Research Article

Study on Species Richness of Aphid through Integrated Pest Management

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Abstract | Yellow moericke and sticky traps are important tools of integrated pest management (IPM), which act as indicators of population trends and fluctuation of flying insects. These traps were evaluated at different growth stages of wheat (seedling, tillering and dough stage) and trap height (0.5, 1.0 and 1.5 meter) on the basis of mean aphid collection and species richness. Results indicated that population appeared in the standard week (SW) 52 of 1st year to SW 18 of 2nd year in both traps. Population peaks in the yellow moericke traps (YMT) and sticky trap (YST) were found during SW 08-14 and SW 10-14, respectively. The YMTs were 50 % more effective due to their higher attraction and killing rate of aphids as compared to the YSTs. The efficiency of attraction depends upon the size, shape, and height of trap, as well as the abiotic factors affecting them. To achieve ideal trap efficacy their height should be adjusted according to the crop growth stage. It is very important to keep traps just above the crop canopy. Traps at 0.5, 1.0 and 1.5 meter heights were more effective at seedling, tillering and dough stages, respectively. The population in the traps was correlated with the average temperature (^{0}C) and humidity (%). Temperature had positive and significant correlation with population captured in the traps while humidity had negative and non-significant correlation with per unit population attraction. There was no significant difference of correlation between the traps attraction and years. Temperature and humidity had 47 and 0.9, 53 and 13 % impact on per unit population change in the YMT during 2019 and 2020, respectively. While in YST temperature and humidity had 55 and 0.7, 83 and 5 % impact on per unit population change during 2019 and 2020, respectively. These traps were installed in the wheat field where it attracted 14 species of aphid. Two new species *Aphis nerii* and *Aphis fabae* were reported in the agro ecological zone of Bhakkar having active periods SW 18-22 and SW 03-07, respectively. Yellow moericke traps are highly recommended to use as indicator as well as control tool of all important aphid species of wheat crop.

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Introduction

Wheat (*Triticum aestivum* L.) is an important cereal crop having nutritional and economical value in the entire world (Wains *et al*., 2010). It feeds more than 35 % population of the world. It is major food crop of Pakistan (Ramzan *et al*., 2020). There are several factors which are responsible for the low production. Aphid is one of the major factors contributing to the low yield of crops, vegetables, ornamental plants and fruits, which cause severe damage by sucking the cell sap in Pakistan when compared to rest of the world. It is commonly called plant lice with 5000 species worldwide (Favret, 2013). The infested plants remain stunted and reduce the quality and quantity. There are four species of aphid that affects wheat in Pakistan i.e. bird cherry oat aphid (*Rhopalosiphum padi* L.), green bug (*Schizaphis graminum* R.), English grain aphid (*Sitobion avenae* B.), and corn aphid (*Rhopalosiphum maidis* F.) (Abbas *et al*., 2018). It is estimated to reduce 90 % of crop yield. This damage relies on crop stage and extent of aphid attack (Rana, 2005). To reduce aphid losses, it is important to carry out its continuous monitoring and tracking. For monitoring or bio ecological studies several techniques are listed in literature such as reviewing host plants or plant organs, shaking insects from plants, using scooping and sucking devices and different color traps (Bannerman *et al*., 2015). These color traps i.e., yellow moericke traps (YMTs) and yellow sticky traps (YSTs) are most successful for this purpose (Borowiak-Sobkowiak and Wilkaniec, 2010; Budzinska and Goszczynski, 2010; Moericke, 1969). Moericke traps are also called pan trap, bowl trap or colored bowls, which are colored yellow to attract the aphids (Jasrotia *et al*., 2016). There are simply filled by water with some chemical or detergent, which insects presume mistakenly as yellow flowers. These traps are most liked by the researchers as they are rapid, simple to install, cheap, easily repeatable and provides systematic continuous information on the pest population build up. Traps continuously catch and retain specimens without involvement of human management. It is important for the traps to place in such a height where they can be visible (Portman *et al*., 2020). The YSTs are card boards, which are pasted with highly sticky substance where insects are unable to fly again after its settling. It is also successfully used in monitoring of whiteflies, leafminers and aphids (Gu *et al*., 2008; Qiu and Ren, 2006). These traps commonly used for aphid monitoring in filed as well as greenhouses. These traps not only reduce the use of chemicals but also protect our environment from pesticide pollution (Jasrotia *et al*., 2016). There are only few factors that affect the efficiency of traps i.e., shape, placement of trap and abiotic factors. The current study was design to evaluate two types of traps i.e., the yellow moericke traps and yellow sticky traps (YMT and YST) to monitor the fluctuation in aphid population during cropping season in relation to abiotic factors. Richness of species at agro ecological zone of Bhakkar was studied in traps keeping at different heights and crop growth stages.

Materials and Methods

Location

The experiment was conducted at Arid Zone Research Institute Bhakkar, Punjab (31.6344°N, 71.12.2°E) during 2019-20 to evaluate yellow moericke traps (YMTs) and yellow sticky traps (YSTs) at different growth stages (seedling, tillering and dough stage) of wheat and trap heights (0.5, 1.0 and 1.5 meter). There were four aphid species on wheat in this area were already reported. Richness of aphid species was studied to identify all aphid species in this locality. Arid Zone Research Institute is located in the south of Punjab with 50 hectare research area having sandy loam soil. It has log hot and dry weather with minimum rainfall. Chickpea, mungbean and wheat are the main crops of this area.

Sampling traps

Two types of traps were used in the current study i.e., YMT and YST. The YMTs are rectangle iron bowls with dimension 20”×12”×3”. These traps colored yellow form inside for aphid attraction and filled with water. These traps were placed on iron from having different heights of 0.5, 1.0 and 1.5 meter from the ground. Total 18 traps were installed at same distances and three different heights. Recommended traps in the literature are 15-20/ acre (Doring and Rohrig, 2016). The YSTs are yellow colored sheets coated with highly sticky substance and mounted on wooden boards on three different heights of 0.5, 1.0 and 1.5 meter. Total 30 traps were installed at same distances and three different heights. Recommended traps in the literature are 25-30/ acre (Doring and Rohrig, 2016). These traps were installed from the month of November to April. The data on mean aphid collection was collected on fortnightly basis. After data collection both the traps were renewed. Aphid

species were identified on the basis of morphological characters under microscope with the comparison of species characters that were already identified (Hulle *et al.*, 2020). Record of total collections of each specie and trap was maintained separately. Mean aphid collections during different standard weeks (SW 02-52) were compared with mean temperature and humidity.

Statistical analysis

Randomized Complete Block Design (RCBD) with three replications was used in the study. To compare the effectiveness of both traps for catching the aphid in term of abundance, the non-parametric Kruskal-Wallis analysis (Ostertagova *et al.*, 2014) was performed. This analysis is basically non-parametric approach to the one way ANOVA. This is used to compare three or more groups on a dependent variable. The difference in number of species and total samples was compared between the traps. Further separation of means was subjected to Tukeys HSD test (Steel and Torrie, 1960). The data of aphid collection and weather factors was subjected for simple correlation and multiple linear regressions to check the variability of population attraction by temperature and relative humidity. Coefficient of determination (R2) and goodness of fit was also determined for the developed models using statistical software Minitab 13 (Minitab, 2013). All the graphical representation was made on Microsoft Excel, 2010 (Katz, 2010). All the tests were performed at 5 % significance level.

Results and Discussion

Different trends of aphid collection were found in both types of traps i.e., Yellow moericke trap (YMT) and yellow sticky trap (YST) in during year 2019-2020. These traps are important tools of IPM control of aphid and indicators of population trends and fluctuations during their activity periods. Population appeared in the standard week (SW) 52 of 1st year to 18 of 2nd year in both traps. Peaks in the YMT were found SW-08 (4th week of February) to SW-14 (2nd week of April) with population 78, 187, 349, 103/trap during 2019 and 66, 103, 124, 275/trap during 2020 in SW-08, 10, 12, 14 respectively. While the peaks in YST were found SW-10 (2nd week of March) to SW-14 (2nd week of April) with population 95, 127, 55/trap during 2019 and 45, 82, 94/trap during 2020 in SW-10, 12, 14, respectively as shown in Figure 1. The YMTs were most effective due to their higher attraction and killing rate of aphids as compared to the YSTs. The efficiency of attraction depends upon the size and shape of attraction source as well as the abiotic factors affecting them (Mainali and Lim, 2010; Sarthou *et al.*, 2005).

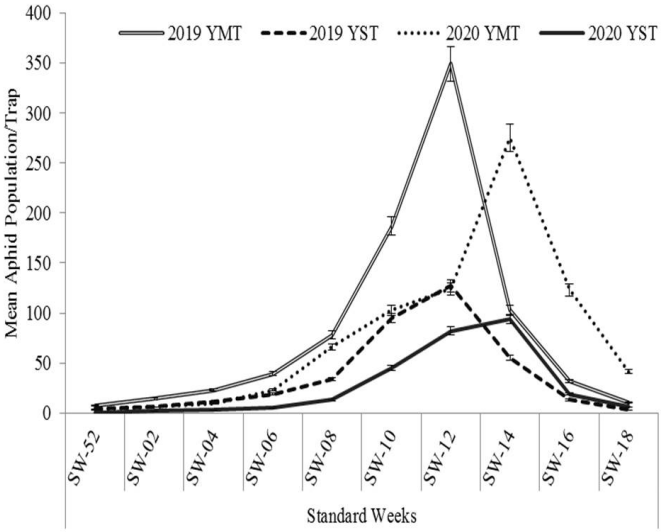

Figure 1: *Mean aphid collection during the cropping season.*

Table 1: *Correlation and regression analysis of aphid's collection in relation with abiotic factors.*

Correlation analysis				
Traps	**2019**		**2020**	
	Temperature (°C)	**Humidity (%)**	**Temperature (°C)**	**Humidity (%)**
YMT	0.692* (0.057)	-0.461^{ns} (0.251)	0.732* (0.039)	-0.453^{ns} (0.265)
YST	0.747* (0.041)	-0.480^{ns} (0.228)	0.912* (0.002)	-0.677^{ns} (0.087)

Regression analysis					
Year	**Equation**	**Impact (%)**		**F value**	**P value**
		X_1	X_2		
2019	YMT = - 267 + 22.4 X_1*+ 0.64 X_2 ^{ns}	47	0.9	3.10	0.196
	YST = - 121 + 9.55 X_1*+ 0.46 X_2 ^{ns}	55	0.7	3.19	0.128
2020	YMT = - 1056 + 42.3 X_1* + 12.3 X_2 ^{ns}	53	13	4.85	0.067
	YST = - 322 + 16.2 X_1*+ 2.99 X_2 ^{ns}	83	05	18.10	0.005

Table 2: *No of aphid species collected traps during cropping season of two years at significance level P≤0.05.*

S. No	Aphid species	Total number of samples		Dominant phase
		YMT±SE	YST±SE	
1	*Rhopalosiphum padi* (L)	3565±158 A*	1849±77 A*	SW 03-08
2	*Schizaphis graminum* (R)	2895±124 A*	1657±42 A*	SW 06-12
3	*Sitobion avenae* (B)	2153±95 B*	1486±29 AB*	SW 10-15
4	*Rhopalosiphum maidis* (F)	1047±22 C	484±24 C	SW 07-12
5	*Aphis craccivora* (K)	482±16 D	143±15 D	SW 10-12
6	*Brevicoryne brassicae* (L)	2645±178 AB*	1284±26 B*	SW 53-04
7	*Macrosiphum rosae* (L)	219±10 E	106±09 D	SW 05-10
8	*Myzus persicae* (S)	854±35 C	278±11 CD	SW 12-14
9	*Toxoptera citricida* (K)	395±28 D	145±08 D	SW 02-06
10	*Toxoptera aurantii* (B)	153±14 E	85±07 DE	SW 03-05
11	*Aphis nerii* (B)	163±19 E	48±05 E	SW 18-22
12	*Aphis gossypii* (G)	804±21 C	53±07 E	SW 06-08
13	*Lipaphis erysimi* (K)	63±36 C	39±02 E	SW 54-03
14	*Aphis fabae* (S)	74±06 E	25±03 E	SW 03-07
Total samples during 2019-20		15512	7682	

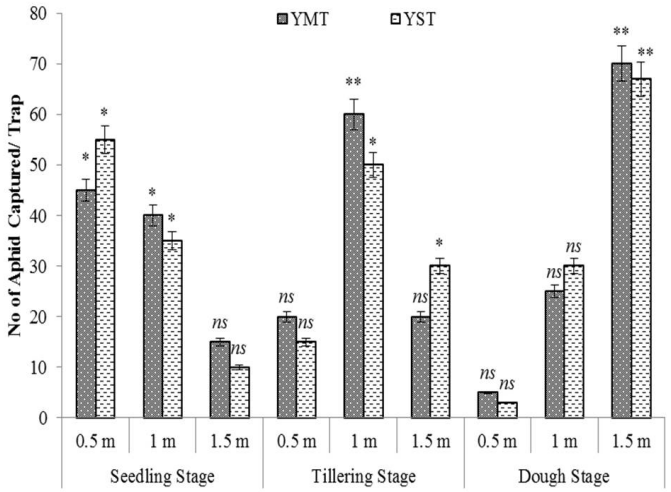

Figure 2: *Effect of traps height on aphid attraction.*

The population in the traps was correlated with the average temperature (°C) and average humidity (%). Table 1 show that temperature had positive and significant correlation with population captured in the traps while humidity had negative and non-significant correlation with per unit population attraction in the traps. There was no significant difference of correlation between the attraction traps and years. Temperature and humidity had 47 and 0.9 % while 53 and 13 % impact on per unit population change in the YMT during 2019 and 2020, respectively. In YST, temperature and humidity had 55 and 0.7 % while 83 and 5 % impact on per unit population change during 2019 and 2020, respectively. These traps were installed in the wheat field where it attracted 14 species of aphid. Among these 4 species were major wheat pest i.e., *R. padi, S. graminum, S. avenae,* and *R. maidis*. Eight species were attacking from different sources in the vicinity and already reported in this area i.e., *A. craccivora, B. brassicae, M. rosae, M. persicae, T. citricida, T. aurantii, A. gossypii, L. erysimi*. Two species were reported 1st time in this area i.e., *A. nerii, A. fabae* as shown in Table 2. YMT was most effective as it collected 15512 samples in comparison with YST which attracted 7682 aphid samples during 2019-20. Maximum collection of population was 3565 and 1849 of *R. padi* followed by 2895 and 1657 of *S. graminum*, 2645 and 1284 of *B. brassicae*, 2153 and 1486 of *S. avenae* in YMT and YST, respectively. Activity period of these aphids was different during entire cropping season. Two newly reported species *A. nerii* and *A. fabae* were active during SW 18-22 and SW 03-07, respectively. The YMT was 50 % more effective than the YST. Investigation was carried out further to verify the effectiveness of these traps by installing them on different heights. Figure 2 shows that effectiveness of these traps depends upon their height according to the crop stage. It is very important to keep traps just above the crop canopy. At seedling stage traps were effective at 0.5 m height. Maximum aphid population was 45 and 50/trap in the YMT and YST, respectively. Minimum aphid population was 15 and 10/trap in the YMT and YST at 1.5 m height, respectively. At tillering stage traps were effective at 1.0 m height. Maximum aphid population was 60 and 50/trap in the YMT and YST, respectively. Minimum aphid population was 20 and 15/trap in the YMT

and YST at 0.5 m height, respectively. Similarly at dough stage traps were effective at 1.5 m height. Maximum aphid population was 70 and 67/trap in the YMT and YST, respectively. Minimum aphid population was 5 and 3/trap in the YMT and YST at 0.5 m height, respectively. Efficacy and importance of moericke traps in the current studies have verified by most of the researchers. Mazon and Bordera (2008) compared the effectiveness of Moericke yellow pan and Malaise traps against insect fliers. Moericke traps were more effective with highest catches of family Orthocentrinae. Yellow sticky sheets in potato berseem mix cropping. He found these sheets effective in reducing population density of *M. persicae* (Saljoqi *et al*., 2009). Singh *et al*. (2010) differs the results where he studied the population dynamics of aphids by using yellow pan and sticky traps. He found yellow pan trap less effective than sticky trap. Wilkaniec *et al*. (2012) compared the efficacy of Moericke and light traps to catch aphids. Total 61 species were captured by combined traps. 44 species were captured by moericke trap, which are much higher than present studies. Where only 14 species with total 8000 specimens were collected in the reported studies. This differs having far less population than present studies, where total 23194 specimens were collected by both traps. This difference my due to different localities and the traps were installed only during the active periods in the current study. Temperature exerted significant impact on insect catches which is similar to the present study findings. Nebreda *et al*. (2004) used Moericke yellow and green tile traps to monitor aphid flights. The yellow moericke traps were proved most effective. Bonneau *et al*. (2019) compared the effectiveness of two trapping techniques, yellow pan and sticky traps. Results showed that the sticky traps are more effective in capturing alates. Lasue and Pinchon (2009) compared the efficacy of Moericke yellow water and yellow pan traps. Both the traps were at par regarding the alate aphid and species. Use of moericke and suction traps were also gave significant contribution to monitor damson hope aphid (Perez *et al*., 2007). Abbas *et al*. (2018) studied the biology of aphid at the matching location of current studies. He confirmed aphid peaks population as reported in the present findings. *R. padi*, *S. graminum* and *S. avenae* were dominant during mid-February to mid-March, month of March-April and 4th week of March to 2nd week of April, respectively. Similar trends were reported by Ramzan *et al*. (2020) where standard weeks 10-11 were most activity periods of wheat aphid species. Wilkaniec *et al*. (2012) found similar trend of aphid peaks and abiotic factors i.e. temperature and relative humidity. Population dynamics of aphids on yellow water showed strong positive correlation with temperature (Wains *et al*., 2010). Relative humidity had negative and non-significant correlation with population fluctuation (Jan *et al*., 2017). Total aphid collections were significantly and positive correlated with temperature (Jagadish *et al*., 2003). Jasrotia *et al*. (2016) monitored the aphid population by using three different types of yellow sticky traps with relation to weather parameters. Correlation showed strong relationship between aphid population and weather parameters with 61 % impact which is quite similar with 53-55 % impact of yellow sticky traps in the present findings. Prasad *et al*. (2008) confirmed similar trends of temperature and relative humidity during rabi and kharif season for the development of alate aphids.

Conclusions and Recommendations

These traps are important tool of integrated pest management not only to control aphid population but also act as indicators of population trends and fluctuations during their activity periods. Yellow moericke traps are highly recommended to use as indicator as well as control tool of all important aphid species of wheat crop. Environmental temperature and trap height always influences the population catches. Trap height should be adjusted according to the crop stage for ideal results.

Novelty Statement

Presence of two new species *Aphis nerii* and *Aphis fabae* were first reported in agro ecological zone of Bhakkar in yellow moericke traps.

Author's Contribution

Khalid Hussain: Planned Research.
Muneer Abbas: Conducted Research and wrote manuscript.
Niaz Hussain: Analysis of Results.
Muhammad Irshad: Proof Read.
Mudassar Khaliq: Layout of Experiment.
Zubeda Parveen: Finalized References.
Sohail Abbas: Reviewed the literature and helped in data collection.
Ali Raza: Reviewed the literature.

Abdul Ghaffar: Finalized Methodology.

Conflict of interest

The authors have declared no conflict of interest.

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