ANNUAL REPORT

2019-20

ENTOMOLOGICAL RESEARCH INSTITUTE, FAISALABAD

director_entofsd@yahoo.com

CONTENTS

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I. INTRODUCTION

The Entomological Research Institute, Faisalabad has the mandate to conduct research on various entomological issues facing by the farming community. Entomological issues are aimed at to furnish solution of these problems and develop effective and economical methods of insect pests control. The research on the cultural, chemical, physical, mechanical and biological control methods of different insect pests remained in progress during the year 2018-19. While planning research programs, a lot of emphasis has been laid to keep in view the requirements of the farmers regarding their pests problems as well as to minimize environmental pollution and the hazardous effects of chemical pesticides on whole of our ecosystem.

Development of resistant varieties is the safer and one of the most important tools in integrated pest management program. Therefore, a lot of emphasis has been given to study the comparative resistance / susceptibility of different crop varieties against the attack of insect pests. A number of microbial insecticides and non-chemical compounds which are not poisonous and act as safer control measure have been evaluated for the control of noxious insect pests of various field crops, vegetables, orchards and stored grains.

The scientists of this Institute remained busy in executing research studies in multiple directions with more stress on integrated pest management to boost up agriculture production of the country. The efforts have been made to find out the optimum dosage rates, time and methods of their application against harmful insect and mite pests. The efficacy of newly developed insecticides has been determined against insect pests of various field crops, vegetables and fruit orchards to find out the most effective and safe chemicals for day to day use by the farmers. Insect growth regulators (IGRs), plant origin insecticides and new chemistry insecticides have been tested against various insect pests.

The research activities on biological control of insect pests were continued and different bio-control agents have been explored and reared for further studies and mass releases in the field.

Beekeeping and Hill Fruit Pests Research Station, Rawalpindi is conducting research studies on domesticated honey bee *Apis mellifera.* These research studies are related to the management of bee colonies during different seasons, selective breeding, honey production

potential, identification and control of bee diseases and other pests. Exploration of bee flora and floral pockets in the province has been identified.

This Institute also extended advisory services to the farmers and Agri. Extension workers through publications, radio / TV talks, refresher courses, farmers gatherings, leaflets etc. for their guidance.

II. LIST OF RESEARCH STAFF

Sr. #.	Name	Designation	Qualification
1.	Dr. Khawar Jawad Ahmad	Director	Ph.D. (Agri. Ento)
2.	Mr. Asif Razzaq	Entomologist	M.Sc. (Hons.) Agri.
3.	Mr. Muhammad Munir	-do-	M.Sc. (Hons.) Agri.
4.	Dr. Qurban Ali	-do-	Ph.D. (Agri. Ento.)
7.	Mr. Zafar Iqbal	Assistant Entomologist	M.Sc. (Hons.) Agri.
8.	Dr. Dilbar Hussain	-do-	Ph.D. (Agri. Ento.)
9.	Dr. Faisal Hafeez	-do-	Ph.D. (Agri. Ento.)
10.	Mr. Mussurrat Hussain	-do-	M.Sc. (Hons.) Agri.
11.	Mrs. Khalida Hamid Abbasi	-do-	M.Sc. (Hons.) Agri.
12.	Mr. Waqar Hussain Shah	-do-	M.Sc. (Hons.) Agri.
13.	Mrs. Humaira Malik	-do-	M.Sc. (Hons.) Agri.
14.	Dr. Abdul Ghaffar	Assistant Research Officer	Ph.D. (Agri. Ento.)
16.	Dr. Qaisar Abbas	-do-	Ph.D. (Agri. Ento.)
17.	Mr. Umair Faheem	-do-	M.Sc. (Hons.) Agri.
18.	Mr. Faheem Akhtar	-do-	M.Sc. (Hons.) Agri.
19.	Ms. Misbah Ashraf	Agriculture Officer	M.Sc. (Hons.) Agri.
20.	Mr. Najuf Awais Anjum	Assistant Research Officer	M.Sc. (Hons.) Agri.
21.	Mr. Muhammad Umar Qasim	-do-	M.Sc. (Hons.) Agri.

22.	Mrs. Ayesha Iftikhar	Agriculture Officer	M.Sc. (Hons.) Agri.
23.	Dr. Muhammad Jawad Saleem	Assistant Research Officer	Ph.D. (Agri. Ento.)
25.	Mr. Asad Aslam	-do-	M.Sc. (Hons.) Agri.
26.	Dr. Tamsila Nazir	-do-	Ph.D. (Agri. Ento.)
27.	Ms. Afifa Naeem	-do-	M.Sc. (Hons.) Agri.
28.	Ms. Kanwal Hanif	-do-	M.Sc. (Hons.) Agri.
29.	Ms. Aqsa Abbas	Agriculture Officer	M.Sc. (Hons.) Agri.

III. BUDGET (2019-20)

Particulars	**Sanctioned (Million)**	**Expenditure (Million)**
Pay of Officers	4851500	1222350
Pay of Other Staff	4600000	1150174
Regular + Other Allowances	8014000	1947096
Contingencies	3010000	-
Total	**20475500**	**4319620**

A. INSECT PESTS OF WHEAT

At Faisalabad

A_1. VARIETAL SCREENING OF WHEAT AGAINST APHIDS

The experiment was conducted in the research area of Entomological Research Institute, Faisalabad to check the susceptibility/ resistance response of 9 wheat linesagainst aphid during crop season 2019-2020. The data regarding aphid population were recorded on per tiller bases from ten randomly selected tillers while the population of natural enemies was counted per five plants at weekly interval. Finally the data were analyzed statistically. The data recorded are as under.

Table 1: Varietal screening of wheat against aphid

Sr. No.	Varieties Coded	Decoding	Mean Aphid Population Per Tiller				
			Jan	Feb	March	Season	Peak Period
1	V_1	V-16005	1.02 a	7.22 ef	7.17 bcd	6.10 de	8.97 de
2	V_2	HYT-55-33	1.07 ab	10.93 cd	6.36 cde	5.29 cd	9.84 cde
3	V_3	V-17179	0.52 d	11.90 bc	7.14 abc	6.97 bc	12.15 bc
4	V_4	V-17177	0.89 bc	13.82 b	7.75 ab	8.51 ab	13.48 ab
5	V_5	V-16157	0.59 cd	6.99 f	5.64 de	4.33 e	6.96 e
6	V_6	V-17157	0.55 cd	9.97 d	3.95 de	5.86 de	9.33 cde
7	V_7	V-17189	0.82 bc	8.11 f	3.99 de	4.78 e	7.29 de
8	V_8	V-16024	0.57 cd	6.88 f	4.55 de	4.51 e	6.68 e
9	V_9	V-16164	0.55 cd	10.84 cd	6.32 bcde	6.50 cd	10.27 cd
	LSD @ 5%		0.35	1.88	1.79	1.35	3.01

During the season, it was recorded dominant population of *Rhopalosiphum padi* L. at tillering stage and *Sitobion avenae* F. during earing stage. The aphid population become visible in the last fortnight of January due to severe cold and gradually increased on all the wheat genotypes. The data regarding aphid population per tiller basis were recorded throughout the season. In case of seasonal average population of aphid per tiller, the lowest aphid population 4.33 / tiller was recorded on advance line V_5 and it was statistically at par with other wheat lines while maximum seasonal population of aphid was recorded on V_4 (8.51/ tiller). In case of Peak season average aphid population, the lowest per tiller aphid population was again recorded on V_8 line that is 6.68 per tiller and it was statistically similar with V_5 that is 6.96.

A_2. RESPONSE OF BIRD CHERRY OAT APHID ON DIFFERENT VARIETIES OF WHEAT

Five different coded varieties of wheat were sown in plastic pots and placed in greenhouse. Three different experiments were conducted on coded varieties to determine categories of resistance. During first experiment, free choice 'antixenosis' preferences and non-preferences tendency of bird cherry oat aphid were observed. None of the tested lines show significant differences after 24 hours, 48 hours and 72 hours post infestation period. While in second experiment, 'antibiosis' when bird cherry oat aphids were caged on tested genotypes, the aphids produced significantly lower number of progeny on coded variety 1 and 3. The third experiment tolerance, coded variety 3 was shown good and significant vigor compared to all tested varieties.

Table 2: Average population density of bird cherry oat aphid on different varieties of wheat

Coded Varieties	24 hours	48 hours	72 hours
V_1	4.2	3.9	4.0
V_2	3.3	3.8	3.6
V_3	4.4	4.5	4.3
V_4	3.8	4.1	3.7
V_5	3.6	4.00	3.8

Table 3: Mean value of progeny produced, pre-reproductive period and intrinsic rate of increase of bird cherry oat aphid on different varieties of wheat

Coded Varieties	Total progeny	Pre-reproductive period	Intrinsic rate of increase
V_1	33.41	8.24	0.1423
V_2	40.62	6.83	0.1642
V_3	29.33	7.11	0.1312
V_4	44.17	4.56	0.1702
V_5	37.35	5.04	0.1640

Table 4: Mean of tolerance index (TI) for shoots and roots of different wheat varieties to bird cherry oat aphid

Coded Varieties	Shoot	Roots
V_1	0.285	0.273
V_2	0.246	0.221
V_3	0.314	0.294
V_4	0.135	0.156
V_5	0.213	0.258

At Bahawalpur

A_3. VARIETAL SCREENING OF WHEAT AGAINST WHEAT APHIDS

Eleven wheat advanced lines Viz., V-1030, V-1154, V-1711, V-1713, V-1725, V-1755, V-2511, V-2557, V-2559, Galaxy-13, and Johar-16 were tested in order to find out the most susceptible / resistant wheat varieties against aphid attack. The aphids and predator's population were recorded from their appearance till crop maturity at weekly intervals on per tiller basis for aphids and on per plant basis for predators. For this purpose 15 randomly selected tillers / plants per plot were examined.

Table 5. Aphids and predators population on different wheat advanced lines

Wheat Variety	Aphid / Tiller	Coccinellids / plant	Syrphidfly Larvae / plant
V-1030	**19.83**	0.22	0.21
V-1154	14.45	0.14	0.17
V-1711	15.60	0.18	0.18
V-1713	**12.60**	0.15	0.11
V-1725	15.25	0.20	0.14
V-1755	17.44	0.21	0.19
V-2511	17.33	0.23	0.17
V-2557	16.16	0.21	0.21
V-2559	15.95	0.13	0.17
Galaxy-13	14.88	0.19	0.18
Johar-16	13.16	0.18	0.16

The results showed that minimum av. aphid population (12.60 / tiller) was recorded on wheat advanced line V-1713 and maximum av. aphid population (19.83/tiller) on V-1030.

At Multan

A_4. ISOLATION OF APHID RESISTANT/TOLERANT VARIETIES OF WHEAT AGAINST WHEAT APHID

The experiment was conducted at Entomological Research Sub Station, Multan. Nine promising Wheat genotypes were sown at the research area and kept under observation. There were three replications under Randomized Complete Block Design (RCBD). The data were recorded from ten tillers randomly selected from each plot. The data were compiled and subjected to statistical analysis.

Table 6: Comparison of population of Wheat Aphid on different genotypes of Wheat during the season 2019-20

Coded Genotypes	Duration					Mean population/ tiller	Ave. Yield (Kg/ha)
	09.03.2020	18.03.2020	30.03.2020	03.04.2020	09.04.2020		
G_1	0.00	4.45	10.29	7.62	3.55	5.18 b	7079 b
G_2	0.00	3.42	5.57	5.61	2.73	3.47 c	7346 ab
G_3	0.00	2.40	7.11	4.57	3.75	3.57 c	5587 d
G_4	0.00	3.41	3.36	3.55	2.44	2. 55 e	7478 a
G_5	0.00	1.65	4.70	4.64	2.46	2.69 e	5664 d
G_6	0.00	2.42	4.08	3.65	2.35	2.50 e	5892 d
G_7	0.00	1.21	5.12	5.74	3.43	3.10 d	4969 e
G_8	1.68	1.32	16.84	12.58	3.99	7.28 a	6697 c
G_9	0.00	4.27	2.67	4.78	3.68	3.08 d	6506 c
Mean	**0.18 e**	**2.73 d**	**6.64 a**	**5.86 b**	**3.15 c**		
LSD 0.05	**0.20**					**0.19**	**352**

Effect of time on Wheat Aphid population

The results showed that the population of Wheat Aphid was begun to start during the 2nd week of March (0.18/tiller) and continues to flourish till the end of March. At this moment Wheat Aphid population was at its peak (6.64 / tiller) which were later declined to 3.15 / tiller.

Effect of Wheat genotypes on Wheat Aphid population

The results indicated that the most resistant genotypes of Wheat in the experiment were G_6, G_4 and G_5. The results were non-significantly different from each other ranging from 2.50-2.69 / tiller. The most susceptible genotypes observed were G_8 (7.28 / tiller) and G_1 (5.18 / tiller). The difference between them was statistically significant.

Yield response of Wheat genotypes

Highest yields were obtained from genotypes G_4 (7478 Kg/ha) and G_2 (7346 Kg/ha). The difference between these genotypes was non-significant. The lowest yields were obtained from the genotypes G_7 and G_5.

At Pasrur

A_5. VARIETAL SCREENING OF WHEAT AGAINST APHIDS AND THEIR RELATIONSHIP WITH PREDATORS

The trial was conducted in RCBD having three repeats with plot size 48 × 120 ft. The data regarding aphids, coccinelid beetles and syrphid flies were recorded from 1st February 2020 to till crop maturity at weekly intervals on per tiller basis for aphids and on per plant basis for predators (coccinellid & syrphidfly). Fifteen randomly selected tillers per plot were examined. The correlation was correlated between aphid and predators population.

Varieties	Total	Average
V_1	12.43	4.14
V_2	24.21	8.07
V_3	23.68	7.89
V_4	22.79	7.59
V_5	21.70	7.23
V_6	24.68	8.22
V_7	23.96	7.98
V_8	24.28	8.09
V_9	25.18	8.39
V_{10}	19.65	6.55

During observations it was evaluated that on all the wheat varieties / lines the aphid population was almost equal except V_1 which was low i.e. 4.14 / tiller and high on V_9 which was 8.39 / tiller. Similarly coccinellid was maximum on V_3 and V_9 i,e. 0.20 per plot, but the syrphidfly was maximum on V_1 and low on V_5 i,e.0.17 and 0.10 per plot respectively.

Table 7: Predators Data

Varieties	Aphid population / tiller	Coccinellid / Plant	Syrphidfly / plant
V_1	4.14	0.18	0.17
V_2	8.07	0.14	0.12
V_3	7.89	0.20	0.13
V_4	7.59	0.06	0.15
V_5	7.23	0.16	0.16
V_6	8.22	0.17	0.15
V_7	7.98	0.18	0.10
V_8	8.09	0.17	0.13
V_9	8.39	0.20	0.14
V_{10}	7.25	0.18	0.14

A_6. STUDIES ON THE POPULATION DYNAMICS OF WHEAT APHID IN RELATION TO WEATHER FACTOR AT VARIOUS LOCALITIES OF THE PUNJAB

The population fluctuation of aphid attacking crop was studied by observing aphid population throughout the crop season.

Table 8: Data regarding aphid was recorded per tiller basis at weekly intervals.

Month	Aphid/Tiller	Average Temperature Maximum	Minimum	Average % Relative Humidity 8:00am	Rainfall (mm)
Feburary-2020	0.95	19.26	10.15	93.92	1.85
	4.75	22.32	8.4	89.97	0
	8.84	25.25	14.77	83.00	0.27
March-2020	10.43	24.02	9.80	81.14	2.18
	3.52	20.67	8.61	81.42	1.27
	3.42	27.25	13.45	78.42	0

	2.40	28.74	16.18	77.71	0

It was observed that aphid population was maximum during the first week of March 2020, i.e. 10.43 per tiller with maximum temperature 24.02 °C and minimum temperature 9.80 °C with 81.14 % relative humidity and 2.18 mm rainfall. In the last week of March 2020 population of aphid was at decline i.e. 2.40 / tiller with maximum temperature 28.74 °C and minimum temperature 16.18 °C with 77.71 % relative humidity and with no rainfall.

At Faisalabad

A_7. STUDIES ON THE POPULATION DYNAMICS OF WHEAT APHID IN RELATION TO WEATHER FACTORS

A. Studies were carried out at Entomological Research Institute, Faisalabad. The collection of aphid was done from three trays each measuring 59 cm × 46 cm × 75 cm, painted with yellow colour inside. These trays were placed at three spots, two and half feet (75 cm) above the ground level on wooden stands adjustable according to crop height during different periods, at a distance of 100 feet from each other. Data on wheat aphids trapped in trays were recorded daily from 9-11 a.m. from each spot. Weather data, i.e., maximum and minimum temperature, R.H %, rainfall and wind velocity of the coinciding dates were also collected from the meteorological observatory of Ayub Agricultural Research Institute, Faisalabad and correlated with aphid density. The data were analyzed and presented in Table.

B. An experiment was conduct to check the fluctuation in the population of wheat aphid in relation to weather factors. Wheat crop was sown in the Entomological Research Institute, Ayub Agricultural Research Institute Faisalabad. The crop was kept under observation throughout the season to record fluctuation of wheat aphid. Crop was grown according to the standard agronomic practices. The data regarding aphid was recorded on per tiller bases at weekly interval. There were three replications in the Plot. The data were started during the month of February and continued till maturity of crop.

Table 9: Aphid Population on Moericke Yellow Water Tray / Week and Weather Data of Coinciding Weeks

Month	Week	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Aphid pop/week/ tray
		Max	Min	8 am	5 pm		
January	1st week	17.54	11.13	90.33	79.79	0.00	3.22
	2nd week	17.02	4.12	83.81	53.18	0.00	9.25
	3rd week	18.22	4.78	85.77	55.98	4.90	21.78
	4th week	18.93	7.48	89.52	72.23	8.00	20.15
February	1st week	19.88	5.91	86.33	64.17	5.80	51.21
	2nd week	23.39	6.56	79.23	39.72	0.00	43.43
	3rd week	28.24	7.40	78.53	41.45	0.00	1093.33
	4th week	27.10	8.87	72.64	34.56	0.00	495.71
March	1st week	27.14	12.65	74.79	42.58	3.70	550.51
	2nd week	23.20	9.76	79.23	52.33	14.50	573.24
	3rd week	31.21	15.56	74.70	45.10	0.00	1234.15
	4th week	36.73	18.94	65.30	34.00	0.00	359.52

Aphid population on wheat crop appeared during the first week of January and gradually increased to its peak on 3rd week of March. The aphid population at that time was 1234.15 per tray/week when maximum temperature was 31.21 °C and relative humidity at 8 am was 74.70 %. When temperature increased and crop began to mature, the aphid population vertically decreased.

Table 10: Average Aphid Population per Tiller and Weather Data of Coinciding Weeks

Month	Week	Temperature (^{o}C)		Relative humidity %		Rainfall (mm)	Predator		Aphid population Per Tiller
		Max.	Min.	8 am	5 pm		Coccid	Syrphid	
January	1st week	17.54	11.13	90.33	79.79	0.00	0	0	0
	2nd week	17.02	4.12	83.81	53.18	0.00	0	0	0.31
	3rd week	18.22	4.78	85.77	55.98	4.90	0	0	0.34
	4th week	18.93	7.48	89.52	72.23	8.00	0	0	0.48
February	1st week	19.88	5.91	86.33	64.17	5.80	0.02	0.00	3.55
	2nd week	23.39	6.56	79.23	39.72	0.00	0.14	12.81	5.83
	3rd week	28.24	7.40	78.53	41.45	0.00	0.13	14.13	5.24
	4th week	27.10	8.87	72.64	34.56	0.00	0.35	10.91	6.39
March	1st week	27.14	12.65	74.79	42.58	3.70	7.96	32.11	8.68
	2nd week	23.20	9.76	79.23	52.33	14.50	10.97	37.88	27.34
	3rd week	31.21	15.56	74.70	45.10	0.00	5.22	31.20	4.42
	4th week	36.73	18.94	65.30	34.00	0.00	4.19	9.12	2.72

The highest per tiller aphid population was recorded during the 2nd week of March (27.34 aphids/ tiller). Aphid attack was appeared during 2nd week of January and its population was increasing gradually and reached to its peak during 4th week of February. Subsequently its population decreased abruptly in the last week of March and reached at 2.72 aphid / tiller.

Table 11: Correlations of Aphid between Weather Factors and Predators

	Temperature (^{o}C)		Relative Humidity		Rain fall	Aphid
	Max.	Min.	8 am	5 pm		
Aphid **P value**	0.6251* (0.025)	0.5844* (0.0397)	-0.5643 (0.0623)	-0.6018 (0.0875)	-0.1242 (0.81)	
Coccinellid **P value**	0.3522 (0.2425)	0.4136 (0.1722)	-0.4112 (0.1871)	-0.2724 (0.3662)	0.4835 (0.1132)	0.4445 (0.2474)
Syrphid Fly **P value**	0.5428 (0.0732)	0.4010 (0.1945)	-0.6174* (0.0367)	-0.6114* (0.0303)	0.34 (0.3673)	0.7106* (0.0129)

Aphid population has positive and significant correlation with maximum temperature (0.6251) and minimum temperature (0.5844). In case of relative humidity, a negative and significant correlation was observed having r value 0.6174.

A_8. EFFECTS OF INTERCROPPING OF DIFFERENT CROPS IN WHEAT ON THE POPULATION DYNAMICS OF WHEAT APHIDS

The experiment was conducted in the research area of Entomological Research Institute, Faisalabad. The trial was laid out in RCBD design with three replications. The crop was kept under observation throughout the season to record fluctuation of wheat aphid. Five treatments i.e **T_1**= wheat+ Garlic+ wheat; **T_2=** wheat+ Peas+ wheat; **T_3**= wheat+ Onion+ wheat; **T_4**= Border Canola and **T_5**= Monoculture Wheat with three replication were examined for the population dynamics of Wheat aphids. Crop was grown according to the standard agronomic practices. The data regarding aphids were recorded on per tiller basis at weekly interval.

Table 12: Effects of intercropping in wheat on wheat aphids

Sr. No.	Treatments	Mean Aphid Population Per Tiller		
		Feb	March	Season
1	**W+G+W**	2.04 a	8.26 b	3.44 b
2	**W+P+W**	2.36 a	7.53 bc	3.30 b
3	**W+O+W**	3.35 a	9.05 ab	4.16 ab
4	**Border Canola**	1.90 a	3.26 c	1.72 c
5	**Wheat**	2.96 a	13.20 a	5.39 a

During the season, Aphid population was not observed in the month of January. Firstly aphid was recorded in 1st week of February in all treatments. There was no significant aphid population difference in the month of February. Aphid population was increased gradually and reached maximum in mono-crop wheat (13.20 aphids / tiller) in March. Despite control, maximum aphid population was found in W+O+W (9.05 aphids / tiller). Lowest was found in Border Canola (1.72 aphids / tiller). It is recorded that in treatments i.e W+G+W, W+P+W and W+O+W, aphid population was lower than monocrop wheat. Intercropping with the garlic, peas, onions have significant decrease the aphid population (df=4; F=11.19; *P*=0.02). It is due to the attraction of

natural enemies to these crops. It is concluded that sowing of border canola is helpful in reducing aphid population.

A_9. STUDIES ON THE EXPLORATION OF PARASITIC FAUNA OF WHEAT APHIDS IN FAISALABAD

The experiment was conducted in the research area of Entomological Research Institute, Faisalabad to identify the parasitoids of wheat aphids. Wheat crop kept under observation during the season and data regarding aphid population and mummified aphid were recorded tiller basis while Sweep net method was used to collect parasitoids. Mummified aphids were collected and brought to lab for rearing at optimum temperature and humidity. The parasitoids reared were preserved for identification.

During the crop season, aphid population appeared from the 1st week of February and gradually increased to its peak on 1st week of March. The aphid population at that time is 13.6/ tiller. When crop began to mature, aphid population decreased and disappeared in the 2nd week of April. The variation in population of the aphid is due to heavy rains during the season.

Table 13: Population dynamic of Wheat Aphids and its Parasitic Fauna

Month	Week	No. of Aphid / tiller	No of parasitoid / sweep	No. of mummified aphid / tiller
January	1st	0	0	0
	2nd	0	0	0
	3rd	0	0	0
	4th	0	0	0
February	1st	0.1	0	0
	2nd	1.15	0	0
	3rd	8.56	0.08	0
	4th	9.3	0.11	0
March	1st	13.6	0.9	0
	2nd	7.01	1.05	1.05
	3rd	8.04	0.89	1.20
	4th	10.2	0	1.55
April	1st	0.9	0	3.40

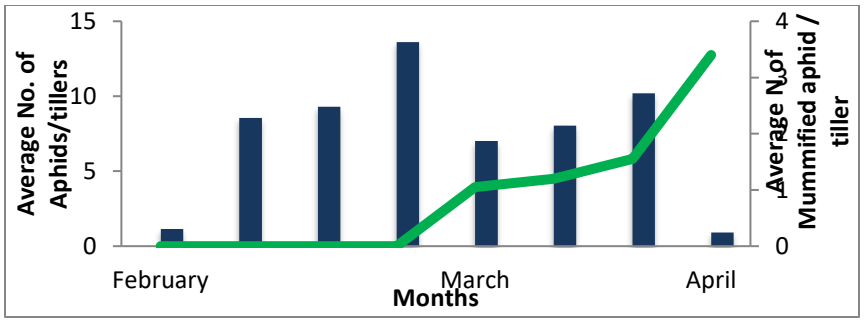


Figure 1: Comparison of Aphids and Mummified Aphids in Wheat crop

Parasitoid population was appeared from 3rd week of February (0.08/sweep) and their highest population recorded on 2nd week of March (1.05/sweep) and then it starts decreasing.

Mummified aphids were recorded from tiller from 2nd week of March as this time parasitoids parasitized the aphid. Highest number of mummies found in 1st week of April (3.40/ tiller) (Fig. 1). The parasitoids emerge from mummies were preserved for identification.

A_{10}. EFFICACY OF SEED DRESSING INSECTICIDES AGAINST WHEAT APHID

The study was conducted at the research area of Wheat Research Institute, Faisalabad under RCBD with three replications to study the efficacy of different insecticides as seed dressers against wheat aphids. The treatments were applied at time of sowing by mixing each insecticide with seed. Seeds required for each treatment were mixed with some amount of water for easy application and absorption of pesticides into seed. Measured amount of each pesticide was sprinkled on seeds and mixed thoroughly with stick so that complete covering of seed with insecticide was ensured. For each treatment new stick was used to avoid the mixing of effect of previous insecticide.

Data regarding aphid population were recorded at weekly started from first week of February till end of March. Counting of aphid from wheat crop was done from 10 randomly selected tillers per plot by observing from base of tiller to top. Aphid from spike was counted by using white paper and aphids were separated from spike with camel hair brush gently.

Table 14: Average population of aphid / tiller on different seed dressing insecticide

Seed dressing insecticide		Dose/ kg seed	Avg. aphid / tiller
T_1	Argyl super	1 gm / kg	3.85 b
T_2	Combinex ultra	1 gm / kg	3.95 b
T_3	Hombre	2 ml / kg	4.01 b
T_4	Control		8.25 a

All the seed treatment insecticides were found effective and they reduced the aphid population from 4.01 per tiller to 3.85 per tiller as compared to control having aphid population 8.25 / tiller.

A_{11}. EFFECT OF DIFFERENT BOTANICALS ON WHEAT APHIDS

The trial was conducted in the field area of Entomological Research Institute, Ayub Agricultural Research Institute, Faisalabad. Seven different botanicals (Beeri patta, Dhatura, Tumma, Akas bail leaf, Ak-leaf, Gajar boti leaf and Bakain) were sprayed at 10 days interval starting from 10th February to 30th March. Layout system was RCBD having three replications having 30 × 15 feet plot area. The data were recorded 1, 2, 3 and 7 days after spray (DAS). The results showed that Tumma, beeri patta and Ak leaf extracts found most effective and percent reduction of aphid population after 7 DAS was 74.72 %, 60.65 % and 58.40 % respectively whereas dhatura, gajar booti, bakain and akas bail showed least percent reduction of aphid population (37.51 %, 42.44 %, 47.25 % and 50.28 %, respectively). These botanicals extracts used as alternative to insecticides and incorporating in integrated pest management technique to manage aphids

Table 15: Comparative effect of different botanicals on wheat aphids

Botanicals	1 DAS	2 DAS	3 DAS	7 DAS
Beeri Patta	61.593 c	65.443 b	62.435 b	60.656 b
Dhatura	47.648 e	45.463 f	42.570 g	37.515 e
Tumma	69.620 a	80.342 a	77.685 a	74.727 a
Akas Bail leaf	56.516 d	53.268 d	51.259 d	50.289 c
Ak leaf	63.594 bc	62.504 c	60.752 c	58.408 b
Gajar Booti leaf	46.425 e	48.583 e	43.284 f	42.445 d
Bakain	65.388 b	60.819 c	59.422 d	47.256 c

B. INSECT PESTS OF BRASSICA

At Bahawalpur

B_{12}. STUDY OF APHID ON BRASSICA UNDER NON SPRAYED CONDITION

This experiment was conducted to screen raya varieties/strains against aphid under non sprayed field conditions. There were 15 entries having 3 replications and plot size of 6 ×1.4 m^2. The experiment was laid out in RCBD and data were recorded on aphid populations from 5 cm length of inflorescence. The recorded data are given below.

Table 16: Average aphids population on different brassica advanced lines

Sr. #	Varieties/strains	Avg. Aphid / 5cm length
		Normal sown
1	BRJ-1003	**11.25**
2	BRJ-1101	13.58
3	BRJ-1301	12.92
4	BRJ-1665	13.32
5	BRJ-1666	14.86
6	BRJ-1667	16.46
7	BRJ-1669	12.06
8	BRJ-1670	16.79
9	BRJ-1671	17.59
10	BRJ-1672	15.33
11	BRJ-1773	**18.86**
12	BRJ-1774	18.26
13	BRJ-1775	14.65
14	BRJ-1776	17.30
15	BRJ-1777	16.32

The results show that minimum aphid infestation was found on BRJ-1003 in normal sown condition. Maximum aphid infestation was observed on strain BRJ-1773 in normal plantings.

C. INSECT PESTS OF PULSES

At Bahawalpur

C_{13}. RESPONSE OF PROMISING CHICKPEA LINES TO (*Helicoverpa armigera* Hb) UNDER NATURAL FIELD CONDITIONS

This experiment was conducted to evaluate the chick pea varieties/ strains against gram pod borer under non-sprayed field conditions. There were ten entries with three replications and plot size of 4×1.2 m^2. The trial was conducted according to RCBD. The percentage damage of pod borer was recorded. The results are given below:

Table 17: Average pod damage percentage

Sr. #	Varieties/ Strains	Av. Pod damage percentage (%)
1	BRC-501	18.8
2	BRC-503	13.0
3	BRC-505	11.0
4	BRC-509	19.0
5	BRC-510	12.0
6	BRC-447	**20.0**
7	BRC-408	**9.1**
8	BRC-390	**9.0**
9	BHAKAR-2011	11.0
10	PUNJAB-2008	13.0

The results show that the average pod damage percentage ranged from 9-20 % due to *Helicoverpa armigera*. Maximum damaged pods was observed on BRC-447 i.e., 20 % whlile, BRC-408 and BRC-390 showed minimum damage by gram pod borer with average pod damage percentage of 9.0 %.

At Faisalabad

C_{14}. SCREENING OF DESI GRAM GENOTYPES AGAINST INSECT PESTS IN RESPONSE TO PHYSIO-MORPHIC CHARACTERS

Seven desi gram genotypes viz: D-16003, D-15003, D-15024, D-16004, Bihlo-2016, D-16020 and D-16029 were screened out to evaluate the response against insect pests. Experiment was laid out

in RCB design with three repeats in the research area of Entomological Research Institute, Faisalabad. Data regarding aphid population were recorded by observing 10 cm length of 15 twigs selected randomly. Data of beneficial insects were recorded per plant basis. For pod borer, total number of pod and number of damaged pods were observed from randomly selected five plants / treatment to calculate pod damage percentage by using formula given below:

$$\text{Pod damage (\%)} = \frac{\text{No. of damaged pod} \times 100}{\text{No. of total pods}}$$

Data regarding physio-morphic characters like pod wall thickness was recorded at pods stage of gram plants. The data recorded are as under:-

Table 18: Screening of desi gram genotypes against insect pests in response to physio-morphic characters

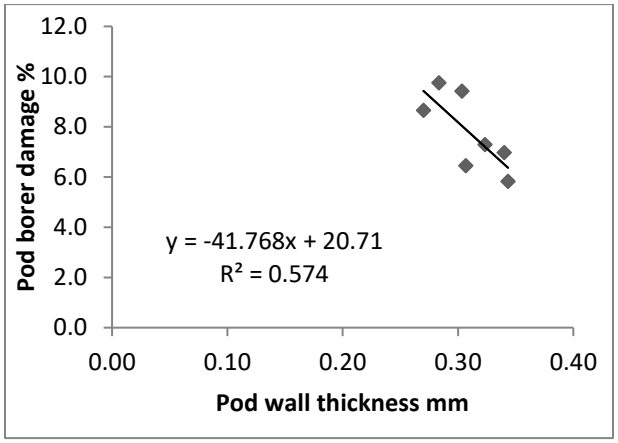
Sr. No.	Treatments	Cut worm infestation %	Aphid/ twig	Gram pod borer infestation %	Bio-control* /plant	Pod wall thickness (mm)	Pod hair density (per cm^2)
G_1	D-16003	5.7 bc	4.7 d	9.4 ab	1.9 a	0.30 d	131.0 c
G_2	D-15003	5.2 bc	4.6 b	6.5 cd	1.8 ab	0.31 cd	170.3 a
G_3	D-15024	8.7 a	5.4 c	5.8 d	1.7 ab	0.34 a	166.0 a
G_4	D-16004	4.1 c	4.1 e	6.9 bcd	1.5 b	0.34 a	134.0 c
G_5	Bihlo-2016	5.7 b	7.9 a	7.3 abcd	1.9 a	0.32 bc	169.0 a
G_6	D-16020	7.3 ab	3.7 e	8.7 abc	1.6 ab	0.27 e	148.7 b
G_7	D-16029	5.8 a	7.6 a	9.8 a	1.7 ab	0.28 e	152.3 b
	LSD 0.05	1.99	0.55	2.57	0.39	0.02	5.53

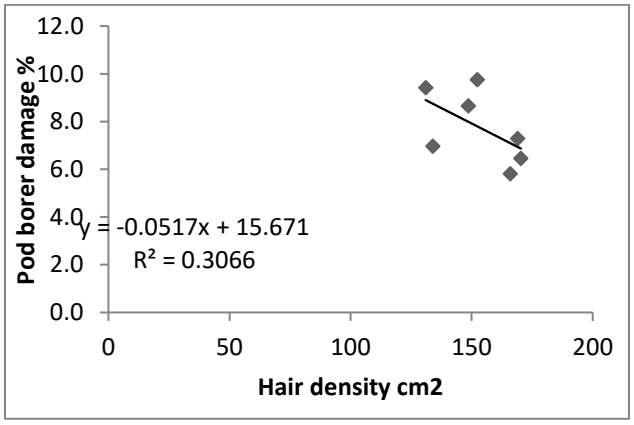
*Bio-control: Ladybird beetle,Syrphid fly, Green lacewing

Minimum cutworm infestation (4.1 %) was found D-16004 while maximum infestation (8.7 %) was recorded on D-15024. Minimum aphid population (3.7 aphid/twig) was recorded on D-16020 followed by D-16004 and D-15003 with (4.1 and 4.6 aphid/twig) while maximum aphid population 7.9 aphid/twig was observed on Bihlo-2016. In the present study, minimum pod borer damage 5.8 % was recorded on D-15024 followed by D-15003 with 6.5 % infestation. Maximum pod borer

infestation 9.8 % was found on D-16029. Beneficial's insect population was found to be statistically at par among all the tested genotypes.

Graph Regression line of gram pod borer percentage infestation with physio-morphic characters





Where:
Y= pod borer damage %
X= Hair density, Pod wall thickness
R^2 = Coefficient of determination (indicates that how much the regression prediction perfectly fit the data)

The slope of the regression line for pod wall thickness and pod borer damage is –41.7/1 i.e pod borer damage is expected to decrease by -41.7 % on average per unit increase in pod wall thickness. While the slope of the regression line for pod hair density and pod borer damage is –0.05/1 i.e pod bore damage is expected to decrease by -0.05 % on average per unit increase in hair density.

$C_{15.}$ SCREENING OF KABULI GRAM GENOTYPES AGAINST INSECT PESTS

Four kabuli gram genotypes were sown in the research area of Entomological Research Institute, Faisalabad, to evaluate the response against insect pests. Trial was laid out in RCB design with three replications. Aphid population was recorded by observing 10 cm length of 15 twigs / treatment selected randomly. For gram pod borer infestation, total and damaged pods from 5 randomly selected plants per treatment were counted and percentage infestation was calculated by formula:

$$\text{Pod damage (\%)} = \frac{\text{No. of damaged pod} \times 100}{\text{No. of total pods}}$$

Bio-control's population was recorded on per plant basis. Data regarding physio-morphic characters i.e. pod hair density and pod wall thickness were calculated at pod stage of gram plants. Data were recorded and statistically analyzed areas under:-

Table 19: Screening of kabuli gram genotypes against insect pests

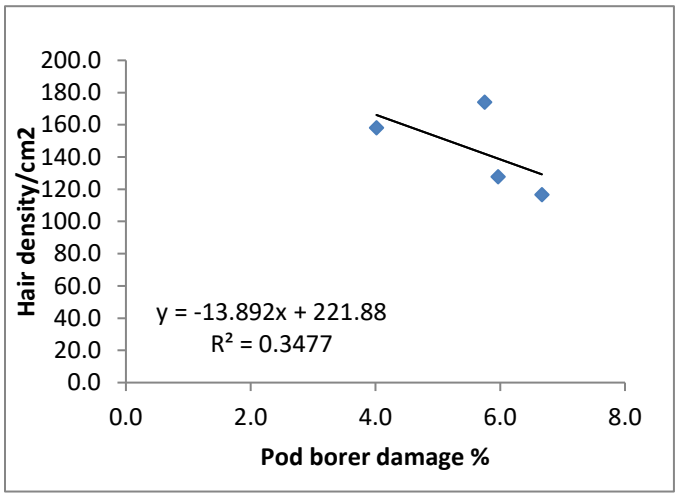
Treatments	Cut worm infestation %	Aphid/twig	Gram pod borer infestation %	Bio-control* /plant	Gram pod wall thickness (mm)	Gram pod hair density (per cm^2)
K01211	5.97 b	6.90 a	9.60 a	1.27 a	1.3 a	127.67 c
K01216	4.01 c	4.80 c	8.07 b	1.23 a	0.29 a	116.67 d
K01241	5.75 b	5.83 b	9.07 ab	1.17 a	0.32 a	158.00 b
K01242	6.67 a	4.47 c	8.23 b	1.33 a	0.29 a	174.00 a
LSD at 0.05	0.431	0.847	1.09	N.S	N.S	1.17

*Bio-control: Ladybird beetle, Syrphid fly, Green lacewing

Cutworm infestation was found to be statistically at par among genotypes. Minimum cutworm infestation (4.01 %) was observed on K01216. Maximum cut worm infestation 6.67 % was observed on K01242. Minimum aphid population 4.47/twig was recorded on K01242 followed by K-01216 (4.80 aphid/twig) while, maximum 6.90 aphid/twig was recorded on K01211. Minimum Pod borer damage 8.07 % was recorded on K-01216 while maximum damage 9.60% was observed

on K01211. Difference in population of beneficial insects among all tested genotypes was found non-significant.

Graph Regression line between gram pod borer infestation and plant physio-morphic characters of kabuli gram



Where: Y= pod borer damage; X= Pod hair density; R^2 = Coefficient of determination (indicates that how much the regression prediction perfectly fit the data)

The slope of the regression line for pod hair density and pod borer damage is -13.8/1 i.e pod borer damage is expected to decrease by -13.8 % on average per unit increase in hair density.

C_{16}. EFFICACY OF DIFFERENT INSECTICDES FOR THE CONTROL OF GRAM POD BORER

Gram crop was sown in research area of Entomological Research Institute, Faisalabad having plot size 20 m × 15 m in randomized complete block design (RCBD) with three replications. Five treatments including check were applied when insect population reached above ETL.

Table 20: List of insecticides used in the study

Sr.No	Active ingredient	Trade name	Dose/acre
1	Lufenuron	Marshal	200 ml
2	Movaluron	Unicorn	300 ml
3	Lufenuron	Match	200 ml
4	Chlorantraniliprole	Coragen	50 ml
5	Emamectin Benzoate	Tycom	200 ml

Data regarding gram pod borer were recorded by observing total and infested pods of 5 randomly selected plants from each treatment. The infestation percentage was calculated by using the following formula:

Infestation % = Infested pods / Total pods × 100

Data were recorded after first and second spray at different time intervals 3 and 7 days after application. The data so recorded were compiled and analyzed statistically.

Table 21: Efficacy of different insecticides for the control of gram pod borer

Treatments	[a] Pre-treatment data	[b] Post-treatment data		Mortality %		Survival of Bio-control's
		72-HAA	7-DAA	72-HAA	7-DAA	7-DAA
Lufenron	14.8	3.9	3.4	73.30 d	79.13 b	54.4 bc
Movaluron	13.7	3.0	1.9	79.70 ab	88.13 a	39.6 c
Lufenron	10.4	3.3	3.2	77.20 bc	80.23 b	70.4 ab
Chlorantraniliprole	11.5	2.5	1.6	82.63 a	89.97 a	54.2 bc
Emamectin Benzoate	14.0	3.5	3.0	75.97 cd	81.87 b	62.3 bc
Check	13.9	14.6	16.3	0.0 e	0.00 c	100.0 a
LSD at 5 %				3.306	2.881	30.1

Where= a: No. of larvae/plant, b: No. of larvae/plant, HAA: Hours after application, DAA: Days after application

All the treatments were found to be statistically different with one another after 03 and 07 days of treatment. Maximum mortality 82.63 and 89.97 was recorded with Clorentriniliprole, followed by Movaluron with 79.70% and 88.13 % mortality after 03 and 07 days of treatment respectively.

D. INSECT PESTS OF VEGETABLES

At Faisalabad

D_{17}. SCREENING OF PEAS HYBRIDS AGAINST INSECT PESTS

Twelve dry peas genotypes viz. DP-17001, DP-17002, DP-17003, DP-17004, DP-17006, DP-17008, DP-17018, DP-17019, DP-17020, DP-17021, DP-no.267 and DP-2018 were screened out to evaluate their response against insect pests. Experiment was laid out in RCB design with three repeats at the research area of Entomological Research Institute, AARI, Faisalabad. Aphid population was recorded from 15 leaves of 15 plants selected at random per plot. Leaf miner data were recorded by counting total no of leaves of a plant and infested no of leaves. Data so obtained were statistically analyzed.

Table 22: Screening of Dry peas against insect pests

Sr. No.	Genotypes	Leaf miner infestation %	Aphid/leaf	*Bio-control/plant
G_1	DP-17001	7.73 b	3.46 e	1.87 d
G_2	DP-17002	6.10 cd	4.13 d	2.27 abcd
G_3	DP-17003	4.90 d	3.06 ef	2.33 abcd
G_4	DP-17004	6.50 bcd	5.16 c	2.53 abc
G_5	DP-17006	6.50 bcd	8.33 b	2.23 abcd
G_6	DP-17008	6.17 bcd	3.13 ef	2.33 abcd
G_7	DP-17018	5.33 d	10.60 a	2.57 ab
G_8	DP-17019	9.53 a	2.86 f	2.00 abcd
G_9	DP-17020	5.90 cd	5.53 c	1.97 bcd
G_{10}	DP-17021	5.03 d	8.56 b	2.20 abcd
G_{11}	DP-No.267	7.37 bc	3.33 ef	2.60 a
G_{12}	DP-2018	5.43 d	4.60 d	1.93 cd
	LSD at 5%	1.631	0.49	0.626

*Bio-control: Ladybird beetle, Syrphid fly, Green lacewing

Leaf miner infestation differs significantly among all tested genotypes. Minimum leaf miner infestation 4.90 % was recorded on hybrid DP-17003 while, maximum leaf miner infestation 9.53 % was recorded on DP-17019. In case of aphids, minimum population 2.86 aphids / leaf were

recorded on DP-17019 whereas maximum population 10.60 aphids / leaf were recorded on DP-17018. Difference between populations of beneficial insect was almost at par among all genotypes.

At Multan

D_{18}. EFFICACY OF DIFFERENT INSECTICIDES AGAINST JASSID ON OKRA CROP

The experiment was laid out in Randomized Complete Block Design with three replications of each treatment in farmer field area, Multan. The below mentioned insecticides were sprayed on Okra crop. The population of Jassid was recorded from 10 leaves selected at random from 10 plants per plot. The leaves were taken from upper, middle and lower portion of selected plants. Data regarding population of Jassid were recorded from each plot before spray and then 24, 72 and 168 hours after spray by counting Jassid population. Average percent mortality was calculated. Finally, the data were compiled and analyzed statistically.

Table 23: Efficacy of different insecticides against jassid on okra crop during 2020

Treatments	Chemical name	Dose/acre	Pre-treatment population of Jassid/leaf	Mortality % of Jassid after		
				24 hr	72 hr	168 hr
Koral 50% WDG	Nitenpyram	40 gm	3.70	79.7	82.7	74.9
Ulala 50% WG	Flonicamid	60 gm	3.66	86.1	86.8	81.9
Acephate 75% SP	Acephate	250 gm	3.30	76.8	78.7	67.0
Oshin 20% SG	Dinotefuran	100 gm	2.60	77.2	82.6	69.7
Dimethoate 40% EC	Dimethoate)	400 ml	3.26	75.4	78.7	71.0
Momentum 80% WDG	Nitenpyram+ chlorfenapyr	150 gm	2.93	78.4	84.1	75.1
Confidor 200 SL	Imidacloprid	250 gm	2.70	67.9	69.5	54.8
Actara	Thiamethoxam	24 gm	2.90	65.7	68.0	54.1
Actrason Super 80% WDG	Dinotefuran+ chlorfenapyr	150 gm	2.56	79.5	84.9	72.7
Lancer Gold	Acephate+ imidacloprid	400 gm	2.56	71.4	74.4	58.9
Control			3.00	0.0	0.0	0.0
				N.S	N.S	N.S

The results showed that all the insecticides had no significant difference in mortality of Jassid after 24, 48 and 168 hours of spray application.

D_{19}. SCREENING OF VARIOUS INSECTICIDES AGAINST ONION THRIPS

The experiment was conducted at Farmer's Field, Multan in Randomized Complete Block Design having three repeats with a plot size 10 × 25 ft. Following insecticides were evaluated. Onion thrips population was recorded before spray, 24 hours, 72 hours and 168 hours after spray from randomly selected 15 plants per plot. The data were recorded and subjected to statistical analysis.

Table 24: Percent mortality of onion thrips against different insecticides

Brand Name	Common Name	Dose/acre	Pre-treatment	24 hr	72 hr	168 hr
Pirate 360 SC	Chlorfenapyr	150 ml	9.86	68.20 a	71.47 a	75.89 a
Dimethoate 40 EC	Dimethoate	400 ml	10.47	59.94 b	64.52 bc	65.36 c
Tracer 240 SC	Spinosad	40 ml	8.99	44.33 ab	65.70 b	70.83 b
Acephate 75 SP	Acephate	250 gm	10.38	62.23 b	60.86 c	68.65bc
Momentum 50 WDG	chlorfenapyr+nitenpyram	150 gm	9.79	64.94 ab	65.87 b	72.48 ab
Neem Leaf Extract (5%)			8.96	23.87 c	30.53 d	31.56 d
Tobacco Leaf Extract (5%)			10.11	24.56 c	22.86 e	28.12 d
LSD 0.05				5.56	4.66	3.95

The results indicate that the highest mortality of Thrips was observed due to Pirate 360 SC ranging from 68.20-75.89 % from 24 hours to 168 hours of application. Momentum 50 WDG was the second most toxic insecticide observed during the experiment. It has shown 72.48 % Thrips mortality after 168 hours of spray. Remaining insecticides also have shown good response against the onion Thrips. The minimum mortality was observed in Neem Leaf Extract (5 %) after 24 hours of application.

E. INSECT PESTS OF FRUITS

At Multan

E_{20}. STUDIES ON FRUIT BORER PREFERENCE TO MANGO VARIETIES

The experiment was conducted at Mango Research Institute, Multan. High value commercial mango varieties were selected for the study. The damage of mango fruit borer from fruit was recorded during peak activity period of the pest. The experiment was laid out with RCB design having three repeats. Three mango trees were selected for each repeat. Five branches having fruits were selected from each tree. Data were recorded on weekly basis. The data were compiled and analyzed statistically.

Table 25: Mango fruit borer infestation percentage on different varieties of mango

S.No	Name of Varieties	Mango Fruit borer infestation %
1	Ratul-12	9.0 a
2	Sohbawali ting	3.67 bc
3	Desi	5.00 b
4	Chaunsa	2.33 cd
5	Sufaid Chaunsa	2.67 bcd
6	Dusehri	0.33 d
7	Langra	4.00 bc
8	Sanglakhi	2.00 cd
9	Anwer Ratul	3.00 bc
10	Fajri	1.67 cd
11	Black Chaunsa	0.33 d
	LSD@5%	2.5676

The result indicated that maximum damage of fruit borer was found on variety Ratul12 i.e. 9.0 % followed by Desi 5.0 % followed by Langra i.e. 4.00 % and Sohbawali ting with 3.67 % damage. However minimum damage was observed on Dusehri i.e. 0.33 % and Black chaunsa i.e. 0.33 %.

E_{21}. EVALUATION OF VARIOUS INSECTICIDES AGAINST MANGO LEAF BLOTCH MINER

The experiment was laid out in the research area of Mango Research Institute, Multan. The trial was conducted in RCBD having three repeats. The population of mango leaf blotch miner was recorded from selected mango trees. The data were recorded before spray and then 24 hours, 72 hours and 168 hours after spray. Calibration was done before spray for measuring the quantity of water to be used in each treatment. The data were compiled and percent reduction was calculated by using the below mentioned formula:

$$\text{Reduction \%} = \frac{\text{Population before spray} - \text{Population after spray}}{\text{Population before spray}} \times 100$$

Table 26: Effect of different insecticides on mango leaf blotch leaf miner

Brand Name	**Common Name**	**Dose/acre**	**3 DAS**	**7 DAS**
Actara 24 WG	Thiamethoxam	24 gm/acre	5.42 a	5.52 a
Koral 50 WDG	Nitenpyram	40 gm/acre	13.2 c	13.6 c
Confidor 200 SL	Imidacloprid	250 ml/acre	9.11 b	9.93 b
Lasenta 80 WG	Fipronil+Imidalcoprid	60 gm/acre	4.55 a	5.45 a
Dimethoate 400 EC	Dimethoate	400 ml/acre	13.37 c	13.15 c
Bifenthrin 10 EC	Bifenthrin	300 ml/acre	5.50 a	4.99 a
Oshin 20SG	Dinotefuran	100 gm/acre	9.01 b	9.14 b
Control			15.5 d	15.43 d
LSD			3.5	3.7

The results indicated that Maximum population of leaf miner was recorded in control treatment i.e. 15.5 / bunch followed by Dimethoate 400 EC i.e. 13.37, 13.15 / bunch 3 days and 7 days after

application of insecticide. However, minimum population of leaf blotch miner was observed in treatment where Lasenta 80 WG, Actara 24 WG and Bifenthrin 10 EC were applied i.e. 4.55-5.45, 5.42-5.52 and 5.50-4.99, respectively.

F. INSECT PESTS OF MAIZE

At Faisalabad

F_{22}. SCREENING OF MAIZE HYBRIDS AGAINST INSECT PESTS

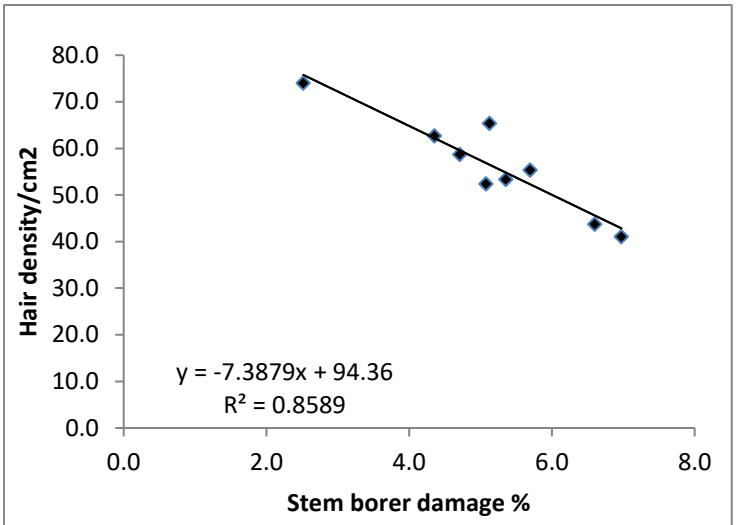
Nine maize hybrids viz. FH-1377, FH-1400, FH-11406, FH-1603, FH-1606, FH-1616, FH-1622, FH-1624 and FH-1731 were screened out to evaluate their response against insect pests of maize. Experiment was laid out in RCB design with three repeats at the research area of Maize Section, AARI, Faisalabad. Attack of shoot fly and stem borer infestation was recorded by examining 20 plants per plot. Sheath hair density was counted by placing the leaf sample (cut with a cm^2 iron dye) under microscope. The data recorded are as under: -

Table 27: Screening of maize hybrids against insect pests

Sr. No	Genotypes	Shoot fly infestation%	Stem borer infestation %	Bio-control/plant	Sheath hair density/cm^2
G_1	FH-1377	5.01 e	5.69 b	2.70 a	55.3 de
G_2	FH-1400	6.22 bc	5.08 bcd	1.78 c	52.3 e
G_3	FH-1406	3.04 f	4.71 cd	1.73 c	58.7 cd
G_4	FH-1603	6.64 b	6.97 a	2.28 abc	41.0 f
G_5	FH-1606	8.05 a	5.35 bc	1.99 abc	53.3 de
G_6	FH-1616	6.12 de	6.60 a	2.22 abc	43.7 f
G_7	FH-1622	5.85 cd	4.35 d	1.83 bc	62.7 bc
G_8	FH-1624	4.88 e	5.13 bc	2.0 0 abc	65.3 b
G_9	FH-1731	5.43 de	2.52 e	2.62 ab	74.0 a
	LSD at 5%	0.79	0.77	0.83	5.91

Bio-control: Ladybird beetle, Syrphid fly, Green lacewing

Shoot fly, infestation differs significantly among genotypes. Minimum shoot fly infestation 3.04 % was recorded on hybrid FH-1406 while, maximum shoot fly infestation 8.05 % was recorded on hybrid FH-1606. In case of stem borer, minimum infestation 2.52 %was observed on hybrid FH-1731 whereas maximum stem borer infestation 6.97% was recorded on hybrid FH-1337 followed by P-15437.33



Graph: regression and stem borer damage % with sheath hair density

Y= Stem borer damage

X= Sheath hair density

R^2 = Coefficient of determination (indicates that how much the regression prediction perfectly fit the data)

The slope of the regression line forstem borer damage and sheath hair density is -7.38/1 i.e stem bore damage is expected to decrease by 7.38 % on average per unit increase in sheath hair density.

G. INSECTICIDE RESISTANCE

At Faisalabad

G_{23}. MONITORING OF INSECTICIDE RESISTANCE IN WHITEFLY

Collection: Whitefly adult was collected from 2 ha. block by zigzag manner to randomize collection by using aspirator. Adult whitefly was brought to lab in glass vials.

Bioassay: Bioassay was done by leaf dip method (IRAC method No. 7). Laboratory dose was calculated and serial dilutions were made up to five treatments for each insecticide. Each treatment was replicated three times and 10 insects were released for each replication. Mortality was recorded after 48 hours. Probit analysis was done to determine LC_{50} values. Resistance factor was also calculated.

Table 28: Insecticides used in this study

Insecticide name	Formulation	Active Ingredient	Dose/100 ml water (ml/mg)	Mode of Action
Confidor	200% SL	Imidacloprid	250 ml	acts by interfering with the transmission of impulses in the nerve system of insects.
Confidor	70% WS	Imidacloprid	5 gm/kg seed	acts by interfering with the transmission of impulses in the nerve system of insects.
Rani	20% SL	Acetamiprid	125	nicotinic agonist that reacts with nicotinic acetylcholine receptors
Dimogreen	40% EC	Dimathoate	300 ml	acetylcholinesterase inhibitor
Polo	500% SC	Diafenthiuron	200 ml	immediate paralysis
Priorty	10.8% EC	Pyriproxyfen	250-500 ml	affects the growth and development of target insects by reducing / inhibiting number of physiological processes
Movento	240% SC	Spirotetramate	125 ml	Acetylcholinesterase inhibitor

Confidor 70 WS showed very high level of resistance, Confidor 200 SL, Rani 20 SL, Polo 500 SC and Dimogreen 40 EC had high LC_{50} value which depicts that these insecticides have high level of resistance while Priorty 10.8 AS and Movento 240 SC showed very low level of resistance. Data recorded were as under;

Table 29: LC_{50} and resistance level of different insecticides in cotton whitefly

Insecticides	LC_{50}	Base Line Values	Resistance Factor	Resistance Level
Confidor 200 SL	641.27	8.17	78.49	High
Confidor 70 WS	754	4.91	153.56	V. High
Rani 20 SL	347.51	4.03	86.23	High
Dimogreen 40 EC	54.32	0.74	73.40	High
Polo 500 SC	103.37	4.09	25.37	High
Priorty 10.8 AS	12.98	0.81	16.02	Low
Movento 240 SC	10.47	1.07	9.78	V. Low

Among the seven tested insecticides; cotton whitefly showed high level of resistance against following insecticides respectively. Confidor 70 WS > Rani 20 SL > Confidor > 200 SL > Dimogreen 40 EC > Polo 500 SC.

G_{24}. MONITORING OF INSECTICIDE RESISTANCE IN COTTON JASSID

Collection: Jassid adults were collected from 2 ha. Block by zigzag manner to randomize collection by using aspirator. Adult jassid were brought to lab in glass vials.

Bioassay: Bioassay was done by leaf dip method (IRAC method No. 7). Laboratory dose was calculated and serial dilutions were made up to five treatments for each insecticide. Each treatment was replicated three times and 10 insects were released for each replication. Mortality was recorded after 48 hours. Probit analysis was done to determine LC_{50} values. Resistance factor was also calculated

Table 30: Insecticides used in this study

Insecticide name	Formulation	Active Ingredient	Dose/100 ml water (ml/mg)	Mode of Action
Confidor	200% SL	Imidacloprid	100 ml	acts by interfering with the transmission of impulses in the nerve system of insects.
Confidor	70% WS	Imidacloprid	5 gm/kg seed	acts by interfering with the transmission of impulses in the nerve system of insects.
Rani	20% SL	Acetamiprid	125 ml	nicotinic agonist that reacts with nicotinic acetylcholine receptors
Dimogreen	40% EC	Dimethoate	300 ml	Acetylcholinesterase inhibitor
Oshin	20% SG	Dinotefuran	100 gm	Acts through contact and ingestion and results in the cessation of feeding
Pyramid	10% AS	Nitenpyram	200 ml	Inhibits postsynaptic nicotinic acetylcholine receptors

Confidor 70 WS and Confidor 200 SL had very high LC_{50} value which depicts that these insecticides have very high level of resistance. Rani 20 SL showed high level of resistance. Dimogreen 4 EC revealed moderate level while Oshin 20 SG and Pyramid 10 AS showed low level of resistance. Data recorded were as under:

Table 31: LC_{50} and resistance level of different insecticides in cotton Jassid

Insecticides	LC_{50}	Base Line Values	Resistance Factor	Resistance Level
Confidor 200 SL	615.75	12.57	48.99	V. High
Confidor 70 WS	934.29	8.31	112.42	V. High
Rani 20 SL	551.79	3.72	148.33	High
Dimogreen 4 EC	187.57	6.17	30.40	Moderate
Oshin 20 SG	53.99	4.29	12.58	Low
Pyramid 10 AS	67.15	5.11	13.15	Low

In this study, cotton jassid showed high level of resistance against following insecticides respectively; Rani 20 SL, Confidor 70 WS and Confidor 200 SL.

G_{25}. MONITORING OF INSECTICIDE RESISTANCE IN COTTON THRIPS

Collection: Thrips adults were collected from 2 ha. Block by zigzag manner to randomize collection by using aspirator. Adult thrips were brought to lab in glass vials.

Bioassay: Bioassay was done by leaf dip method (IRAC method No. 7). Laboratory dose was calculated and serial dilutions were made up to five treatments for each insecticide. Each treatment was replicated three times and 10 insects were released for each replication. Mortality was recorded after 48 hours. Probit analysis was done to determine LC_{50} values. Resistance factor was also calculated.

Table 32: Insecticides used in this study

Insecticide name	Formulation	Active Ingredient	Dose/100 ml water (ml/mg)	Mode of Action
Confidor	200% SL	Imidacloprid	250 ml	Acts by interfering with the transmission of impulses in the nerve system of insects.
Confidor	70% WS	Imidacloprid	5 gm/kg seed	Acts on several types of post-synaptic nicotinic acetylcholine receptors in the nervous system
Rani	20% SL	Acetamiprid	125 ml	Reacts with nicotinic acetylcholine receptors
Dimogreen	40% EC	Dimethoate	300 ml	Acetylcholinesterase inhibitor
Tracer	240% SC	Spinosad	50 ml	
Thimet	25% WP			

Confidor 200 SL, Confidor 70 WS, and Rani 20 SL had high LC_{50} value which depicts that these insecticides have very high level of resistance. Dimogreen 4 EC showed moderate level while low level of resistance was observed in Tracer 240 SC and Thimet 25 WP. Data recorded were as under:

Table 33: LC_{50} and resistance level of different insecticides in cotton Thrips

Insecticides	LC_{50}	Base Line Values	Resistance Factor	Resistance Level
Confidor 200 SL	1831.58	10.37	176.61	V.High
Confidor 70 WS	1480.35	8.98	164.84	V.High
Rani 20 SL	735	8.34	88.13	V.High
Dimogreen 4 EC	288.63	6.31	45.74	Moderate
Tracer 240 SC	51.94	5.71	9.09	Low
Thimet 25 WP	89.11	6.77	13.16	Low

Widespread use of insecticides causes resistance in insects against them. In this experiment Confidor 200 SL, Confidor 70 WS and Rani 20 SL were found highly resistant for cotton thrips.

G_{26}. MONITORING OF INSECTICIDE RESISTANCE IN *Helicoverpa armigera*

Insect larvae were collected from infested field. Larvae then transferred in separate vials and reared on natural diet. Adult were fed with 6 % honey solution. Eggs were obtained on cotton pads and kept in plastic bags of 11 × 12 cm size. 1st instar progeny was released on artificial diet.

For the purpose of bioassay, IRAC method No.7 was used. Laboratory dose was calculated and serial dilutions were made up to five treatments for each insecticide. Each treatment was replicated three times and 10 insects were released for each replication. Mortality was recorded after 48 hours. Probit analysis was done to calculate corresponding LC_{50} values. Resistance factor was determined.

Table 34: Insecticides used in this study

Insecticide name	Formulation	Active Ingredient	Dose	Mode of Action
Belt	48% EC	Flubendiamide	50 ml	Larvicidal (disrupt Ca2+ balance)
Match	50% EC	Lufenuron	800 ml	Chitin inhibitor
Proclaim	19% EC	Emamectin benzoate	200 ml	Inhibit muscle contraction
Lorsban	40% EC	Chlorpyrifos	1000 ml	prevents breakdown of ACh in the synaptic cleft.
Curacron	50% EC	Profenofos	800 ml	Acetylcholine esterase inhibitor

Proclaim had low LC_{50} values which depicted low level of resistance whereas, Belt and Lorsban showed very low level of resistance against *Helicoverpa armigera*. Data recorded were as under:

Table 35: LC_{50} and resistance level of different insecticides in *Helicoverpa armigera*

Treatments	**LC_{50}** **Field strain**	**LC_{50}** **susceptible strain**	**Resistance factor**	**Resistance level**
Belt	9.17	0.83	11.04	Very low
Match	26.94	3.19	8.44	Moderate
Proclaim	12.69	0.53	23.94	Low
Lorsban	8.34	1.21	6.89	Very low
Curacron	72.11	4.98	14.47	High
Resistance scale	**Very low <10, low >11-20,Moderate>21-50, high>51-100, very high>100**			

Helicoverpa armigera showed low level of resistance to tested insecticides in the order; Lorsban, Belt, Proclaim, Match and Curacron, respectively. It is concluded that these insecticides can be effectively used against *Helicoverpa armigera*.

G_{27}. MONITORING OF INSECTICIDE RESISTANCE IN ARMYWORM ON CAULIFLOWER

Insect larvae were collected from infested field. Larvae then transferred in separate vials and reared on natural diet. Adult were fed with 6 % honey solution. Eggs were obtained on cotton pads and kept in plastic bags of 11 × 12 cm size. 1^{st} instar progeny was released on artificial diet.

For the purpose of bioassay, IRAC method No.7 was used. Laboratory dose was calculated and serial dilutions were made up to five treatments for each insecticide. Each treatment was replicated three times and 10 insects were released for each replication. Mortality was recorded after 48 hours. Probit analysis was done to calculate corresponding LC_{50} values. Resistance factor was determined.

Table 36: Insecticides used in this study

Insecticide name	Formulation	Active Ingredient	Dose	Mode of Action
Belt	48% EC	Flubendiamide	50 ml	Larvicidal (disrupt Ca2+ balance)
Match	50% EC	Lufenuron	800 ml	Chitin inhibitor
Proclaim	19% EC	Emamectin benzoate	200 ml	Inhibit muscle contraction
Lorsban	40% EC	Chlorpyrifos	1000 ml	prevents breakdown of ACh in the synaptic cleft
Curacron	50% EC	Profenofos	800 ml	Acetylcholine esterase inhibitor

Belt and Match depicted moderate level of resistance, Proclaim and Lorsban showed low level of resistance, whereas, Curacron showed high level of resistance. Data recorded were as under;

Table 37: LC_{50} and resistance level of different insecticides in Army worm

Treatments	LC_{50} Field strain	LC_{50} susceptible strain	Resistance factor	Resistance level
Belt	22.00	2.29	9.60	Moderate
Match	25.13	0.97	25.90	Moderate
Proclaim	19.78	1.27	15.57	Low
Lorsban	13.99	5.01	2.79	Low
Curacron	65.10	2.98	21.84	High
Resistance scale	**Very low <10, low >11-20,Moderate>21-50, high>51-100, very high>100**			

Among the tested insecticides, Armyworm showed low level of resistance to Lorsban and Proclaim, so these insecticides can be used effectively against this insect.

G_{28}. COMPARATIVE TOXICITY OF INSECTICIDES AGAINST *Bracon hebetor*

The experiment was conducted in the Bioassay lab. of ERI Faisalabad. The experiment was laid out in CRD having five repeats to study the toxicity by using IRAC method (leaf dip method).

For this purpose, leaf discs of 2.5 inches dipped in insecticide solution (field recommended dose) for 1 minute. Five adults were released in each replication. The data regarding mortality were collected after 24 and 48 hours of application.

Table 38: Insecticides used in this study

Insecticide name	Formulation	Active Ingredient	Dose	Mode of Action
Imidacloprid	20% SL	Imidacloprid	100 ml	Acts on post-synaptic nicotinic acetylcholine receptors
Emamectin benzoate	1.9% EC	Emamectin benzoate	200 ml	inhibit muscle contraction
Bifenthrin	10% EC	Bifenthrin	250 ml	affects the central and peripheral nervous system
Flubendiamide	48%SC	Flubendiamide	50 ml	Larvicidal (disrupt the Ca2+ balance)
Lufenuron	25% EC	Lufenuron	100-200 ml	Chitin inhibitor
Pyriproxyfen	10.8 % EC	Pyriproxifen	400 ml	insect growth regulator
Flonicamid	50% WG	Flonicamid	60 gm	inhibits feeding behavior of insects

Overall results revealed that Bifenthrin, Pyriproxyfen, Imidacloprid and Flubendiamide were more toxic to *Bracon hebetor* as compare to other tested insecticides. Data recorded were as under;

Table 39: Percent mortality of *Bracon hebetor* against different insecticides

Insecticides	**% Mortality after 24 hrs**	**% Mortality after 48 hrs**
Imidacloprid	35.42 e	61.00 f
Emamectin benzoate	38.41 f	44.67 c
Bifenthrin	54.40 g	85.23 e
Flubendiamide	25.67 bc	53.87 e
Lufenuron	22.34 b	39.02 b
Pyriproxyfen	40.12 e	78.19 f
Belt	21.97 b	44.25 c
Flonicamide	30.01 d	46.33 d
Control	0.00 a	3.76 a
LSD	1.29	1.01

In this study Bifenthrin, Pyriproxyfen, Imidacloprid and Flubendiamide were found more toxic to *Bracon hebetor*. So it can be concluded that these insecticides are not compatible for using in combination with *Bracon hebetor*.

H. BIOLOGICAL CONTROL

H_{29}. DEVELOPMENT OF MASS REARING TECHNOLOGY OF LARVAL PARASITOID, *Bracon hebetor*

For the mass rearing of *Bracon hebetor*, protocol was developed by the help of following steps;

Host rearing

i. Collection of host (wax moth) of *B. hebetor*
ii. Mass rearing of wax moth (*Galleria melonella*) on artificial diet
iii. Separation of wax moth eggs
iv. Filling of eggs into artificial diet
v. Separation of pupae of wax moth
vi. Shifting of adults in mating jars for egg laying

***Bracon* rearing**

i. Preparation of wax moth cards for parasitoid (*B. hebetor*)
ii. Release of *B. hebetor* for parasitism

The prepared cards were utilized for the different experiments

The mass rearing of *B. hebetor* has been successfully achieved and in progress.

I. BEE-KEEPING AND HILL FRUITS PEST, STATION, RAWALPINDI

I_{30}. STUDIES ON THE SCENARIO OF AMERICAN FOUL BROOD AND HONEYBEE MITE IN THE APIARIES

Surveys of different private apiaries in the Districts of Rawalpindi and Attock were carried out to determine the infection and infestation level of honeybee disease and mite in the private apiaries and to provide advisory services accordingly. The infection and infestation of honey bee disease and mite were recorded to ascertain the extent of damage done to the honey bees by inspecting bee colonies of the total stock. Advisory services were also provided as per pest situation to beekeepers.

Table 40: Data regarding studies on the scenario of different insect pests in apiaries

Name of Apiarist	Locality	No. of Colonies	%Mites	%AFB	%EFB	%C.B	Any other
NOVEMBER 2019							
Akram(0346-5955515)	Hassanabdal	55	10.38	-	---	9.00-	-
Ikhlaq Ahmed (03455613173)	Hassanabdal	50	30.00	-	-	20.00	-
Naveed Aftab (03459731128)	Hassanabdal	60	33.33	-	-	-	-
DECEMBER ,2019							
Nadir Khan	Wah	90	8.8	-	-	-	-
M. Ali (0307-8290536)	Tret	105	33.3	-	-	-	-
Ameer Khan	Hassanabdal	100	25.00	-	-	10	-
Siddiq Ullah	Bajwal	150	26.66	-		10.0	
JANUARY 2020							
M. Agha	Bajwal	60	10.5	-	-	-	-
M. Yousaf (0311-06922800	Kohat Road	120	20	-	-	10	-
Rahmat Ullah (03408566223)	Hattar	65	38.46	-	-	10	-
M. Afzal	Rawalpindi	60	20	-	-	-	-
February 2020							
Wali Khan	Satramil	100	30.5	-	-	-	-
M. Aslam	Kohat road	230	30.43	-	-	8.69	-
M. Afzal(0307-8721055)	Rawalpindi	50	10	-	-	-	-
MARCH,2020							
M. Yousaf (0311-0692280)	Kohat Road	100	15.5		-	-	-
Ramahatullah(0340-8566223)	Kohat Road	120	35.5		-	10.5	-
Saad Wali(0342-4577342)	Salghran	160	30		-	10	-
M. Ali (0307-8290536)	Tret	130	20		-	2	-

It was observed that minimum 8.8 % and maximum 38.46 % infestation of honeybee mite and 10-20 % chalk brood was recorded from the private apiaries during the reported period.

I_{31}. CAPACITY BUILDING AND TRAINING PROGRAM FOR BEEKEEPERS AND INTERESTED PERSON

Beekeepers and the interested persons were trained in the enterprise of beekeeping with schedule as under:

Batch No.	Month	Duration	No of Participants
1	Novembr,2019	01 Day	09
Total			09

Syllabi for the subject training are as under:

1. Introduction to beekeeping
2. Colony System
3. Bee Forage plants
4. Beekeeping equipments
5. Honey bee diseases and enemies
6. Seasonal management
7. Bee products
8. Honey extraction
9. Honey processing and marketing
10. Wax processing

One beekeeping training course was organized at Rawalpindi during 20119-2020 and 40 persons participated in these training courses. They were imparted theoretical and practical training in bee management and other related topics**.** The proposed training programmers of March, 2020 and April, 2020 couldn't be held because of Covid 19 pandemic situation and Govt. lockdown.

I_{32}. COMPARATIVE EFFICACY OF FLUVALINATE AND FLUMETHRINE AGAINST THE CONTROL OF HONEY BEE MITES *Varroa destructor* AND ITS TOXICITY ON THE LIFE CYCLE OF HONEYBEES

Apis mellifera colonies having almost even population was selected for study purpose to evaluate the toxicity of different acaricides on honey bees and mites (*Varroa destructor*). White sheets were placed on the bottom board of the hives to record the colony's natural mite mortality. The treatments were applied by hanging the recommended strips between frames. The pre and post treatment data were recorded weekly. Each treatment was replicated three times. The data recorded and subjected to analysis by using RCBD design in statistics 8.1 software

Treatments:

T_1= ½ fluvinate strip (1 mg dose)
T_2= 1 fluvinate strip (2 mg dose)
T_3= 1½ fluvinate strip (3mg dose)
T_4 = 2 fluvinate strip (4 mg dose)
T_5= Control

T_1= ½ flumethrin strip (1 mg dose)
T_2= 1 flumethrin strip (2 mg dose)
T_3= 1½ flumethrin strip (3mg dose)
T_4 = 2 flumethrin strip (4 mg dose)


Table 41: (FLUVALINATE STRIPS) SAMPLE OF 100 HONEYBEES

Treatments	PRE TREATMENT DATA			Treatments	POST TREATMENT DATA			Treatments	PERCENT MORTALITY			
	Replicates				Replicates				Replicates			
	1	2	3		1	2	3		1	2	3	GM
1	32.00	29.33	32.66	1	22.33	22.66	22.33	1	30.02	38.31	31.05	33.12 b
2	30.66	29.33	31.66	2	18.33	16.33	19.00	2	39.89	20.43	39.80	33.37 b
3	28.66	30.66	28.00	3	11.33	12.00	13.33	3	60.00	60.67	45.56	55.41 a
4	30.33	29.00	29.66	4	9.0	6.66	9.33	4	70.31	76.91	68.15	71.79 a

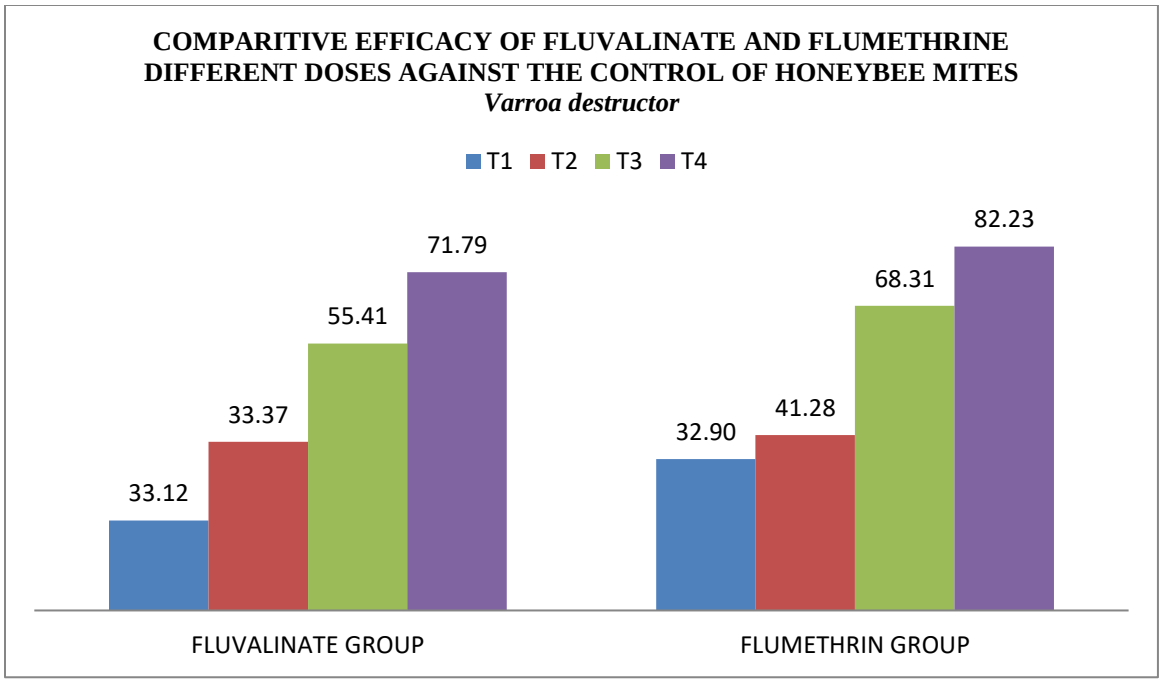
LSD VALUE =17.231 (There are 2 groups A and B in which the means are not significantly)

Table 42: (FLUMETHRIN STRIPS) SAMPLE OF 100 HONEYBEES

Treatments	PRE TREATMENT DATA			Treatments	POST TREATMENT DATA			Treatments	PERCENT MORTALITY			
	Replicates				Replicates				Replicates			
	1	2	3		1	2	3		1	2	3	GM
1	29.33	29.0	28.66	1	19.0	19.66		1	34.80	34.43	29.56	32.90 d
2	29.66	30.00	71.66	2	17	7.33		2	42.36	39.87	41.61	41.28 c
3	29.33	30.33	29.66	3	9	9.33		3	69.37	69.23	66.33	68.31 b
4	299.0	29.00	28.66	4	5	5.0		4	82.70	82.70	81.30	82.23 a

LSD VALUE =2.95 There are 4 groups (A, B, etc.) in which the means are significantly different from one another).

The overall results in comparison showed that in fluvalinate group , T4 (fluvalinate strip 2 dose) gave better results as compare to all other treatments ,while in flumethrin group the T4 (2 dose) gave good results, however in comparison of both group the flumethrin group gave better results



I_{33}. COMPARATIVE STUDY OF OILS EXTRACTS VS POWDERS DUST FOR THE CONTROL OF *Varroa destructor*

The experiments were conducted in the private apiaries on twenty-four *Apis millifera* colonies naturally infested with *Varroa destructor* with three repeats to determine the efficacy of oil extracts and powder form of different organic compounds for the control of *V. destructor*. The bottom board of the hives was covered with sheet of white paper. Powders form was applied to each treatment in the form of dusting, while the oil was applied to each treatment in the form of spraying with ordinary plastic sprinkler. The rate of *V. destructor* infestation and treatment efficacy was estimated by counting the falling mites on the sheet of paper by counting the dead mites in the sealed worker and drone brood cells before and after treatment.

Treatments

T1= vegetable oil @15 ml/ hive
T2= clove oil 15 ml /
T3= tobacco oil 15ml/hive
T4= control

TI = garlic powder @ 5 g/hive
T2 = ginger powder 5 g/ hive
T3 = niazboo powder5g/ hive
T4 = control

Table 43: Percentage mortality of mites (Oil group)

Treatment	Pre-treatment data	GM
1	4.00	16.58 **a**
2	5.00	22.66 b
3	7.00	7.08 c
4	9.00	4.41 d

LSD = 1.6711

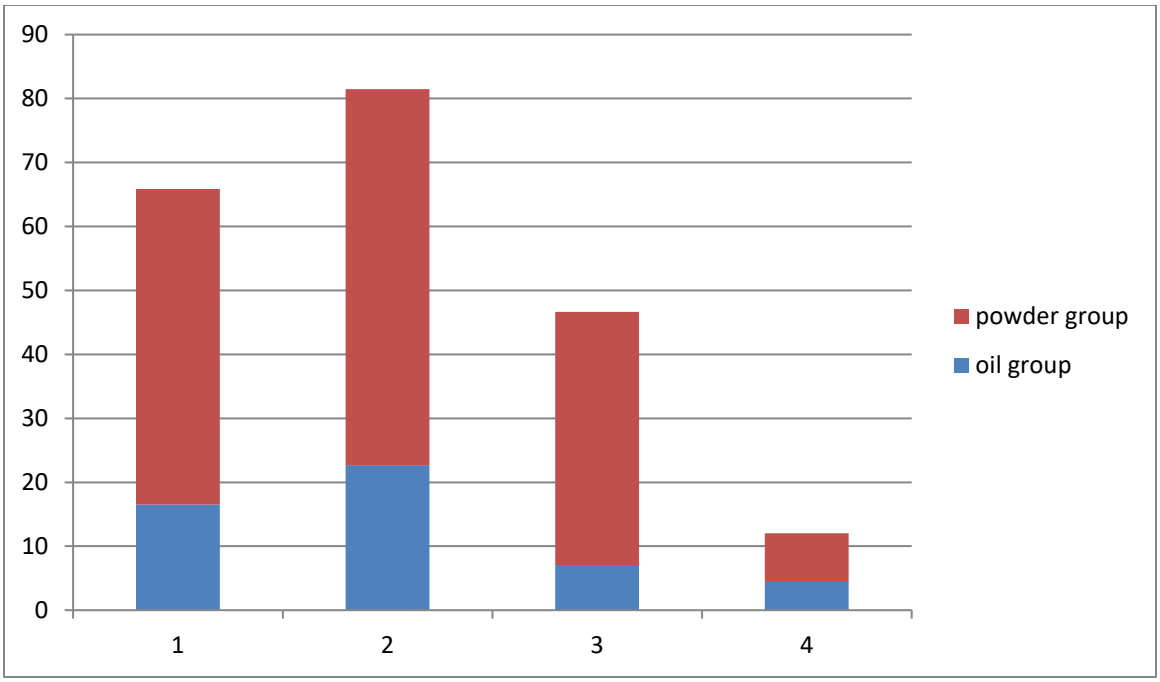
The results showed that all means are significantly different from each other and maximum percentage of mite mortality (22.667) was achieved from (T_2) clove oil in group I (oils)

Table 44: Percentage mortality of mite (Powder group)

Treatment	Pre treatment data	GM
1	7.00	49.33
2	7.00	58.83
3	7.00	39.58
4	9.00	7.6

LSD = 1.420

The results showed that means are significantly different from each other. Maximum percentage of mite mortality (58.83) was achieved from (T_2) ginger powder in group II (powder dust). Over all in comparison powder dust gave better results as compare to oil extracts, and (T_2) ginger powder showed significantly higher results than ginger and niazboo powder.



Graph presenting the control of mites by using the methods of 2 groups, oil extract and powder dust

I_{34}. DEVELOPING BEST MANAGEMENT PRACTICES FOR MANAGING HONEYBEE COLONIES DURING WINTER; DETERMINING BETTER HEAT INSULATION

Four different types of insulation materials were used to cover the bee colonies. The basic purpose of study was to develop best management practices for beekeepers regarding winter management of hives. Following material were used as treatment

T_1 = Styrofoam sheets

T_2 = Cotton pads

T_3= Polyester pads

T_4 = Wheat straw pads

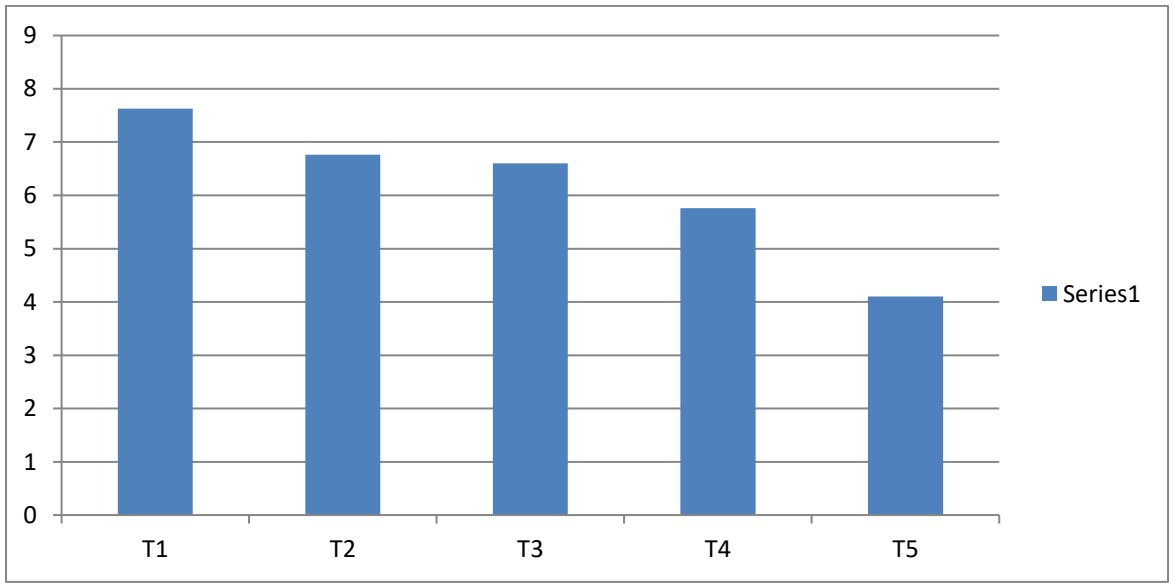
T_5 = Control

All four treatments were replicated three times. The treatments were applied on the sides of the bee hives and on top of the hives. So that minimum cold affects the colony. The data recording were done every fortnightly to save bees from cold shock and avoid continues disturbance. The data regarding number of bees' frames, queen egg laying or raising of new brood were observed. At the end of season over all colony health was compared with control.

The experiment results showed that treatment T_1 was most effective in providing insulation to the bees there were 7.63 bee frames in every colony after overwintering. While T_2 and T_3 remained statistically at par with mean bees population 6.7 and 6.6 bee frames per colony. However wheat straw pad T_4 showed less insulation with mean population of bees upto 5.76 bees frame per colony. While control have been much influenced by the cold weather and only 4.1 frames bees were recorded in each box after winter season.

S. NO.	Treatments	MEANS
1	T_1	7.63 a
2	T_2	6.76 b
3	T_3	6.60 b
4	T_4	5.76 c
5	T_5	4.10 d

LSD =0.8273



Mean number of bee frames per box after overwintering

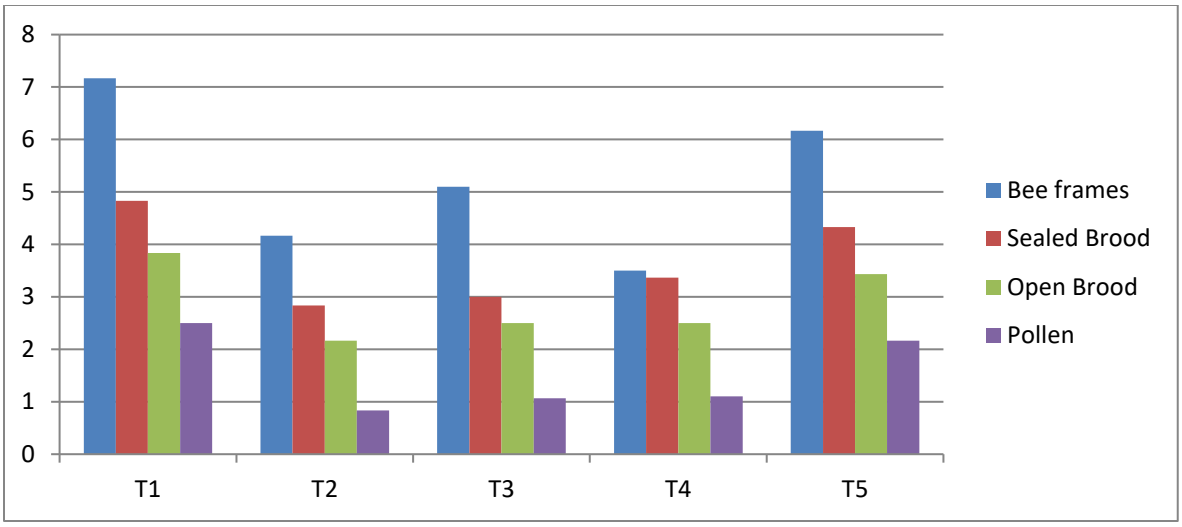
I_{35}. EVALUATION OF DIFFERENT PLUSES AS PROTEIN SOURCE IN POLLEN SUBSTITUTES AND POLLEN SUPPLEMENT FOR *Apis melifera*

Different bee pollen substitutes offered to the bees in the form of patties to determine best protein source for pollen substitute. Five pulses i. e., soybean (*Glycine max* (L.) Merr.), mungbean (*Vigna radiata* L. Wilczek), Mash been (*V. mungo*), cowpea (*V. unguiculata*) and chick pea (*Cicer arietinum* L.) were taken. Three formulations prepared i.e. solid, semi- solid and semi- liquid (slurry) by mixing the different ingredients in water. Feeding inside the hive was less wasteful.

For this reason, diets were made available to the bees by directly introducing the formulations into the frames. Each candidate pollen substitute/supplement diet was given to a set of three colonies. Every week 100 g of pollen substitute/ supplement diet and one liter of 50 percent sugar syrup were given to each colony. The unused portion of the diet was discarded. Each colony was given 1700 g of the diet from July to October. The control colonies received one litre of 50 percent sugar syrup per week only.

All the colonies had newly mated and lying queens which were raised in March 2019. The experimental colonies equalized. Each test colony having one frame of unsealed brood (650 cm^2), one frame of sealed brood (650 cm^2) and a half frame of honey (350 cm^2). Different attributes of the test colonies was recorded every 21 days (the developmental period of a worker honeybee). The recorded attributes included unsealed/uncapped brood area, sealed/capped brood area, honey area, pollen area (all in cm^2), and honeybee strength. Each diet was tested on a set of four colonies selected for each treatment. Warm water was added to the weighed diet until the mixture turn into the desired formulation (solid, semisolid or slurry form).

Five treatments were used to feed bees as pollen substitute. It was observed that soybean T_1 was most preferred as pollen substitute with bees frames buildup to 7.16 frames, sealed brood 4.83 frames open brood 3.83 and pollen storage 2.5 frames. While second preferred protein source was chickpea powder with bees build up to 6.16 six frames, sealed brood 4.33 frames, unsealed brood 3.43 frames, and pollen storage 2.1 frames. While third priority was given to the T_3 mash bean with bees population upto 5.1 frames, sealed brood 3.0 frames, open brood 2.5 frames and pollen 1.06 frames. While T_2 mung bean and T_4 mash bean were least preferred as alternate protein sources. The T_2 and T_4 resulted in very low bees buildup 4.1 and 3.5 statistically at par, brood sealed 2.8, 3.36 frames, open brood 2.16, 2.5 and pollen storage 0.83 and 1.10 frames respectively. Hence it can be inferred that soybean powder and chick pea powder can be used as protein source for bees feeding as supplement of pollen substitute.



I_{36}. ENHANCEMENT OF HONEY PRODUCTION BY USING MODERN TECHNIQUES AT RAWALPINDI

A. Survey for exploration and adaptation of new flora for pollens and nectar

B. Site selection of winter season flora for colony management

Site selected at Beekeeping Research Farm Rawalpindi, sown mustard flora as source of pollen and nectar for honeybees. Full bloom of mustard flora have been recorded, Also observed /recorded flora of (seasonal flowers, radish crop, fruit plants and *Eucalyptus spp* etc)

March/April: Sowing of sunflower and early Maize & Millet varieties at Research Farm Rawalpindi normal germination rate have been found.

May: Normal crop growth stand

June: Full bloom of sunflower has been recorded as source of pollen and nectar for honeybee.

I_{37}. QUEEN REARING AND BREEDING IN THE LOCAL CLIMATIC CONDITIONS

The imported bee strains were proliferated through Queen rearing to increase the population and colonies of imported bee strains. For the queen rearing different methods were used.

I-Through Larval Grafting

Four feeding and 30 mating colonies were used at Beekeeping and Hill fruit pests research station Rawalpindi. Grafting method was used for queen bee rearing. Two Queens less breeder colonies were used for each grafting group instead of using starter or starter-finisher colony. One grafting comb with three units queen cell cups were given to each breeder colony. Thirty, 1, 2 and 3d old larvae ten larvae each in group was grafted, respectively. Cell cups used as queen cell cup were attached to a bar with melted wax. The cups were pressed into the soft barely melted wax and spaced about 2.5 cm from center to center, ten cups were placed on each bar. The forming sticks were dipped into barely melted wax three or four times. The queen cells cups were kept in feeder colony until the cups completely close. Their heights were measured and they were placed into incubator (33.0 ± 0.5°C and 60-65 % RH) till queen emergence. Shortly after emergence queens were weighed, marked and numbered and were placed in mating colonies (nuclei) in cages. Virgin queens were permitted to mate or were inseminated after 24h.

II -Nicot Method

Through nicot method Queen was caged in nicot kit for 24 hours or till egg laying. The kit was left in laying queen colony till hatching of the eggs. The one day old larvae cups were mounted on the frames and kept in feeder colony. As the queen cells get closed the cells were transferred in

incubator for hatching. Rest the procedure was followed as described above in larval graft method.

B. HASSANABDAL

I_{38}. MANAGEMENT OF VARROA MITE BY USING SAFE MATERIALS DURING DIFFERENT SEASONS

(i). Four even populated bee colonies with 5 frames were selected for study to evaluate the mite control methods during different environmental conditions. Using the Germen bee hives having moveable bottom trays and mesh wire above it. The treatments were applied by spraying. Each treatment was repeated after three days.

T_1= sugar syrup (SS) 1:1 (suagr:water, w/w) (using 4 ml per comb)

T_2= sugar syrup 1:1 mixed with drone larvae extract (EDL) (20 drone larvae at 5th day were dissolved in 100 ml water and filtered, then 2 ml of the extract were mixed with 2 ml sugar syrup per comb)

T_3= sugar syrup 1:1 mixed with propolis extract (EP) (5 gm propolis were mixed with 100 ml water and filtered, then 2 ml of the extract were mixed with 2 ml sugar syrup per comb).

Pre and post treatment data were recorded by counting the no. of dead and alive mites on paper sheet. The mites were classified as normal or deformed (groomed) by using light microscope. The grooming behavior of colonies were assessed as percentage of groomed mites by using the following formula

$$\boldsymbol{Percentage\ of\ groomed\ mites} = \frac{\boldsymbol{No.\ of\ groomed\ mites}}{\boldsymbol{Total\ No.\ of\ Varoa}}\ \boldsymbol{x100}$$

It was compared before and after treatment data. The data were subjected to ANOVA by using statistix 8.1

(ii). The effects of these materials on nurse bee workers were assessed under laboratory conditions. Each of SS, EDL, and EP were replicated four times (four jars and 15 bees per jar, a total of 60 bees per treatment). The jars were covered with mesh covers. The treatments were presented daily to the bees using cotton pieces saturated with each treatment above the mesh covers. The number of dead bees was counted daily for 7 days. Then, the mortality rates were calculated in each jar by dividing the daily number of dead bees on the total number of bees per jar (15) × 100. Means were calculated and compared. The collected data were subjected to Statistical software.

Treatment	Results
T_1= sugar syrup (SS) 1:1 (suagr:water, w/w)	43.327± 1.52 c
T_2= sugar syrup 1:1 mixed with drone larvae extract (EDL)	51.663± 1.33 b
T_3= sugar syrup 1:1 mixed with propolis extract (EP)	57.440± 1.64 a

LSD = 3.77

C. LAHORE

I_{39}. EFFICACY OF DIFFERENT VEGETABLE OILS AGAINST DIFFERENT SPECIES OF HONEYBEE PARASITIC MITES i. e. *Tropilaelaps clareae* AND *Varroa destructor*

Fifteen bee colonies of same population were selected at random to reduce the cost of bee colony maintenance and provide beehives products free from the residues of dangerous chemicals harmful to bees, environment and human beings. Pre-treatment data of fifty (50) honey bees were taken out from each colony and put in bottle containing tap water and then population of mites was counted.

T_1 = Cumin oil (25 drops add in one lit sugar syrup)

T_2 = Thymol oil (25 drops add in one lit sugar syrup)

T_3 = Menthol oil (25 drops add in one lit sugar syrup)

T_4 = Lemon oil (25 drops add in one lit sugar syrup)

T_5 = Control (no feeding)

All treatments except control applied once at 10 days interval. Post treatment data were recorded after 24 hours of treatment application by taking out 50 honeybees as per procedure, mentioned in pre-treatment data. Data regarding reduce percentage of mite population had been worked out for comparisons. The final field efficacy was estimated after the treatments using the formula developed by Jelinski et al 1994.

$E=100-I_1/I_0x100$

E=Field efficacy.

I_1=Rate of infestation before treatment.

I_0=Rate of infestation after treatment.

Sr. No.	Name of different plant material	Percent population reduction

1	Cumin oil (25 drops add in one liter sugar)	50.31± 0.50 d
2	Thymol oil (25 drops added in one litter sugar)	63.79± 0.33 c
3	Menthol oil (25 drops added to one liter sugar)	66.73± 1.01 b
4	Lemon oil (25 drops added to one liter sugar)	70.16± 0.69 a
5	Control	13.97± 0.70 e

LSD = 1.86

J. MISCALLENOUS

At Multan

J40. SCREENING OF DIFFERENT ROSE GENOTYPES AGAINST THRIPS (*Frankliniella tritici* FITCH)

The experiment was laid out at Floricultural Research Sub Station, old Shujabad Road Multan under Randomized Complete Block Design (RCBD). There were three replications of each treatment. The newly developed genotypes sown in Floricultural Research Sub Station were selected for the study. From each genotype ten plants were selected randomly. The population of thrips was counted from buds and flowers by visual counts method by shaking 3 times on white paper. The recorded data were further compiled and analyzed statistically.

Sundertha, Cauliflower wonder, Lady berg, Hox pox, Madam amputation, Neppeck perfume, Queen alzbeth, Cool white, Medas touch, M.yaqoob, Hafiz zaman, Orange amputation, Micheal angelo, Morus atrailo, Dandily standard, New Changa rose, wedding bill, diamond, California dream, Kainat, Lahore city, Blue for all, American hero.

Table 45: Screening of different rose genotypes against thrips (*Frankliniella tritici* fitch)

Sr#	Rose Genotypes	Rose Thrips per Bud.Flower			
		February	March	April	Overall Season
1	**Sundertha**	2.51 bc	6.54 a	10.78 a	6.61 a
2	**California wonder**	0.19 i	0.69 k	1.74 j	0.87 l
3	**Lady berg**	0.37 hi	1.47 ijk	4.14 h	2.00 hijkl
4	**Hox pox**	2.53 bc	4.88 b	10.17 a	5.86 ab
5	**Madam amputation**	1.81 de	4.32 bc	6.64 cde	4.25 bcde
6	**Neppeck perfume**	2.13 cd	2.85 def	4.20 h	3.06 defghij
7	**Queen alzbeth**	1.58 ef	3.31 cde	5.00 gh	3.30 cdefgh
8	**Cool white**	2.32 bcd	3.22 de	6.51 def	4.01 cdef
9	**Medas touch**	0.90 gh	3.54 cd	7.31 cd	3.92 cdefg
10	**M.Yaqoob**	0.53 hi	1.51 hijk	3.01 i	1.68 hijkl

11	**Hafiz zaman**	2.82 b	6.55 a	8.31 b	5.89 ab
12	**Orange amputation**	0.30 i	1.08 jk	2.41 ij	1.26 kl
13	**Michal angelo**	0.28 i	1.91 fghij	6.41 def	2.87 efghijk
14	**Morus atrailo**	1.17 fg	0.73 k	2.46 ij	1.45 ijkl
15	**Dandily standard**	1.15 fg	2.50 efgh	5.59 fg	3.08 defghij
16	**New Chhanga rose**	0.31 i	2.65 defg	4.33 h	2.43 fghijkl
17	**Wedding bell**	1.19 fg	1.82 ghij	6.82 cde	3.27 cdefgh
18	**Diamond**	1.13 fg	2.13 fghi	6.12 ef	3.13 cdefghi
19	**California dream**	0.48 hi	1.55 hijk	4.51 h	2.18 ghijkl
20	**Kainaat**	0.22 i	1.05 jk	2.69 ij	1.32 jkl
21	**Lahore city**	1.81 de	4.97 b	7.37 bcd	4.72 bcd
22	**Blue for all**	0.39 hi	1.07 jk	2.21 ij	1.23 kl
23	**American hero**	3.85 a	3.23 de	7.50 bc	4.86 abc
	LSD@5%	**0.53**	**1.02**	**0.96**	**1.76**

The result indicated that during the month of February maximum population of rose was observed on genotype American hero i.e. 3.85/flower or bud followed by Hafiz zaman i.e. 2.82/flower or bud. However, minimum thrips population was found on California wonder and Kainat i.e. 0.19 and 0.22/flower or bud respectively. During the month of March maximum population of thrips was recorded on Sundertha i.e. 6.54/flower or bud followed by Hafiz zaman 6.55/flower or bud and Lahore city i.e. 4.97/flower or bud however minimum population of thrips was recorded California wonder i.e. 0.69/flower or bud and Morus atralio i.e. 0.73/flower or bud. During month of April maximum population of thrips was found on genotype Sundertha i.e. 10.78/flower or bud followed by Hox pox i.e. 10.17/flower or bud and Hafiz zaman followed by 8.31/flower or bud. While minimum population of thrips was observed on Blue for all and Morus atrailo blue for all i.e. 2.21 and 2.46/flower or bud respectively.

K. PUBLICATION

I. Research Articles

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III. Radio talk

Identification and management of Locust on 19-05-2020

IV. Significant activity

Monitoring and surveillance for identification of present life cycle of locust during 2019-20 in different Districts of Punjab