Pakistan J. Zool., pp 1-8, 2021. **DOI**: https://dx.doi.org/10.17582/journal.pjz/20200427210427

Monitoring of Sucking Pest on Mustard Crop through Different Colours Sticky Traps

Arshad Ali Lashari[1], Shakal Khan Korai[1]*, Imtiaz Ahmed Nizamani[1], Khalid Hussain Qureshi[1], Abdul Mubeen Lodhi[1], Amir Khan Korai[1] and Punhoon Khan Korai[2]*

[1]*Department of Plant Protection, Faculty of Crop Protection, Sindh Agricultural University, Tandojam, Sindh 70060.*
[2]*Department of Soil Science, Faculty of Agriculture, Lasbela University of Agriculture, Water and Marine Science Uthal 90150 Balochistan, Pakistan.*

Arshad Ali Lashari and Shakal Khan Korai contributed equally to this article.

Article Information
Received 27 April 2020
Revised 29 June 2020
Accepted 07 July 2020
Available online 05 April 2021

Authors' Contribution
AAL and AKK designed methodology and analysed the data. SKK and PKK presented the concept of the studyand wrote the manuscript. IAN supervised the study while KHQ co-supervised it. AML analysed the data.

Key words
***Brassica rapa*, Colours sticky traps, Sucking pests, Aphid, IPM**

ABSTRACT

Colours sticky traps are key components used to monitor and reduce the pest population by trapping individuals and killing them. In this study, four different colours sticky traps, including yellow, green, red and blue were screened on following ten mustard varieties including P-23R-2, NM-8, P-25, UCD-1202, ER-22, P-107R7, NRT02/8, P6, P1191 and Sindh Raya to evaluate the attractiveness of sucking insect pests. The results showed that, the maximum number of jassid (12.40±0.99) was recorded on the yellow trap followed by green (7.70±0.85) and blue (1.60±0.22), whereas the minimum number (0.50±0.16) was recorded on red trap in all mustard varieties. The maximum thrip (54.30±1.89) was recorded on yellow trap followed by green (18.20±1.22) and blue (7.40±0.70), whereas the minimum number of thrips (2.00±0.25) was recorded on red trap. Whitefly maximum number (19.50±1.42) was recorded on yellow trap followed by green (6.90±0.62) and blue (5.40±0.42), whereas minimum (0.50±0.16) was recorded on red trap in all mustard varieties. The maximum population of aphid (78.30±4.51) was recorded on yellow trap followed by green (51.50±2.34) and blue (32.30±2.68), and minimum population (10.30±1.15) was recorded on red trap in all mustard varieties. The results indicated that, there was a significant difference ($p<0.05$) in the number of jassid, thrips, whitefly and aphid catches through different sticky traps in all mustard varieties. The experiment was conducted at the Oilseeds Section, Agriculture Research Institute, Tandojam, Sindh, Pakistan during 2017-18 on the monitoring of sucking pest on mustard crop through different colours sticky traps.

INTRODUCTION

Mustard (*Brassica rapa*) belongs to family Brassicaceae and it is economically important crop because of seed oil contents and some other plant parts like leaves which are edible and can be used as seeds after oil extraction are changed to the shape of cake which is very nutritious and used to feed animals (Shakeel *et al*., 2019). Rapeseed-mustard is a traditional oilseed crop in Pakistan and considered as second most important source of edible oil. The contribution of these crops in Pakistan towards edible oilseed production is about 16-20%. The consumption of domestic edible oil is higher than its production i.e. 2.821 million tons in the country out of which about 0.684 million tons are met through local resources and rest of it (2.1 million tons) is met by import. The bill on imported oil of Pakistan is considered to be the second largest after petroleum. *Brassica* seed contain 30-35% erucic acid and 80- 100 µ m/g oil free meal. Seed meal of *Brassica* contains 35 % protein with balanced amino acid but the quantity of protein percentage is lower than its demand (Nadeem *et al*., 2019). Brassicaceae family is very attractive for insect pollinators for a good source of pollens and nectar. Absence of cross-pollination generally reduces seeds number, seeds size, and viability of seeds that can lead to decrease in yield. Pollination by insect not only increase crop yield but also improve physiochemical properties of the fruits (Bashir *et al*., 2018). The mustard crop is more vulnerable to a wide variety of insect pests from sowing till harvest than other oil seed crops (Shah *et al*., 2020).

Insect-pests are one of the most important factors in reducing the crop yield. About 50 insect species have been reported on mustard crop throughout Asia. Out of many insect pests, sawfly (*Athalia lugens proxima* Klug.), leaf miner (*Chromatomyia horticola* Gorreau), painted bug (*Bagrada cruciferarum* Kirk.), flea beetle (*Phyllotreta*

* Corresponding author: khanshakal7@gmail.com; punhoonkorai@gmail.com
0030-9923/2021/0001-0001 $ 9.00/0

cruciferae Goeze), diamond back moth (*Plutella xylostella* L.), cabbage butterfly (*Pieris brassicae* L.), mustard aphid (*Lipaphis erysimi* Kalt.), cabbage aphid (*Brevicoryne brassicae* L.), green peach aphid (*Myzus persicae* Sulzer), whitefly, (*Bemisia tabaci* Genn.), thrip (*Thrips tabaci* Lind.), jassid, (*Amrasca devastans* Dist.), aphid (*Aphis gossypii* Glover), American bollworm, (*Helicoverpa armigera* Hb.), spotted bollworm, (*Earias* spp.) are considered important, which cause considerable yield losses (Patel *et al*., 2019; Rakha *et al*., 2017; Sun *et al*., 2017; Thongjua *et al*., 2015). In sucking pests both nymphs and adults suck the sap from plants, reducing the vitality and yield of the crop. The nymphs secrete honeydew which promotes the growth of sooty mould disease (Bhati *et al*., 2015). There are several defense mechanisms against pests, such as the number and type of *trichoms* (biological control) and chemicals substances as well as the pod thickness (Ali and Rizvi, 2011). Several insect pests reported such as, mustard aphid *L. erysimi* Kalt., Thrip *T. tabaci* and Whitefly *B. tabaci* (Gennedius) as the major and most destructive causing severe reduction in seed yield losses in mustard crop varying from 15.0 to 73.3% (Bhati *et al*., 2015; Rakha *et al*., 2017). Hence, there is a great scope to study on insect-pests of rapeseed-mustard.

Several studies have been reported on mustard crop to monitor or reducing the pest population through different colour sticky traps, because of its significant results. The pests belongs to order hemiptera and thysanoptera are more attractive on different colors sticky traps (Hassan and Mohammed, 2004; Ranamukhaarachchi and Wickramarachchi, 2007; Blackmer *et al*., 2008; Mazzoni *et al*., 2011; Thongjua *et al*., 2015). However, yellow traps are often preferred over blue traps by the growers because it's also can be used to monitor other pests and pollinator (Shakeel *et al*., 2015). No or limited studies have been reported on monitoring the sucking insect pests on mustard crop through different colors sticky traps worldwide and Pakistan. Mustard is one of the most growing crop throughout the worldwide and the second most growing crop in Pakistan and contribute to the world economy as well in Pakistan. The present study revealed to monitor the pest populations of adult on different colors sticky traps to improve mustard IPM and help former for better control of sucking pest, and reduce the yield losses caused by sucking pests. The fact is sticky traps have been widely used with several advantages for growers such as low cost and low training demands, the development of decision-making tools based on sticky traps (e.g. sampling protocols and economic thresholds (ET) has been rather limited.

MATERIALS AND METHODS

The field experiment to study insect pest complex of rapeseed-mustard was conducted at the Oilseeds Section, Agriculture Research Institute Tandojam, Sindh, Pakistan during 2017-18 on the monitoring of sucking pest on mustard crop through different colours sticky traps.

Experimental design

For the development of IPM strategies against soft bodied insects on mustard crop, this experiment was conducted to monitoring the sucking pest through different colours sticky traps such as green, yellow, red and blue. Four insect-pests were recorded during the cropping season at different stages of *Brassica* species of which 3 belonged to hemiptera, and one each to the order Thysanoptera. The experiment was laid out in a Randomized Complete Block Design (RCBD) having net plot size of 5 x 1.2 m to monitor the population dynamics of sucking insect pests on mustard.

Selection of mustard cultivars

Ten mustard varieties i.e. P-23R-2, NM-8, P-25, UCD-1202, ER-22, P-107R7, NRT02/8, P6, P1191 and Sindh Raya were screened to evaluate the relative resistance against sucking insect pests.

Monitoring and data collection

The monitoring of the sucking insect pests was started right from the germination till the crop harvest in all the mustard varieties. The population buildup of each sucking insect pest was monitored at weekly interval. The observations regarding the sucking insect pest population was noted on the basis of randomly selected twenty five plants from top, middle and bottom for each mustard variety. The sucking insect pests were identified and recorded their population in separate data recording sheets weekly.

Data analysis

Data was analysed using descriptive statistics (Statistix ver. 8.1). The significance of the differences in population level of the insect pests was evaluated using analysis of variance and least significant difference test.

RESULTS

Population of jassid

The result in regards to number of jassid catches through different sticky traps in various varieties of mustard is presented in Table I. Maximum number of jassid (18) were catches in 'UCD-1202' variety on yellow trap and minimum number of jassid (0) were catches in varieties P-23R-2, P-25, NRT02/8, P6 and Sindh Raya on red trap. In case of sticky traps, maximum number of jassid (12.40±0.99) was recorded on yellow trap followed

by green (7.70±0.85) and blue (1.60±0.22) in all mustard varieties. Minimum number of jassid (0.50±0.16) was recorded on red trap in all mustard varieties. Analysis of the obtained showed that there was highly significant ($p<0.05$) difference in number of jassid catches among the sticky traps.

Population of thrip

The result in regards to number of thrips catches through different sticky traps in various varieties of mustard is presented in Table II. Maximum number of thrips (64) was catches in 'ER-22' variety on yellow trap and minimum number of thrips (1) were catches in varieties P-25, P6 and Sindh Raya on red trap. In case of sticky traps, maximum number of thrips (54.30±1.89) was recorded on yellow trap followed by green (18.20±1.22) and blue (7.40±0.70) in all mustard varieties. Minimum number of thrips (2.00±0.25) was recorded on red trap in all mustard varieties. Analysis of the obtained showed that there was highly significant ($p<0.05$) difference in number of thrips catches among the sticky traps.

Population of whitefly

The result in regards to number of whitefly catches through different sticky traps in various varieties of mustard is presented in Table III. Maximum number of whitefly (26) was catches in 'UCD-1202' variety on yellow trap and minimum number of whitefly (0) were catches in varieties P-23R-2, P-25, ER-22, NRT02/8 and P1191 on red trap. In case of sticky traps, maximum number of whitefly (19.50±1.42) was recorded on yellow trap followed by green (6.90±0.62) and blue (5.40±0.42) in all mustard varieties. Minimum number of whitefly (0.50±0.16) was recorded on red trap in all mustard varieties. Analysis of

Table I. Number of jassid catches through different sticky traps in various varieties of mustard.

Varieties	Colours sticky traps				
	Yellow	Green	Red	Blue	Mean±SE
P-23R-2	12	6	0	1	4.75±5.50
NM-8	10	8	1	1	5.00±4.69
P-25	13	10	0	2	6.25±6.24
UCD-1202	18	7	1	2	7.00±7.79
ER-22	14	5	1	1	5.25±6.13
P-107R7	10	4	1	2	4.25±4.03
NRT02/8	12	6	0	3	5.25±5.12
P6	16	13	0	1	7.50±8.19
P1191	12	10	1	2	6.25±5.56
Sindh raya	7	8	0	1	4.00±4.08
Mean±SE	12.40±0.99a	7.70±0.85b	0.50±0.16c	1.60±0.22c	

ANOVA interaction significantly shows *P value*. Mean±SE within a row with different superscript alphabet are significantly different ($p<0.05$).

Table II. Number of thrips catches through different sticky traps in various varieties of mustard.

Varieties	Colours sticky traps				
	Yellow	Green	Red	Blue	Mean±SE
P-23R-2	53	19	3	10	21.25±22.16
NM-8	48	22	2	8	20.00±20.46
P-25	55	14	1	7	19.25±24.42
UCD-1202	59	17	3	5	21.00±26.08
ER-22	64	21	2	9	24.00±27.80
P-107R7	50	24	2	4	20.00±22.33
NRT02/8	44	19	3	6	18.00±18.67
P6	53	12	1	8	18.50±23.44
P1191	60	14	2	11	21.75±26.00
Sindh raya	57	20	1	6	21.00±25.31
Mean±SE	54.30±1.89 a	18.20±1.22 b	2.00±0.25 d	7.40±0.70 c	

ANOVA interaction significantly shows *P value*. Mean±SE within a row with different superscript alphabet are significantly different ($p<0.05$).

Table III. Number of whitefly catches through different sticky traps in various varieties of mustard.

Varieties	Colours sticky traps				
	Yellow	Green	Red	Blue	Mean±SE
P-23R-2	15	5	0	7	6.75±6.24
NM-8	18	7	1	5	7.75±7.27
P-25	22	9	0	4	8.75±9.57
UCD-1202	26	5	1	3	8.75±11.62
ER-22	14	11	0	7	8.00±6.06
P-107R7	19	6	1	5	7.75±7.80
NRT02/8	21	8	0	7	9.00±8.76
P6	25	7	1	5	9.50±10.63
P1191	22	5	0	6	8.25±9.54
Sindh raya	13	6	1	5	6.25±4.99
Mean±SE	19.50±1.42 a	6.90±0.62 b	0.50±0.16 b	5.40±0.42 c	

ANOVA interaction significantly shows *P value*. Mean±SE within a row with different superscript alphabet are significantly different ($p<0.05$).

Table IV. Number of aphids catches through different sticky traps in various varieties of mustard.

Varieties	Colours sticky traps				
	Yellow	Green	Red	Blue	Mean±SE
P-23R-2	82	50	5	41	44.50±31.67
NM-8	84	55	8	46	48.25±31.35
P-25	83	47	10	32	43.00±30.69
UCD-1202	82	38	12	22	38.50±30.91
ER-22	71	52	14	38	43.75±24.01
P-107R7	62	59	5	34	40.00±26.50
NRT02/8	52	63	13	28	39.00±22.67
P6	94	57	9	37	49.25±35.74
P1191	71	50	11	25	39.25±26.61
Sindh raya	52	44	16	20	33.00±17.70
Mean±SE	78.30±4.51 a	51.50±2.34 b	10.30±1.15 d	32.30±2.6 c	

ANOVA interaction significantly shows *P value*. Mean±SE within a row with different superscript alphabet are significantly different ($p<0.05$).

the obtained showed that there was highly significant ($p<0.05$) difference in number of whitefly catches among the sticky traps.

Population of aphid

The result in regards to number of aphid catches through different sticky traps in various varieties of mustard is presented in Table IV. Maximum number of aphid (94) was catches in 'P6' variety on yellow trap and minimum number of whitefly (5) were catches in varieties P-23R-2 and P-107R7 on red trap. In case of sticky traps, maximum number of aphid (78.30±4.51) was recorded on yellow trap followed by green (51.50±2.34) and blue (32.30±2.68) in all mustard varieties. Minimum number of aphid (10.30±1.15) was recorded on red trap in all mustard varieties. Analysis of the obtained showed that there was highly significant ($p<0.05$) difference in number of aphid catches among the sticky traps.

DISCUSSION

The fact is many insects show preference to particular light wavelengths has lead entomologists and researchers involved in plant protection to develop monitoring tools and control strategies against many insect pests exploiting this behavior. One good example of such an approach is the use of coloured traps. Sticky traps in particular have been a subject of research for many decades, and incorporated in management programmes of various most destructive insect pests such as, whitefly, *Bemisia tabaci* (Genn.), thrip *Thrips tabaci* (Lind.), jassid *Amrasca devastans* (Dist.), aphid, *Aphis gossypii* (Glover), American bollworm,

Helicoverpa armigera (Hb.) and the spotted bollworm, *Earias* spp. in number of crops (Beckham, 1969; Berlinger, 1980; Byrne *et al*., 1986; Demirel and Yildirm, 2008; Hoddle *et al*., 2002; Kirk, 1984; Thongjua *et al*., 2015; Rakha *et al*., 2017; Sun *et al*., 2017). The infestation of sucking insect pests is one of the important factor responsible for yield reduction in mustard. The mustard crop is more vulnerable to a wide variety of insect pests from sowing till harvest compared to other oil seed crops (Ahmed *et al*., 2013).

The findings of the present study indicated that the highest (54.30±1.89) thrips population was recorded on yellow trap followed by green (18.20±1.22) and blue (7.40±0.70) however, the supported study also observed the highest attraction to thrips, *Scirtothrips dorsalis* in okra on yellow colour trap followed by green colour (Malik *et al*., 2012), while Devi and Roy (2017) indicated that thrips were attracted to blue as well as to white colour. A few studies have been reported that, blue and white sticky traps have been considered as the most preferred for several species of thrips, including *T. tabaci*. Blue traps caught significantly more thrips than the white ones (Liu and Chu, 2005), while the present study also reported the related results for thrips on blue traps. In another study, blue and white colours were reported to be more effective in trapping the thrips, *Ceratothripoides claratris* followed by purple in tomato (Ranamukhaarachchi and Wickramarachchi, 2007). Since thrips are very cryptic in nature and were difficult to trace the population to decide upon initiation of control measure, the specific colour trap can suitably be used to monitor their population and thereby help the farmers to protect the crop at the early stage of thrips infestation. The focus was mainly directed towards choosing the specific colours for trapping thrips. In early study, the yellow sticky color traps was more attractive on different species of thrip, including avocado thrips, *Scirtothrips perseae*, basswood thrips, *Thrips calcaratus* Uzel, pear thrips, *Taeniothrips inconsequens* (Uzel) and native basswood thrips, *Neohydatothripstiliae burungae* (Hood) (Rieske and Raffa, 2003; Cho *et al*., 1995; Hoddle *et al*., 2002). Conversely, the blue sticky plastic cup traps were significantly attractive for onion thrips in field condition (Liu and Chu, 2005; Demirel and Cranshaw, 2005). Similarly, the blue color traps were the most attractive traps for *Frankliniella occidentalis* (Chu *et al*., 2000).

Many countries using biological control agents and insecticides as their primary control strategies, often combined in integrated pest management programs. In early study, cotton, sugar beets, lucerne, yardlong bean and groundnut fields were screened with nine different color traps for evaluating attraction of *Empoasca* spp. adults, on white, rum, red, woodland green (dark green), true blue and black sticky color traps (Chu *et al*., 2000). Therefore, determining the relationship between trap catches of the pest with its numbers in the crop and related yield losses are critical to make correct control decisions. On the other hand, the red sticky color traps caught more *Scaphoideus titanus* than white, yellow or blue (Lessio and Alma, 2004). *Scaphoideus titanus* males were significantly more attracted to red rather than to yellow and white coloured traps, while the present findings for jassid highest growth (12.40±0.99) was recorded on yellow trap followed by green (7.70±0.85) and blue (1.60±0.22). One of study reported that the highest population was observed on green colored cards, followed by the red, black, and yellow colored cards (Wagan *et al*., 2019; Murtaza *et al*., 2019). Another study indicated that the yellow sticky color traps were significantly attractive for *Amrasca biguttula biguttula* than red color traps (Raja and Arivudainambi, 2004). Similar findings also were found in the present study, while the lowest rate (0.50±0.16) was observed on red trap. In spite of the fact that sticky traps have been widely used with several advantages for growers such as low cost and low training demands, the development of decision-making tools based on sticky traps (e.g. sampling protocols and economic thresholds (ET) has been rather limited. Nevertheless, whitefly control decisions are commonly guided by adult densities on traps (Pinto-Zevallos and Vänninen, 2013; Johansen *et al*., 2018).

The *Brassica* spp. crops were also attacked by mustard aphid *Lipaphis erysimi* Kalt. *L. erysimi* has been serious mustard pest in tropical regions of the world. The nymphs and adults of aphids suck sap from leaves, stems, inflorescence and pods as the plant shows stunted growth, withered flower and deformed pod (Singh, 2017; Singh *et al*., 2016; Agarwala and Datta, 2015; Fekri *et al*., 2013). Mustard aphid reported as the most destructive insect and causing severe reduction in seed yield varying from 15.0 to 73.3%. The mustard aphid showed about more than one peak each during entire growing season of mustard (Sahito *et al*., 2010). The present study reported that the highest growth of aphid (78.30±4.51) was recorded on yellow trap followed by green (51.50±2.34) and blue (32.30±2.68) whereas the lowest rate (10.30±1.15) was observed on red trap, supported study also reported highest population was recorded on yellow sticky traps (Pal *et al*., 2018), another study (Rőth *et al*., 2016) also reported similar result that the yellow sticky color traps was more affective for aphid. The early study also reported that yellow color sticky traps was more attractive to aphid population (Kumar *et al*., 2009).

Whitefly (*Bemisia tabaci* Genn.) is oval and light colour nymphs having 4 wings and fed on surface and

clusters of leaves and bred around the year and it takes 3-6 days for egg hatch. Whitefly eggs are generally laid on the underside of leaves. Both nymphs and adults suck the sap from plants, reducing the vitality and yield of the crop. The nymphs secrete honeydew which promotes the growth of sooty mould disease (Shakeel *et al*., 2019). The whitefly (*B. tabaci*) showed two peaks during entire growing season of mustard. The present finding showed that the highest growth of whitefly (19.50±1.42) was recorded on yellow trap followed by green (6.90±0.62) and blue (5.40±0.42), while the minimum infestation of whitefly (0.50±0.16) was recorded on red trap, the analysis significant ($p<0.05$) difference in number of whitefly catches among the sticky traps. In (Wagan *et al*., 2017) study reported that the highest population of whitefly on yellow sticky cards was observed and the green sticky trap was the second strongest attractant of whitefly in okra, similar result with the present findings. Following the yellow and green traps, the purple card was observed to be favored by the whitefly, with black cards were found to be a poor attractant for whiteflies throughout the season. Another study also reported the highest catching rate on yellow sticky traps (Pinto-Zevallos and Vänninen, 2013), which is supporting to the present finding, the highest rate was observed on yellow trap.

CONCLUSION

Using colour sticky traps, it was determined that the maximum population of thrips (54.30±1.89), jassid (12.40±0.99), whitefly (19.50±1.42) and aphid (78.30±4.51) were caught on yellow sticky trap as compared to green, blue and red, while the lowest infestation of thrips (2.00±0.25), jassid (0.50±0.16), whitefly (0.50±0.16) and aphid (10.30±1.15) were recorded on red trap. Analysis of the obtained data showed that there was highly significant ($p<0.05$) difference in number of sucking pests catches among the sticky traps. The yellow color trap was significantly attractive for sucking insect pests in all the tested varieties of mustard crop. Therefore, the yellow color sticky trap is strongly suggested for monitoring these pest population densities in mustard crop and the yellow colour sticky trap could be a useful component in IPM and economically best for growers and for scientists to estimate the densities of pest populations.

Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Agarwala, B.K. and Datta, N., 2015. Life history response of the mustard aphid *Lipaphis erysimi* to phenological changes in its host. *J. Pl. Sci*., **39**: 199-205.

Ahmad, M., Naeem, M. and Khan, I.A., 2013. Relative abundance of aphid's population on different *brassica* genotypes. *Sarhad J. Agric*., **29**: 133-138.

Ali, A. and Rizvi, P.Q., 2011. Screening of different cultivars of rapeseed-mustard against mustard aphid, *Lipaphis erysimi*, Kaltenbach with respect to sowing Dates. *Asian J. Pl. Sci*., **10**: 383. https://doi.org/10.3923/ajps.2011.383.392

Bashir, S., Rizwan, M.S., Salam, A., Fu, Q., Zhu, J., Shaaban, M. and Hu, H., 2018. Cadmium immobilization potential of rice straw-derived biochar, zeolite and rock phosphate: Extraction techniques and adsorption mechanism. *Bull. environ. Contam. Toxicol*., **100**: 727-732. https://doi.org/10.1007/s00128-018-2310-z

Beckham, C.M., 1969. Color preference and flight habits of thrips associated with cotton. *J. econ. Ent*., **62**: 591-592. https://doi.org/10.1093/jee/62.3.591

Berlinger, M.J., 1980. A yellow sticky trap for whiteflies: *Trialeurodes vaporariorum* and *Bemisia tabaci* (Aleurodidae). *Ent. Exp. Appl*., **27**: 98-102. https://doi.org/10.1111/j.1570-7458.1980.tb02952.x

Bhati, R., Sharma, R.C. and Singh, R., 2015. Studies on occurrence of insect-pests of different *Brassica* species. *Int. J. Curr. Sci*., **14**: 125-132.

Blackmer, J.L., Byers, J.A. and Rodriguez-Saona, C., 2008. Evaluation of color traps for monitoring *Lygus* spp. design, placement, height, time of day, and non-target effects. *J. Crop Prot*., **27**: 171-181. https://doi.org/10.1016/j.cropro.2007.05.003

Byrne, D.N., Bretzel, P.K. and Hoffman, C.J., 1986. Impact of trap design and placement when monitoring for bandedwinged whitefly and sweetpotato whitefly. *Environ. Ent*., **5**: 300-304. https://doi.org/10.1093/ee/15.2.300

Capinera, J., 2020. *Handbook of vegetable pests*. Academic press.

Cho, K., Eckel, C.S., Walgenbach, J.F. and Kennedy, G.G., 1995. Comparison of colored sticky traps for monitoring thrips populations (Thysanoptera: Thripidae) in staked tomato fields. *Entomol. Sci. J*., **30**: 176-190. https://doi.org/10.18474/0749-8004-30.2.176

Chu, C.C., Pinter Jr, P.J., Henneberry, T.J., Umeda, K., Natwick, E.T., Wei, Y.A., Reddy, V. and Shrepatis, M., 2000. Use of CC traps with different trap base colors for silverleaf whiteflies (Homoptera: Aleyrodidae), thrips (Thysanoptera: Thripidae), and leafhoppers (Homoptera: Cicadellidae). *J. econ.*

Ent., **93**: 1329-1337. https://doi.org/10.1603/0022-0493-93.4.1329

Demirel, N. and Yildirm, A.E., 2008. Attraction of various sticky color traps to *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) and *Empoasca decipiens* Paoli (Homoptera: Cicadellidae) in cotton. *J. Ent*., **5**: 389-394. https://doi.org/10.3923/je.2008.389.394

Demirel, N. and Cranshaw, W., 2005. Attraction of color traps to thrips species (Thysanoptera: Thripidae) on *brassica* crops in Colorado. *Pak. J. biol. Sci*., **8**: 1247-1249. https://doi.org/10.3923/pjbs.2005.1247.1249

Devi, M.S. and Roy, K., 2017. Comparable study on different coloured sticky traps for catching of onion thrips, *Thrips tabaci* Lindeman. *J. Ent. Zool. Stud*., **5**: 669-671.

Fekri, M.S., Samih, M.A., Imani, S. and Zarabi, M., 2013. Study of host preference and the comparison of some biological characteristics of *Bemisia tabasi* (Genn) on tomato varieties. *J. Pl. Protec. Res*., **53**: 137-142. https://doi.org/10.2478/jppr-2013-0020

Hassan, A.A. and Mohammed, A.D., 2004. Trapping efficiency of various colored traps for insects in cucumber crop under greenhouse conditions in Riyadh, Saudi Arabia. *Pak. J. biol. Sci*., **7**: 1213-1216. https://doi.org/10.3923/pjbs.2004.1213.1216

Hoddle, M.S., Robinson, L. and Morgan, D., 2002. Attraction of thrips (Thysanoptera: Thripidae and Aeolothripidae) to colored sticky cards in a *California avocado* orchard. *Crop Protec*., **21**: 383-388. https://doi.org/10.1016/S0261-2194(01)00119-3

Johansen, N.S., Torp, T. and Solhaug, K.A., 2018. Phototactic response of *Frankliniella occidentalis* to sticky traps with blue light emitting diodes in herb and Alstroemeria green houses. *Crop Protec*., **114**: 120-128. https://doi.org/10.1016/j.cropro.2018.08.023

Kirk, W.D.J., 1984. Ecologically selective coloured traps. *Ecol. Ent*., **9**: 35-41. https://doi.org/10.1111/j.1365-2311.1984.tb00696.x

Kumar, G., Anandhi, P., Varma, S. and Elamathi, S., 2009. Seasonal occurrence of *Brevicoryne brassicae* and natural enemies on cabbage. *Ann. Pl. Protec. Sci*., **17**: 476-478.

Lessio, F. and Alma, A., 2004. Dispersal patterns and chromatic response of *Scaphoideus titanus* Ball (Homoptera: Cicadellidae), vector of the phytoplasma agent of grapevine *Flavescence dorée*. *Agric. Forest Entomol*., **6**: 121-128. https://doi.org/10.1111/j.1461-9563.2004.00212.x

Liu, T.X. and Chu, C.C., 2005. Comparison of absolute estimates of *Thrips tabaci* (Thysanoptera: Thripidae) with field visual counting and sticky traps in onion field in south Texas. *Southwest Ent*., **29**: 83-90.

Malik, M.I., Khuhro, R.D., Dhiloo, K.H., Zaman, B. and Khuhro, S.N., 2012. Response of sucking insect complex to various colors of sticky traps in okra crop. *Pakistan J. Ent*., **27**: 181-186.

Mazzoni, V., Trona, F., Ioriatti, C., Lucchi, A., Eriksson, A. and Anfora, G., 2011. Attractiveness of different colours to *Scaphoideus titanus* Ball (Hemiptera: Cicadellidae) adults. *IOBC/wprs Bull*., **67**: 281-284.

Murtaza, G., Ramzan, M., Ghani, M. U., Munawar, N., Majeed, M., Perveen, A. and Umar, K., 2019. Effectiveness of different traps for monitoring sucking and chewing insect pests of crops. *Egypt. Acad. J. Biol. Sci*., **12**: 15-21. https://doi.org/10.21608/eajbsa.2019.58298

Nadeem, M.A., Zia-Ullah, H.M., Khan, A.M., Hussain, F., Ahmad, I., Saleem, S. and Ali, I., 2019. Super Raya: A new high yielding mustard variety released for general cultivation in south Punjab (Pakistan). *Int. J. Bot. Stud*., **4**: 162-165.

Pal, D., Dean, J.G., Liu, T., Li, D., Watson, C.J., Hudetz, A.G. and Mashour, G.A., 2018. Differential role of prefrontal and parietal cortices in controlling level of consciousness. *Curr. Biol*., **28**: 2145-2152. https://doi.org/10.1016/j.cub.2018.05.025

Patel, S., Singh, C.P. and Yadav, S.K., 2019. Monitoring of insect-pest complex on rapeseed-mustard at Pantnagar. *Int. J. entomol. Res*., **43**: 73-76. https://doi.org/10.5958/0974-4576.2019.00014.8

Pinto-Zevallos, D.M. and Vänninen, I., 2013. Yellow sticky traps for decision-making in whitefly management: What has been achieved? *Crop Protec*., **47**: 74-84. https://doi.org/10.1016/j.cropro.2013.01.009

Raja, K. and Arivudainambi, S., 2004. Efficacy of sticky traps against bhendi leaf hopper, *Amrasca biguttula biguttula* Ishida. *Insect Env*., **10**: 32.

Rakha, M., Hanson, P. and Ramasamy, S., 2017. Identification of resistance to *Bemisia tabaci* Genn. in closely related wild relatives of cultivated tomato based on trichome type analysis and choice and no-choice assays. *Genet. Resour. Crop Ev*., **64**: 247-260. https://doi.org/10.1007/s10722-015-0347-y

Ranamukhaarachchi, S.L. and Wickramarachchi, K.S., 2007. Color preference and sticky traps for field management of thrips *Ceratothripoides claratris* (Shumsher) (Thysanoptera: Thripdae) in tomato in central Thailand. *Int. J. Agric. Biol*., **9**: 839-844.

Rieske, L. and Raffa, K., 2003. Evaluation of visual and olfactory cues for sampling three thrips species (Thysanoptera: Thripidae) in deciduous forests of the northern United States. *J. econ. Ent*., **96**: 777-782. https://doi.org/10.1093/jee/96.3.777

Rőth, F., Galli, Z., Tóth, M., Fail, J. and Jenser, G., 2016. The hypothesized visual system of *Thrips tabaci* (Lindeman) and *Frankliniella occidentalis* (Prgande) based on different coloured traps' catches. *North-West J. Zool*., **12**: 40-49.

Sahito, H.A., Lanjar, A.G. and Mal, B., 2010. Studies on population dynamics of sucking insect pests of mustard crop (*Brassica campestris*). *Pakistan J. Agric. Agric. Eng. Vet. Sci*., **26**: 66-74.

Shah, S.J., Solangi, B.K., Ali, Z., Shah, S.A., Ullah, A., Bakhsh, K. and Mastoi, T.A., 2020. Screening of mustard varieties against sucking insect pests of mustard. *Pure appl. Biol*., **9**: 1522-1531. https://doi.org/10.19045/bspab.2020.90159

Shakeel, M., Ali, H., Ahmad, S., Said, F., Khan, K.A., Bashir, M.A. and Ali, H., 2019. Insect pollinators diversity and abundance in *Eruca sativa* Mill. (Arugula) and *Brassica rapa* L. (Field mustard) crops. *Saudi J. biol. Sci*., **26**: 1704-1709. https://doi.org/10.1016/j.sjbs.2018.08.012

Shakeel, M., Inayatullah, M. and Ali, H., 2015. Checklist of insect pollinators and their relative abundance on two canola (*Brassica napus*) cultivars in Peshawar, Pakistan. *J. Ent. Zool. Stud*., **3**: 326-330.

Singh, A.P., Singh, P.P. and Singh, Y.P., 2016. Pest complex of Indian mustard, *Brassica juncea*, in eastern Rajasthan. *Indian J. Ent*., **68**: 48-149.

Singh, K.K., 2017. Thermal time based forewarning model development for mustard aphid (*Lipaphis erysimi* kalt.) at Bharatpur and Hisar. *Edit. Board*, **2017**: 244.

Sun, Y., Cheng, H., Cheng, Q., Zhou, H., Li, M., Fan, Y. and Jones, S.B., 2017. A smart-vision algorithm for counting whiteflies and thrips on sticky traps using two-dimensional Fourier transform spectrum. *Biosyst. Eng*., **153**: 82-88. https://doi.org/10.1016/j.biosystemseng.2016.11.001

Thongjua, T., Thongjua, J., Sriwareen, J. and Khumpairun, J., 2015. Attraction effect of thrips (Thysanoptera: Thripidae) to sticky trap color on orchid greenhouse condition. *J. Agric. Technol*., **11**: 2451-2455.

Wagan T.A., Dhaunroo A.A., Jiskani W.M., Sahito M.H., Soomro A.A., Lakho A.B.J., Wagan S.A., Memon Qurat Ul Ain and Tunio S.K., 2017. Evaluation of four color sticky traps for monitoring whitefly and thrips on okra crops at Tando Jam, Pakistan. *J. biol. agric. Hlthcare.*, **7**: 12-15.

Wagan T.A., Dhaunroo A.A., Jiskani W.M., Sahito M.H., Soomro A.A., Lakho A.B.J., Wagan S.A., Memon Q.A. and Tunio S.K., 2019. Evaluation of colored sticky traps for monitoring and managing the jassid population in okra. *J. Biol. Agric. Hlthcare.*, **7**: 12-15.