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Research Article

Performance of various colored sticky traps in monitoring against insects of maize crop

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Abstract

The field study on relative performance of various colored sticky traps against insects of maize crop (*Zea mays* L.) was conducted during 2019. Five different colored sticky traps i.e., yellow, blue, green, white and transparent were installed, where each trap was replicated four times. The field was divided into four blocks, each having a size of 30,000 square feet. In each block, five colored sticky traps were randomly installed at one feet above the crop height. Weekly observations were taken to count the number of insects attracted to various colored from germination till harvesting of crop. Identification of insects were done on available literature. Data of abiotic factors were also obtained to determine their influence on attractiveness of colored sticky traps for insects. During the study, five insect pests and one predator species were found i.e., *Rhospalosipum maidis*, *Cicadulina mbila*, *Frankliniella occidentali*, *Atherigona soccata*, *Adelphocoris suturalis* and *Cheilomenes sexmaculata* on various colored traps. All the insects were strongly attracted toward yellow colored traps as compere to others. The overall weekly observation showed that peak populations of *R. maidis*, *F. occidentali*, *A. suturalis*, *C. sexmaculata* were recorded on 31st March, 2019 on various colored traps. The maximum population of *C. mbila* and *A. soccata* was recorded on 6th April and 5th May, respectively. The populations of *R. maidis*, *Cicadulina mbila*, *F. occidentali* and *C. sexmaculata* showed positive and significant. Weakly a-biotic factors significantly affected on the performance of colored sticky traps to attract various insect. Based on the findings, yellow colored traps should be used for the early detection and monitoring of maize insects.

Key words: Maize insects; performance; Sticky traps

Introduction

Maize (*Zea mays* L.) (Family Poaceae) is a yearly, cross-pollinated, kharif crop. It provides nourishment to people, feed for animals and raw material for many important agro-based industries [1]. It is estimated that maize crop will be the largest staple crop of developing world by 2050 and the demand for maize in the developing world is expected to double [2]. Maize is third and largest growing crop after wheat and rice and the USA is the largest maize producing country [3]. In Pakistan, maize ranked as fourth largest cultivated crop after wheat, cotton and rice. Except for potato, maize crop is the most gainful, stable and reliable crop in Pakistan [4].

Although, the maize is grown on large scale in Pakistan, but its per acre yield is comparatively very low than globe. The

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lower yield of maize is attributed to various biotic and a-biotic factors [5]. In Pakistan 2016-2017, the total production of maize was recorded at 6.134 million tons with area under cultivation of 1348,000 hectors areas, however, both production and area under cultivation declined during 2017-18 and remained at 5.702 million tons and 1229,000 hectares, respectively, showing a decline of 7.0% [6] (GOP, 2018). There are numerous elements which are responsible for the low yield of maize within which insect pests are major ones [7].

Several control measures are applied to control the infestation and to increase per acre grain as well as green fodder yield. Generally, the maize growers control the pests through the application of chemical insecticides [8]. The use of chemical insecticides is highly practiced particularly in developing countries including Pakistan. Chemicals can suppress the pest population rapidly below the threshold, but their continuous uses introduce many environmental problems [9]. Therefore, it is urgent need to introduce eco-friendly control measures against insect pests. Plantation of resistant varieties is the best approach to overcoming the problems of synthetic insecticides [10]. Though the chewing insect is major pest status, the control of this pest through nonchemical practices (biological, cultural, and host plant resistance etc.) utilized by the advance farmers and researchers throughout the world are insufficient [11]. Thus, an effective population scouting and monitoring is crucial for successful implementation of insect and vector control programs [12]. Among the monitoring tools, use of sticky colored traps are one of the effective tools for insect pests scouting in agro-ecosystem. The use of sticky traps gives a basic technique for monitoring relative evaluations of pest population with small efforts mostly used in integrated pest management programs in diverse agricultural crops [13]. Recently, various colored sticky traps are used to determine the presence and monitoring of many important insect pests of various crops such as thrips, white flies, hoppers etc. [14]. The attraction of pest towards trap crop is based on the plantation time along with spacing of trap crop and the main crop. Therefore, considering the importance of sticky traps in early detection and monitoring of insect pests, this study was designed to evaluate the performance of different colored sticky traps against insects of maize.

Materials and Methods

Experimental setup, data recording and analysis

The maize variety P1429 was sown at its recommended seed rate (9.5 kg / acre) at a farmer's field located at Palejani Village, Taluka and District Matiari. The distance between row to row and plant to plant was managed at 27 inches and 7 inches, respectively. The experiment was arranged in a Randomized Complete Block Design (RCBD) as farmer's field was divided into four blocks, each block with a size of 30×100 feet. Thus, the total experimental area used in the study was 120,000 sq. feet. In each block, five colored sticky traps i.e., white, yellow, green, blue and transparent were randomly installed at one feet above the crop height. Thus, height of the traps were adjusted according to the crop stage. The size of individual trap was 1x1 square feet. The sticky traps were glued with transparent lubricant from both size to maximize the number of insects' attraction.

Observations on insects attracted to various colored sticky traps were recorded on weekly basis from germination till harvesting of crop. After each observation, sticky traps were thoroughly washed using detergent and re-glued as mentioned above. The data of temperature, relative humidity and wind velocity was obtained from the

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Meteorological Station, TandoJam to determine their influence on the attractiveness of colored sticky traps for insects. Identification of insects were done on available literature. **[15-18]**

After data collection, Analysis of Variance was used to analysis the data, whereas, the Least Square Difference test was applied to determine the means with significant differences. Moreover, Pearson's correlation was applied to get the relationship of insect's attraction on various colored sticky traps with respect to temperature, relative humidity and wind velocity. The Statistix 8.1 computer software was use d for the entire analysis.

Results

The present study was conducted to evaluate the performance of sticky traps of five different colored (white, yellow, green, blue and transparent) to attract various insects of maize crop under field conditions. During the study six different species of insects attracted toward the sticky traps. Namely aphids (*Rhospalosipum maidis*), mirid bugs, (*Adelphocoris suturalis*) leafhopper, (*Cicadulina mbila*), shootfly (*Atherigona soccata*), thrip (*Frankliniella occidentali*), zigzag beetle (*Cheilomenes sexmaculata*) was recorded. The detailed results are discussed below:

The result of the effects of various colored sticky traps on attractiveness of aphids (*Rhospalosipum maidis*) is shown in (Table 1) indicated that the highest population of *R. maidis* (56.23±16.18) was recorded on yellow sticky traps, followed by blue (33.68±10.00), green (29.45±8.64), white (15.84±3.89) and transparent (9.70±2.25) colored traps. Thus, overall the maximum number of *R. maidis* attracted to various sticky traps was recorded on 31st March (101.90±31.42), followed by 6th April (65.40±20.48), whereas, the minimum number of *R. maidis* (0.55±0.39) was recorded on 16th March, followed by 27th April (1.75±1.08). The ANOVA results indicated in Appendix I that highly significant difference ($F = 108.90$, $P < 0.001$) of *R. maidis* population was recorded on various colored traps. Whereas Results also showed that *R. maidis* population showed a significant difference ($F = 108.26$, $P < 0.001$) on various observation dates.

The (Table 2) showed the results regarding the attractiveness of leafhoppers (*Cicadulina mbila*) on different colored sticky traps that showed almost the similar trend as that of *R. maidis*. Accordingly, the maximum attraction of *C. mbila* (43.02±15.91) was recorded on yellow sticky traps, whereas, the minimum population was observed (23.14±8.82) on white sticky traps. Thus, the highest number of *C. mbila* was attracted on 6th April (130±14.71), followed by 31st March (81.75±14.22). Whereas, the minimum number of *C. mbila* were recorded (4.85±1.13) on 16th May, followed by 27th May (5.44±1.43). Thus, a significant difference ($F = 4.92$, $P < 0.001$) was recorded on the level of attraction of different colored sticky traps to attract *C. mbila*. Results also showed in Appendix II that highly significant difference ($F = 39.99$, $P < 0.0001$) was also recorded for number of *C. mbila* attracted to different colored sticky traps on various observation dates.

The (Table 3) indicated that the population of *F. occidentali* was started in first week of March, increased till last week of March and then started decreasing. Peak population of *F. occidentali* (122.05±3.06) was recorded on 31st March, followed by 6th April (61.25±9.76), whereas the lowest *F. occidentali* population (8.95±2.40) was recorded on 9th May, followed by (14.3±1.36) 2nd May and then completely disappeared afterwards till last week of May. According to sticky traps result also showed the maximum population of *F. occidentali* (31.08±13.81) was recorded on yellow sticky traps, Followed by white

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(22.41±12.32), blue (20.64±8.91), transparent (18.14±8.63), and green (11.78±3.23) color traps. The ANOVA results illustrated in Appendix III that the attractiveness of thrips (*Frankliniella occidentali*) population varied highly significantly (F = 42.15, P < 0.001) throughout various observation dates on different colored sticky traps. According to sticky traps result also showed that the highly significant difference (F = 5.51, P < 0.001) of *F. occidentali* population was recorded on various colored traps.

The ANOVA results of shoofly (*Atherigona soccata*) showed in Appendix IV that the highly significant difference (F = 15.69, P < 0.001) regarding their attraction on various colored sticky traps. ANOVA results also indicated highly significant difference (F = 20.06, P < 0.001) among population of *A. soccata* on various observation dates. Whereas, the (Table 4) Indicated that the maximum population of *A. soccata* (3.35±1.09) was recorded on yellow sticky traps, followed by green (1.35±0.60), blue (1.26±0.48), transparent (0.78±0.26) and white (0.75±0.28) colored traps. The *A. soccata* population gradually started during 1st week of March to last week of March. Then, population of *A. soccata* was not recorded up to last week of April. Then *A. soccata* population increased during 2nd week of May and reached its peak (6.65±1.76) on the 1st week of May. Whereas, the lowest population (0.45±0.2) was recorded on 22nd March. Then, again *A. soccata* population disappeared continually till harvesting of the crop.

The result of the effects of various colored sticky traps on attractiveness of mirid bugs (*Adelphocoris suturalis*) are shown in (Table 5) The highest numbers of *A. suturalis* was recorded (1.35±0.28) on 31st March, followed by 8th March (0.95±0.22). Thus, the minimum numbers of *A. suturalis* were recorded (0.25±0.16) on 15th March, followed by 16th 27th May (0.30±0.15). The maximum population of *A. suturalis* (1.06±0.18) was recorded on yellow sticky traps, followed by green (0.60±0.12), white (0.42±0.18), transparent (0.33±0.12) and blue (0.33±0.11) color traps. Whereas, the ANOVA results indicated in Appendix V that *A. suturalis* population showed highly significant difference (F = 5.46, P < 0.001) on various observation dates. Result also showed that highly significant difference (F = 8.24, P <0.001) of *A. suturalis* population was recorded on various colored traps.

In **(**Table 6) showed the results regarding the attractiveness of zigzag beetles (*Cheilomenes sexmaculata*) on various colored sticky traps that showed almost the similar trend as that of *C. mbila*. Accordingly, the peak population of *C. sexmaculata* (1.5±0.26) was recorded on yellow sticky traps, whereas the minimum population (0.5±0.10) was recoded on white colored traps. According to weekly observation dates, the highest number of *C. sexmaculata* was recorded on 31st March (1.65±0.25), followed by, 2nd May (1.45±0.59). Moreover, the minimum number of *C. sexmaculata* were recorded (0.40±0.20) on 20th April, followed by 16th April 27th May (0.55±0.15). Thus, a significant difference (F = 9.01, P < 0.001) was recorded on the level of attraction of different colored sticky trap showed in Appendix VI. ANOVA results also indicated that *C. sexmaculata* population showed a highly significant difference (F = 4.76, P < 0.001) on various observation dates.

Pearson's correlation between insect populations and a-biotic factors

The correlation results given in (Table 7) indicated that temperature showed a positive, significant but weak influence on the population of *R. maidis* (r =0.1314, P < 0.05), *C. mbila* (r =0.1921, P < 0.05), *F. occidentali* (r =0.1287, p < 0.05) and *C. sexmaculata* (r =0.1207, p = < 0.05),

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whereas, no significant impact of temperature was recorded on the population of *A. soccata* (r =0.0420, p = > 0.05) and *A. suturalis* (r =0.1003, p = > 0.05). Moreover, relative humidity showed a significant, weak but negative relationship with population of *R. maidis* (r = -0.3061, p = < 0.05), *C. mbila* (r = -0.1572 =, p = < 0.05) and *F. occidentali* (r = -0.2572 =, p = < 0.05), whereas, no significant impact of relative humidity was found on population of *A. soccata* (r = -0.312, p = > 0.05), *A. suturalis* (r = -0.455, p = > 0.05) and *C. sexmaculata* (r = -0.0652, p = > 0.05). Similar to relative humidity, wind also exhibited highly significant, moderate and negative impact on population fluctuation of *R. maidis* (r = -0.3586, p = < 0.05), *C. mbila* (r = -0.2582, p = < 0.05), *F. occidentali* (r = -0.2806, p = < 0.05) and *C. sexmaculata* (r = -0.2005, p = < 0.05). No significant impact was recorded between wind and *A. soccata* (r = -0.0731, p = > 0.05), *A. suturalis* (r = -0.0842, p = > 0.05) population.

Table 1. Weekly mean population of aphids (*Rhospalosipum maidis*) on various colored sticky traps.

Date	Yellow	Blue	Green	White	Transparent	Over all mean
2/3/19	13.75±5.54	12.00±2.16	8.75±2.39	10.00±2.04	7.25±0.85	10.35±1.15f
8/3/19	52.25±6.65	36.25±5.01	41.00±4.14	21.75±3.75	9.25±0.85	32.10±7.52d
15/3/19	97.50±13.73	63.25±4.97	52.25±4.61	27.75±3.90	14.00±2.16	50.95±14.53c
22/3/19	108.75±13.61	70.00±9.04	51.75±6.43	32.00±3.76	18.75±2.10	56.25±15.75c
31/3/19	206.25±19.67	122.00±20.10	106.00±13.81	46.75±10.50	28.50±5.44	101.90±31.42a
6/4/19	131.75±18.71	77.75±9.78	72.75±9.59	28.75±5.07	16.00±2.74	65.40±20.48b
13/4/19	59.50±6.08	40.00±5.76	3.25±0.75	10.50±3.69	7.50±1.44	24.15±10.96de
20/4/19	26.00±7.07	5.25±2.29	15.25±3.90	6.00±3.19	7.25±5.02	11.95±3.94f
27/4/19	5.75±1.93	0	2.25±1.11	0.75±0.48	0	1.75±1.08g
2/5/19	45.25±10.61	31.50±3.93	36.25±5.01	23.00±3.76	14.50±4.17	30.10±5.31d
9/5/19	38.50±10.25	13.50±3.10	22.00±3.92	14.50±2.90	12.75±2.14	20.25±4.85e
16/5/19	2.00±0.71	0	0.75±0.25	0	0	0.55±0.39g
Overall Mean	56.23±16.18a	33.68±10.00b	29.45±8.64b	15.84±3.89c	9.70±2.25d	

Appendix I. ANOVA for the population of *R. maidis* on different colored sticky traps

Source	DF	SS	MS	F	P
Date	**13**	**236942**	**18226.3**	**108.26**	**0.0000**
Traps	**4**	**73332**	**18333.1**	**108.90**	**0.0000**
Date * Traps	**52**	**95648**	**1839.4**	**10.93**	**0.0000**
Error	**210**	**35355**	**168.4**		
Total	**279**	**441278**			

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Table 2. Weekly mean population of leafhopper (*Cicadulina mbila*) on various colored sticky traps

Date	Yellow	Blue	Green	White	Transparent	Overall Mean
2/3/19	15.25±2.14	11.50±3.12	13.75±6.25	11.25±3.15	7.00±1.22	11.75±1.40ef
8/3/19	25.00±6.12	16.25±5.54	11.25±6.57	11.25±3.15	12.50±5.95	15.25±2.602 cdef
15/3/19	22.50±9.46	17.50±1.44	21.25±5.54	18.75±4.27	20.00±6.12	20±0.88cde
22/3/19	31.25±8.26	28.75±8.75	26.25.6.25	25.00±5.00	27.50±7.50	23.75±3.89cd
31/3/19	133.00±27.67	70.75±20.30	90.00±26.39	52.50±18.43	62.50±29.31	81.75±14.22b
6/4/19	187.50±42.70	125.00±32.27	106.25±41.30	112.50±31.46	118.75±37.33	130±14.71a
13/4/19	46.00±19.65	22.50±6.29	33.75±9.87	23.75±9.89	25.50±8.23	30.3±4.39c
20/4/19	21.50±3.50	10.50±2.10	16.25±4.25	9.75±2.32	6.25.2.02	12.85±2.679def
27/4/19	9.25±4.35	3.75±1.31	3.00±1.22	4.50±2.22	3.75±2.39	4.85±1.13ef
2/5/19	22.50±7.46	13.75±4.13	24.25±4.25	14.00±2.16	12.25±3.09	17.35±2.49cde
9/5/19	20.75±5.34	9.00±2.74	18.50±6.40	6.25±2.46	5.50±2.22	12±3.19def
16/5/19	11.00±4.43	2.73±1.11	4.50±2.06	4.75±3.30	4.25±2.10	5.44±1.43def
23/5/19	9.25±4.35	3.75±1.31	3.00±1.22	4.50±2.22	3.75±2.39	4.85±1.13ef
30/5/19	1.75±1.18	1.00±1.00	0.50±0.50	1.50±0.96	0.75±0.75	1.1±0.23f
Overall Mean	43.02±15.91a	24.08±10.32b	28.95±9.55b	23.14±8.82b	24.22±9.64b	

Appendix II. ANOVA for the population of *C. mbila* on different colored sticky traps

Source	DF	SS	MS	F	P
Date	**13**	**333438**	**25649.1**	**39.99**	**0.0000**
Traps	**4**	**12626**	**3156.5**	**4.92**	**0.0008**
Date * Traps	**52**	**25509**	**490.6**	**0.76**	**0.8736**
Error	**210**	**134679**	**641.3**		
Total	**279**	**506252**			

Table 3. Weekly mean population of thrips (*Frankliniella occidentali*) on various colored sticky traps

Date	Yellow	Blue	Green	White	Transparent	Overall Mean
2/3/19	11.00±3.32	6.50±1.85	9.25±2.53	5.00±1.22	3.50±1.71	7.05±1.37de
8/3/19	25.00±8.66	31.25±4.27	10.25±3.42	20.00±7.91	22.50±9.46	21.8±3.44cd
15/3/19	42.50±13.15	18.75±5.15	25.00±9.57	15.00±4.56	30.00±9.13	26.25±4.81c
22/3/19	37.50±15.48	22.50±9.46	20.00±7.07	30.00±5.77	15.00±2.89	25±3.95c
31/3/19	187.50±31.46	112.50±31.46	17.75±5.92	175.00±48.56	117.50±31.19	122.05±3.06a
6/4/19	92.50±39.45	75.00±27.84	40.00±14.14	47.50±10.31	51.25±17.12	61.25±9.76b

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13/4/19	3.25±2.29	0.25±0.25	1.25±0.95	1.00±1.00	2.25±1.03	1.60±0.52e
20/4/19	2.50±0.87	0.25±0.25	0.75±0.48	0.50±0.29	0	0.8±0.44e
27/4/19	0	0	0	0	0	0.00±0.00e
2/5/19	17.75±3.42	14.00±2.94	16.25±2.25	13.75±3.94	9.75±1.55	14.3±1.36cde
9/5/19	15.75±2.95	8.00±1.41	12.75±2.59	6.00±1.83	2.27±1.11	8.95±2.40de
16/5/19	0	0	0	0	0	0.00±0.00e
23/5/19	0	0	0	0	0	0.00±0.00e
30/5/19	0	0	0	0	0	0.00±0.00e
Overall Mean	31.08±13.81a	20.64±8.91b	11.78±3.23c	22.41±12.32b	18.14±8.63bc	

Appendix III. ANOVA for the population of *F. occidentali* on different colored sticky traps

Source	DF	SS	MS	F	P
Date	**13**	**296070**	**22774.6**	**42.15**	**0.0000**
Traps	**4**	**11915**	**2978.8**	**5.51**	**0.0003**
Date * Traps	**52**	**72401**	**1392.3**	**2.58**	**0.0000**
Error	**210**	**113467**	**540.3**		
Total	**279**	**493854**			

Table 4. Weekly mean population of shoot fly (*Atherigona soccata*) population on various colored sticky traps

Date	Yellow	Blue	Green	White	Transparent	Overall Mean
2/3/19	4.75±1.25	1.50±0.29	2.25±0.63	1.75±0.85	0.50±0.29	2.15±0.70c
8/3/19	5.50±1.66	4.00±1.41	0.75±0.48	1.75±0.85	1.75±1.18	2.75±0.86bc
15/3/19	6.75±1.38	1.00±0.41	0.75±0.48	0.50±0.29	2.00±0.71	2.2±1.16c
22/3/19	1.00±0.41	0.50±0.29	0.75±0.48	0	0	0.45±0.2d
31/3/19	7.50±4.79	2.50±1.44	2.00±1.08	1.25±0.48	2.25±1.31	3.1±1.11bc
6/4/19	0	0	0	0	0	0.00±0.00d
13/4/19	0	0	0	0	0	0.00±0.00d
20/4/19	0	0	0	0	0	0.00±0.00d
27/4/19	0	0	0	0	0	0.00±0.00d
2/5/19	12.50±2.78	6.25±2.02	8.25±2.32	3.75±1.55	2.50±1.55	6.65±1.76a
9/5/19	9.00±2.08	2.00±0.85	4.25±1.44	1.50±0.87	2.00±0.71	3.75±1.39b
16/5/19	0	0	0	0	0	0.00±0.00 d
23/5/19	0	0	0	0	0	0.00±0.00 d
30/5/19	0	0	0	0	0	0.00±0.00 d

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Overall Mean	3.35±1.09a	1.26±0.48b	1.35±0.60b	0.75±0.28b	0.78±0.26b	

Appendix IV. ANOVA for the population of *A. soccata* on different colored sticky traps

Source	DF	SS	MS	F	P
Date	**13**	**1069.45**	**82.2651**	**20.06**	**0.0000**
Traps	**4**	**257.37**	**64.3429**	**15.69**	**0.0000**
Date * Traps	**52**	**461.93**	**8.8832**	**2.17**	**0.0001**
Error	**210**	**861.25**	**4.1012**		
Total	**279**	**2650.00**			

Table 5. Weekly mean population of mirid bugs (*Adelphocoris suturalis*) on various colored sticky traps

Date	Yellow	Blue	Green	White	Transparent	Overall Mean
2/3/19	0.75±0.48	0.25±0.25	0.50±0.29	0.25±0.25	0	0.35±0.13cde
8/3/19	1.50±1.96	0.74±0.48	0.25±0.25	1.25±0.95	1.00±0.46	0.95±0.22ab
15/3/19	0.75±0.48	0	0.50±0.29	0	0	0.25±0.16de
22/3/19	0	0	0	0	0	0.00±0.00e
31/3/19	1.50±0.29	1.25±0.63	0.50±0.29	2.25±0.63	1.25±0.63	1.35±0.28a
6/4/19	1.50±0.65	0.75±0.48	1.00±0.71	0.50±0.50	0.75±0.48	0.90±0.17ab
13/4/19	1.25±0.48	0.75±0.48	1.00±0.41	0.75±0.48	0.25±0.25	0.80±0.17bc
20/4/19	1.00±0.41	0	0.75±0.48	0	0	0.35±0.22cde
27/4/19	0.75±0.48	0	0.25±0.25	0	0.50±0.29	0.30±0.15de
2/5/19	1.25±0.48	0.50±0.29	1.00±0.41	0.50±0.29	0.25±0.25	0.70±0.18bcd
9/5/19	2.50±0.87	0	1.50±0.87	0	0	0.80±0.51bc
16/5/19	0	0	0	0	0	0.00±0.00 e
23/5/19	0.75±0.48	0	0.25±0.25	0	0.50±0.29	0.30±0.15de
30/5/19	0	0	0	0	0	0.00±0.00 e
Overall Mean	1.06±0.18a	0.33±0.11b	0.60±0.12b	0.42±0.1b	0.33±0.12b	

Appendix V. ANOVA for the population of *A. suturalis* on different colored sticky traps

Source	DF	SS	MS	F	P
Date	**13**	**42.243**	**3.24945**	**5.46**	**0.0000**
Traps	**4**	**19.621**	**4.90536**	**8.24**	**0.0000**
Date * Traps	**52**	**31.079**	**0.59766**	**1.00**	**0.4750**
Error	**210**	**125.000**	**0.59524**		
Total	**279**	**217.943**			

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Table 6. Weekly mean population of zigzag beetle (*Cheilomenes sexmaculata*) on various colored sticky traps

Date	Yellow	Blue	Green	White	Transparent	Overall Mean
2/3/19	1.50±0.65	0.50±0.29	1.75±0.85	0.75±0.48	0.50±0.29	1.00±0.26bcd
8/3/19	2.50±0.96	1.50±0.96	1.25±0.95	0.75±0.48	0.50±0.29	1.30±0.35abc
15/3/19	2.00±0.71	1.00±0.41	0.75±0.48	0.50±0.50	1.25±0.95	1.10±0.26abcd
22/3/19	1.50±0.96	0.75±0.48	0.75±0.48	1.00±0.50	0.25±0.25	0.85±0.20cd
31/3/19	2.50±1.26	1.76±0.48	1.50±0.50	1.00±0.71	1.50±0.65	1.65±0.25ab
6/4/19	0.75±0.95	1.75±1.18	1.50±0.96	1.25±0.75	1.75±0.63	1.40±0.19a
13/4/19	1.75±1.03	1.00±0.58	1.25±0.95	0.25±0.25	1.00±0.41	1.05±0.24bcd
20/4/19	1.00±0.41	0.25±0.25	0.75±0.48	0	0	0.40±0.20de
27/4/19	1.00±0.71	0.75±0.48	0.50±0.29	0.25±0.25	0.25±0.25	0.55±0.15de
2/5/19	3.50±0.65	1.00±0.58	2.00±0.71	0.50±0.29	0.25±0.25	1.45±0.59abc
9/5/19	2.00±0.71	0.50±0.29	1.00±0.58	0.50±0.29	0.25±0.25	0.85±0.31cd
16/5/19	0	0	0	0	0	0.00±0.00e
23/5/19	1.00±0.71	0.75±0.48	0.50±0.29	0.25±0.25	0.25±0.25	0.55±0.15de
30/5/19	0	0	0	0	0	0.00±0.00e
Overall Mean	1.5±0.26a	0.82±0.15bc	0.94±0.16b	0.50±0.10c	0.55±0.15bc	

Appendix VI. ANOVA for the population of *C. sexmaculata* on different colored sticky traps

Source	DF	SS	MS	F	P
Date	**13**	**80.544**	**6.1957**	**4.76**	**0.0000**
Traps	**4**	**46.952**	**11.7379**	**9.01**	**0.0000**
Date * Traps	**52**	**33.724**	**0.6485**	**0.50**	**0.9982**
Error	**209**	**272.250**	**1.3026**		
Total	**278**				

Table 7. Pearson's correlation to determine role of abiotic factors on the performance of colored sticky traps

Insects	*R. maidis*	*C. mbila*	*F. occidentali*	*A. soccata*	*A. suturalis*	*C. sexmaculata*
Temperature	r=0.1314 P=0.0282	r=0.1921 P=0.0013	r=0.1287 P=0.0316	r=0.0420 P=0.4846	r=0.1003 P=0.945	r=0.1207 P=0.0440
Relative humidity	r=-0.3061 P=0.0000	r=-0.1572 P=0.0085	r=-0.2572 P=0.0000	r=-0.312 P=0.6040	r=-0.455 P=0.4492	r=-0.0652 P= 0.2775
Wind	r=-0.3586 P=0.0000	r=-0.2582 P=0.0000	r=-0.2806 P=0.0000	r=-0.0731 P=0.2237	r=-0.0842 P=0.1609	r=-0.2005 P=0.0008

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Discussion

In present study, examined the relative attractiveness of maize insects toward the different colored sticky traps in field conditions. Five different colored sticky traps (white, yellow, green, blue and transparent) were randomly installed at one feet above the crop height. Thus, height of the traps was adjusted according to the crop stages. Correlation of sticky traps and a-biotic factors (temperature, wind velocity and relative humidity) on insects of maize was investigated. The data was taken from 2nd March, 2019 to 30nd May, 2019. Six different insect species i.e., *R. maidis*, *C. mbila*, *F. occidentali*, *A. soccata*, *A. suturalis* and *C. sexmaculata* were responded to various colored traps in maize field. The collected data indicated that the all insects were strongly attracted on yellow sticky traps as compared to blue, green, white and transparent.

The results of this study are in accordance with many previously research experiment. **[19]** reported that among several installed sticky colored cards, the adults of predators were highly attracted towards the yellow sticky cards, especially before pollen shed. Blue colored traps captured more bumble bees (*Bombus* spp.) **[20]** whereas seven-spotted ladybird, *Coccinella septempunctata* (L.) were more attracted on yellow colored trap in alfalfa **[21]** Studied on the population dynamics of maize insect pests and their associated natural enemies in maize field with three sampling methods to count the predator's population showed that the highest numbers of thrips were attracted to yellow adhesive card and dark colored cards in circular shape than on blue, or green traps **[22, 23]**. However red, green, and yellow colored cards were more effective to attract *Elatobium. abietinum* than blue, white, and dark adhesive cards **[19]**. Moreover, **[24]** Found that yellow adhesive cards were more effected to attract adult mango hoppers, while pink and purple colors were found less attractive. The use of sticky traps gives a basic technique for monitoring relative evaluations of pest population with small efforts mostly used in integrated pest management programs in diverse agricultural crops **[13]**. Similar observations on yellow, white, or blue adhesive cards are presently suggested for detecting and managing thrips **[25]**.

The study results also found that weather parameters i.e., temperature, relative humidity and wind velocity showed a weak and significant impact on the population of *R. maidis*, *F. occidentali*, *C. mbila*, and *C. sexmaculata*, whereas, they did not show any important role in the population of *A. soccata* and *A. suturalis*. Many previous studies also confirmed the role of temperature, relative humidity and wind in the population regulation of many important pests of crops. it has been reported that the insects are highly susceptible to the environmental conditions **[5]** revealed the influence of abiotic stresses on the incidence of maize insect pests on different maize varieties. The highest infestation was observed at low relative humidity high and optimum temperature ranges. Furthermore, sunshine and wind velocity were positively correlated with pest population.

Conclusion and Recommendations

From the present experiment, it has been concluded that yellow sticky traps showed a strong attractiveness for *R. maidis*, *C. mbila*, *F. occidentali*, *A. soccata*, *A. suturalis* and *C. sexmaculata*. Whereas, according to overall weekly observation the maximum numbers of insects were scouted by colored traps during March and April in maize corp. Furthermore, a-biotic factors (temperature, relative humidity, wind velocity) significantly affected on the performance of colored sticky traps to attract various insects. Based on the experiment following suggestions are recommended. Yellow,

sticky traps should be used for the early detection and monitoring the populations of different insects on maize crop.

Authors' contributions

Conceived and designed the experiments: A Rajput, Performed the experiments: A Rajput, JA Soomro, AL Baloch & GQ Junejo, Analyzed the data: A Rajput, Contributed materials/ analysis/ tools: A Rajput & JA Soomro, Wrote the paper: A Rajput.

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