aloe vera as a botanical insecticide and blue sticky trap in suppression of the thrip population in the field. Further, the impact of treatments on yield and the cost-benefit ratio of onions was also observed in comparison to conventional farmer practices so that growers can maximize their profit by adopting environmentally friendly management practices.

MATERIALS AND METHODS

The studies were conducted at the experimental field of the Plant Protection Research Institute (formerly Entomological Section), Agriculture Research Sindh, Tandojam, during the cropping season of 2019. Various Good Agricultural Practices (GAP) packages used in the study were as follows:

- T1 (GAP1): Marigold as a trap crop and Blue sticky trap.
- T2 (GAP2): Marigold and *Aloe vera* as a botanical pesticide.
- T3 (GAP3): Blue sticky trap and *Aloe vera*.
- T4 (GAP4): Marigold, *Aloe vera*, and Blue sticky trap.
- T5 (Control): Conventional farmer's practice.

The Phulkara onion variety was transplanted on 20th August 2019 for all the treatments. All agronomic practices such as weeding, fertilizers, and irrigation were carried out as per the recommendations and requirements of the crop. The marigold (trap crop) was grown on the alternate ridges surrounding onions with four feet distance among individual marigold plants. The blue sticky traps (30 x 30 cm) were glued from both sides using a transparent lubricant that was re-glued after each observation. Five sticky traps were placed per replication. Five kilograms of aloe vera (botanical pesticide) were thoroughly washed with tap water, air-dried under the shade, cut into small pieces and boiled in 10-litter water for 60 minutes. The solution was then sieved through fine muslin cloth to remove the extra particles and get a fine solution. In the final solution, 125 g of detergent powder was added to avoid clotting of the botanical. The obtained stock solution of the individual plant materials was then stored properly at 30±2°C temperature and 60±5% relative humidity in the laboratory of Plant Protection Research Institute, Tandojam, Pakistan for the spray. Aloe vera was applied with 5 kegs of plant material per acre and calibrated accordingly for the replicated plot as 5 grams of detergent was added to the spray solution to enhance its wetting properties and avoid clotting of the botanical. The conventional farmer's practice treatment was maintained with the usual spray schedules with Pirate (Chlorfenapyre) keeping in view the economic threshold levels of *T. tabaci* i.e., 20-25 thrips per plant. In GAP2 and control, two sprays were carried out during the 5th and 9th week of data collection, whereas only one spray of botanical pesticide i.e., aloe vera was done during the 8th week of observations in GAP4 and the 6th week in GAP3.

The Experiment was arranged in a Randomized Complete Block Design design where five replications were maintained for each treatment. The size of each replicated plot was 4.6 x 9.1 square meters. Data collection on the population of *T. tabaci* by observing its numbers (both nymphs and adults) on the individual onion plant was started two weeks after the transplanting from fifteen randomly selected onions per replication per treatment. Observations were continued weekly till the harvesting of onions. Entire replicated plots were harvested to obtain the yield data. The Cost: Benefit (C: B) ratio was calculated on actual expenses and receipts of the individual treatment packages. Analysis of Variance was used for the data analysis, whereas the Least Significant Difference (LSD) test at 5% probability was used to separate the means with significant differences. The STATISTIX 8.1 computer software was used for the analysis of the data.

RESULTS AND DISCUSSION

Results of the study confirmed highly significant differences among weekly thrips populations ($F_{44,4436} = 43.42$; $P < 0.001$) about various GAP packages and the control over the entire study duration (Fig. 01). According to results, *T. tabaci* population on onions during the first week after transplantation that ranged between 2.9±0.2 thrips per plant observed in GAP4 to 4.5±0.3 thrips per plant in the control treatment. A rapid rise in the thrips population was recorded in control, GAP1, and GAP3 treatments in the subsequent weeks of the observations. In contrast, a comparatively lower rise in the *T. tabaci* population was observed in GAP3 and GAP4 treatments (Fig. 01) due to a combination of marigold and blue sticky traps. However, *T. tabaci* population declined substantially in the treatments where Aloe vera or Pirate were applied. Accordingly, per week maximum mean population of *T. tabaci* was recorded in GAP1 (58.8±4.1 thrips per plant), followed by control (30.4±1.4 thrips per plant), GAP3, (27.6±1.4 thrips per plant), GAP4 (27.3±2.2 thrips per plant) and GAP2 (25.8±2.6 thrips per plant), all observed during the eleventh week after the transplanting of onions. A sharp decline in the population of *T. tabaci* was recorded in various treatments when sprays were carried out with either aloe vera (GAP2, GAP3 and GAP4) or Pirate (control).

Results regarding the overall mean *T. tabaci* population recorded over the entire study period are given in Fig. 02 confirming a highly significant ($F_{4,4436} = 386.17$; $P < 0.001$) among various GAP treatments and control. The highest mean population of *T. tabaci* was recorded in GAP1 (34.1±1.1 thrips per plant), whereas the lowest *T. tabaci* population was observed in GAP4 (12.6±0.3 thrips per plant), which was not significantly different from population recorded in GAP3 (13.0±0.4 thrips per plant) and control (13.6±0.5 thrips per plant). Moreover, the overall The mean population of *T. tabaci* recorded in GAP2 was 14.2±0.4 thrips per plant.

The adaptation of various GAP packages not only has an effect significantly in the management of *T. tabaci* populations on onions but also its yield. Accordingly, a highly significant ($F_{4, 20} = 26.1$: $P < 0.001$) difference was recorded in the yield of onions among various GAP treatments and controls. Although the maximum yield was recorded in control i.e., 2597.6±73.8 Kgs per ha, the same was not significantly different from the yield recorded in GAP4 (2484.2±59.2 kegs per ha). The lowest yield of onions was recorded in GAP1 i.e., 1933.6±46.0 kegs per ha, whereas the yield obtained in GAP2 (2089.1±38.0 kegs per ha) and GAP3 (2147.4±49.5 kegs per ha) were not significantly different from each other (Figure 03).

Table 01 describes the cost-benefit ratio of the two best treatments i.e., GAP4 (marigold as a trap crop, blue sticky trap, aloe vera as botanical pesticides) and Conventional farmer's practice (control). The total general cost for the cultivation of onions i.e., land preparation, onion seed, transplanting and labor cost, and cost of fertilizers were the same for the two treatments; however, there was a difference in the cost of weedicides, weeding and plant protection. Accordingly, the cost of cultivation of onions in GAP4 and control was calculated as Rs.57, 560/= and Rs.61, 700/=, respectively, with the cost of protection against *T. tabaci* as Rs.2, 900/= and 10,900/=, respectively. Therefore, the overall cost of production of onions in GAP4 and control treatments to manage *T. tabaci* was recorded as Rs.60, 460/= and Rs.72, 600/=, respectively. Considering the average yield of the two packages i.e., 2484.2±59.2 kegs per ha for GAP4 and 2597.6±73.8 kegs per ha for control, total income calculated @ Rs.40/ kg was Rs.244, 800/= and Rs.256, 000/=, respectively. Thus, the net income calculated for GAP4, and control was Rs.184, 340/= and Rs.183, 400/= with the cost: benefit ratio of 3.05 and 2.53, respectively.

Studies on various GAP practices to manage the population of *T. tabaci* in onions were found to differ

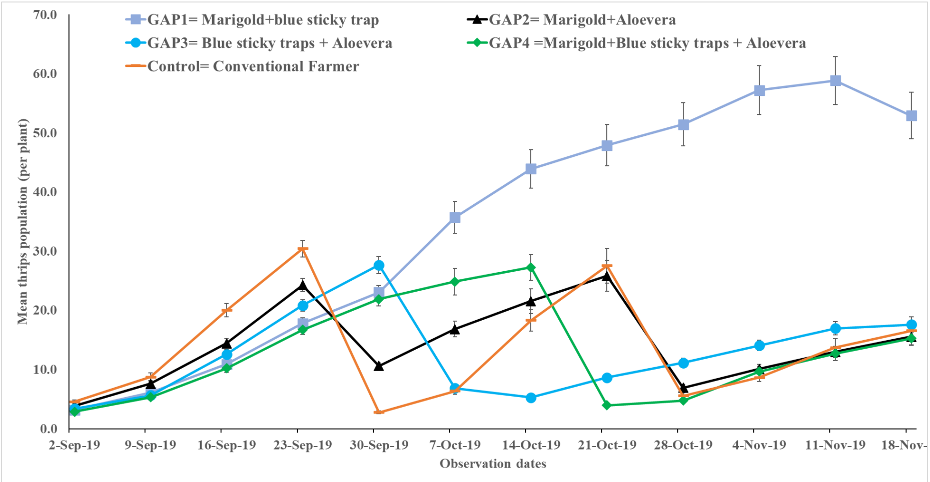

Figure 1: Impact of Good Agricultural Practices on the weekly mean population of *Thrips tabaci* on onion.

**Means followed by the same letters are not significantly different (LSD = 4.5464; P < 0.05)*

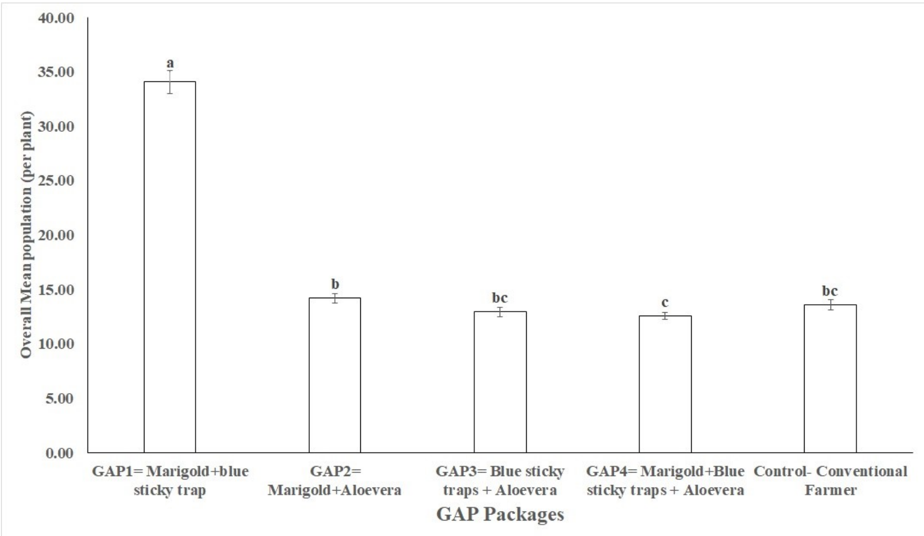

Figure 2: Effect of Good Agricultural Practices on the overall mean population of *Thrips tabaci* on onions

**Means followed by the same letters are not significantly different (LSD = 1.3124; P < 0.05)*

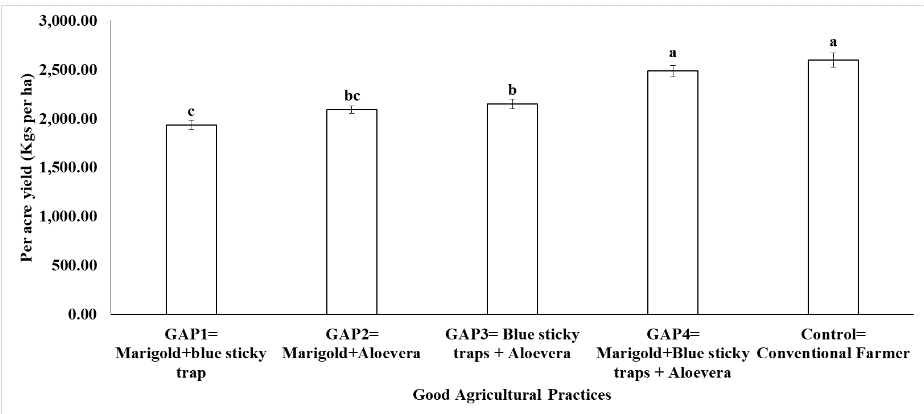

Figure 3: Yield of onion grown under various GAP treatments

**Means followed by the same letters are not significantly different (LSD = 161.36; P < 0.05)*

significantly among themselves. The GAP package four consisting of marigold, blue sticky traps, and aloe vera was found to be the most effective and non-significant with conventional farmer's plots in reducing *T. tabaci* infestation. Due to the combination of diversified control measures in GAP4, only one spray was done in comparison to two sprays in conventional farmers' practices onion plots. Moreover, a rapid rise was recorded in the population of *T. tabaci* in control, GAP1, and GAP3 treatments, whereas an

Table 1: Cost-Benefit Ratio of Onions Grown Under Selected Good Agricultural Practices

Expenditure/Acre	GAP4 Practice (Rs.)	Farmer Practice (Rs.)
A. Cost of Cultivation		
Land Preparation	6,000	6,000
Onion Seed	3,000	3,000
Transplanting	3,000	3,000
Labor Cost	5,000	5,000
Fertilizer	15,000	15,000
Weedicides	1,000	0
Weeding	4,000	6,000
Other Expenses	19,560	24,700
Total (A)	**57,560**	**61,700**
B. Cost of Protection		
Aloe vera	1,000	0
Blue Sticky Traps	1,600	0
Trap Crops (Marigold)	300	0
Chemical Control (Pirate)	0	10,900
Total (B)	**2,900**	**10,900**
Total Cost (A + B)	**60,460**	**72,600**
C. Income		
Onion Production (Maunds)	**153**	**160**
D. Gross Income (Rs.)	**244,800**	**256,000**
E. Net Income (Rs.)	**184,340**	**183,400**
F. Cost-Benefit Ratio	**3.05**	**2.53**

increase in GAP3 and GAP4 treatments was relatively less due to the combination of trap crop (marigold) and blue colored sticky traps. A sharp decline in the population of *T. tabaci* was recorded in various treatments when sprays were done with either aloe vera (GAP2, GAP3, and GAP4) or Pirate (control). Overall, the lowest population of *T. tabaci* was recorded in T4, not significantly different from the population recorded in GAP3 and control.

Studies confirmed that a combination of various non-chemical approaches could keep the *T. tabaci* population below threshold levels. Srinivasan (2016) suggested the integration of resistant varieties i.e., C 521, AC 525, AC 584, TA 189, and TA 243), plantation of castor, keeping the soil moist during critical thrips' infestation period of bulb formation along with mulching and use of botanical pesticides could help to manage the *T. tabaci* on onions in India. The integrated approaches in onions treated with carbosulfan intercropped with maize (outside) and wheat (inside) along with the application of neem, profenofos and carbosulfan + neem oil was found effective to reduce *T. tabaci* infestation by 50% with the highest marketable yield as compared to control and farmer's practice treatments (Singh *et al.*, 2013). Srinivas and Lawande (2002) also confirmed the significant impact of the integrated approach of using predators i.e., coccinellid, Syrphids, spiders, *C. carnea* and barrier crops on sucking pests including *T. tabaci* in onions. In India, integrated management programs are gaining importance and adoption in agricultural crops due to adverse impacts of the synthetic pesticides... This is because farmers not only are aware of the role of natural enemies such as *Trichoderma viride*, and *Pseudomonas fluorescens*, yellow sticky traps, mulching, and application of various neem products in managing *T. tabaci* in onions, but they are also practically using them for reducing the losses of *T. tabaci*in their onion (Kiruthika, 2013; Krishna *et al.*, 2017). A recent study evaluating varietal onion characters i.e., semi-glossy and waxy provided with reflective mulch, with or without bio-pesticides (spinosad + neem oil tank mix) confirmed lower *T. tabaci* populations in IPM treatments sprayed with bio-pesticides than unsprayed plots regardless of mulch and cultivar type i.e., Rossa di Milano, B5336AxB5351C or Bradley" (Iglesias *et al.*, 2021a).

Studies have shown the potential of various botanical extracts such as neem tree seeds or leaves (*Azadirachta indica* Juss.), tobacco (*Nicotiana glauca* Graham), datura (*Datura spp*.) along with bio-pesticides- especially, Spinosad in reducing the *T. tabaci* infestation in onions. However, the performance of these pesticides depend upon the type of pesticides applied (Nault and Hessney, 2010; Fitiwy *et al.*, 2015; Waters and Skoczylas, 2015; Iglesias *et al.*., 2021b). In some studies, comparable onion yields were obtained in bio-pesticide treatments with those of traditional synthetic pesticides i.e., lambda-cyhalothrin (Khaliq *et al.*, 2014). As in the above studies, aloe vera extracts used botanical pesticides in this study proved effective in reducing the population of *T. tabaci*, either alone or in combination with blue sticky traps. Significant insecticidal potential of aloe vera has been recorded in managing many noxious insect pests as Rind *et al.* (2023) found substantial reduction in *T. tabaci* populations with the use of aloe vera that was not significantly different from Chlorfenapyre and neem extracts. However, Padaliya *et al.* (2018) recorded relatively lower performance of aloe vera in comparison to neem-based products in reducing *Scirtothrips dorsalis* infestation on cotton. The studies also confirmed significant role of aloe vera extracts in managing the population of many stored grain pests i.e., Sitophilus oryzae (Mallavadhani *et al.*, 2016), *Sitotroga cerealella* (Mahmood, 2018), and *Callosobruchus maculatus* (Kabir, 2023) along with housefly (El-Monairy *et al.*, 2022) and mosquitoes (Subramaniam *et al.*, 2012; Dinesh *et al.*, 2015).

The cost-benefit ratio of the IPM study also indicated comparatively higher returns to farmers when they adopt the onion farming based on the use of trap crop (marigold), blue sticky trap, and application of aloe vera to manage *T. tabaci* in onions. The findings of Zereabruk *et al.* (2019) while evaluating the role of different intercrops and insecticide control plots in the management of *T. tabaci* mentioned that intercropping onions with cabbage alone or in combination with carrots and lettuce were influential to reduce the population of thrips as compared to untreated control. Though, maximum control of thrips was observed with the application of Karate (lambda cyhalothrin), but, due to the higher cost of insecticides, it gave the lowest gross income as compared to onions grown with lettuce and other intercropped treatments.

CONCLUSION

The GAP used elicited a significant impact on reducing the population of *T. tabaci* in onions with GAP4 comprised of marigold, aloe vera, and blue sticky trap proved most effective in managing its population. The highest onion yield was recorded in conventional farmer’s treatment, but not significantly different from the yield obtained from GAP4. However, the cost-benefit ratio of the GAP4 was comparatively higher (3.05) than conventional farmer’s treatment (2.53) with a total cost of production of Rs.60, 460/= and Rs.72, 600/=, and total income of Rs.244, 800/= and Rs.256, 000/=, respectively. Therefore, GAP4 should be adopted in promising onion cultivars against *T. tabaci* to get better benefits.

CONFLICT OF INTEREST

Authors declared no conflict of interest.

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