

POPULATION DYNAMICS OF CITRUS WHITEFLIES, APHIDS, CITRUS PSYLLA LEAF MINER AND THEIR BIOCONTROL AGENTS IN KHYBER PAKHTUNKHWA

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ABSTRACT

Population densities of different sucking pests of citrus and their biocontrol agents were studied during 2001-2003 at Charbagh (Swabi), Palai (Malakand Agency) and Khanpur (Haripur) areas of Khyber Pukhtun Khawa. Data at all sites were recorded at fifteen days interval. Population density of whiteflies and citrus psyllids were recorded as number of adults per leaf, while the leaf miner infestation was recorded as % infested leaves and the aphid's infestation was recorded as % infested shoots. The type and number of predators were counted per tree at the same time and collected for identification. Parasitoids were collected from infested leaves and shoots. Maximum infestation of whiteflies (2.27 adults per leaf) was recorded from Khanpure in April followed by Palai (1.96 adults per leaf) and Charbagh (0.25 adults per leaf) in August. Leaf miner was active throughout the year especially on fresh growth. The heaviest leaf miner infestation (55%) was recorded at Charbagh and Palai (49%) in October; while at Khanpur highest infestation (29%) was recorded in September. Citrus psylla population was highest (34 adults/leaf) in May at Khanpur followed by Palai (5.5 adults/leaf) in June. Lowest population (0.7 adults/leaf) was recorded in August at Charbagh. Maximum infestation 38.5% of aphids was observed at Khanpur in January followed by Charbagh 35.5% in November and 29% at Palai in March. Eight species of spiders and eight species of coccinellids were recorded at all locations. Green lace wing (*Chrysoperla carnea*) and syrphid fly (*Syrphid sp.*) were recorded only at Charbagh (Swabi). *Binodoxys shillongensis* was found as aphid parasitoid. Leaf miner was found to be parasitized by *Alloceastichus obscurus* and an unidentified chalcidoid wasp was reared from citrus psylla nymphs. No parasitoid was recovered from whitefly nymphs.

Key Words: Citrus psylla, population dynamics, biocontrol agents, citrus pests

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INTRODUCTION

In Pakistan, citrus are grown on an average area of 193.2 thousand hectares with production of 1472.4 thousand tones annually (MINFAL, 2000). Several species of insects pests such as whitefly, *Dialeurodes citri* Ashmead, citrus psylla, *Diaphorina citri* Kuwayama, leaf miner, *Phyllocnistis citrella* Stainton, citrus caterpillar, *Papilio demoleus* Linnaeus, citrus red scale, *Aonidiella aurantii* Maskell and fruit piercing moth, *Ophideres* spp., attack citrus trees. Citrus psylla sucks sap and produce honeydew promoting the growth of sooty mold, leaf may wither and die, and fruits remain small and juiceless (Hashmi, 1994). Citrus leaf miner damage is indirect and cause distortion of mined leaves. In case of heavy attack, the growth can be slowed down in young trees, and yield is reduced in mature trees (Garrido, 1994). Citrus whiteflies is one of the most important pests of *Citrus* spp., to which it may cause serious damage, through the extraction of large quantities of sap and the development of sooty mould on the abundant excreted honeydew. Direct interventions are usually required against *Dialeurodes citri* in newly colonized areas, where natural enemies are scarce, and in citrus groves where pesticide treatments, mostly directed at other pests, have broken the natural balance (CAB International, 2005). Citrus growers in Pakistan rely on chemicals for the control of citrus pests which poses negative effects on the beneficial insects (Giovanni, 1996). Due to WTO constraints, farmers have to rely on non-chemical methods and biological control provides a good alternative to chemical control. In order to promote biocontrol agents instead of chemicals, there is a need to monitor pest population regularly and identify peak time of their emergence and the time when their natural enemies are abundant in the fields. The present studies were conducted to record population dynamics of common citrus pests in Khyber Pukhtun Khawa and their biocontrol agents with time frame.

MATERIALS AND METHODS

Studies on monitoring insect pests of citrus and their biocontrol agents were conducted during January 2002 to December 2002 at three major citrus growing sites, Charbagh (Swabi), Palai (Malakand Agency) and Khanpure (Haripure) areas of Khyber Pukhtun Khawa, Pakistan. The data were recorded at fifteen days interval on five selected plants per site. Populations of whiteflies *Dialeurodes citri*, leaf miner *Phyllocnistis citrella* and citrus psylla *Diaphorina citri* were monitored on five leaves each randomly selected from top, middle and bottom portions of each tree and average number of adults per leaf was calculated. Green citrus aphid *Aulacorthum solani* population was recorded on fifteen shoots per plant. The shoots were selected from top, middle and bottom portions of data trees and percent infested shoots were recorded. Ladybird beetles, spider and green lacewings were monitored from the same data plants. The number of predators per tree was counted from the same data trees at each site and average number of ladybird beetles, spider and green lacewings was calculated. Adults or nymphs were collected and preserved in laboratory for identification. If immature these were collected and reared within the laboratory till they emerged to adult stage for identification. For the emergence of potential parasitoids, nymphs/larvae of whiteflies, life miners, citrus psylla and citrus aphids were counted and kept in a glass jar sealed with fine muslin cloth and kept in laboratory at ambient temperatures (27°C, 60-65% RH). Percent-parasitism was calculated.

The means and standard deviation of the population was calculated in MS. EXCEL and the standard errors of means were calculated by using the statistical formula

$StErr = StDev / \sqrt{n}$. The same model was applied by (Shah et al., 2006) for distribution pattern of the cereal aphids in the wheat growing areas of Khyber Pakhtunkhwa.

RESULTS AND DISCUSSION

Whiteflies *Dialeurodes citri* Ashmead

Table I shows population trend of whiteflies. In Khanpur and Palai attack started from March 15th. Maximum population of whiteflies (2.27 adults per leaf) was recorded in Khapur, followed by Palai (1.96 adults per leaf) in April. In Charbagh whiteflies incident started from June 15th and reached to highest level of (0.25 adults per leaf) on August 1st. Reinfestation was observed from mid June in Khanpur, while in Palai from July 1st. In Charbagh whiteflies population restarted from September 1st and maintained till October 1st. Population at all sites leveled at zero till next March. Two peak population levels were observed for whiteflies in all the three locations. Whiteflies have two to six generations depending upon the environmental condition of the area (CAB International, 2005).

Table I Population trend of citrus whiteflies in Khyber Pukhtunkhwa

	Palai	Charbagh	Khanpur	Data interval effect	Mean \pm SEM
1/1/02	0.00	0.00	0.00		0.00 \pm 0.00
15/1/02	0.00	0.00	0.00		0.00 \pm 0.00
1/2/02	0.00	0.00	0.00		0.00 \pm 0.00
15/2/02	0.00	0.00	0.00		0.00 \pm 0.00
1/3/02	0.00	0.00	0.00		0.00 \pm 0.00
15/3/02	1.03	0.00	0.73		0.59 \pm 0.31
1/4/02	1.96	0.00	2.27		1.41 \pm 0.71
15/4/02	0.00	0.00	0.00		0.00 \pm 0.00
1/5/02	0.00	0.00	0.00		0.00 \pm 0.0
15/5/02	0.00	0.00	0.00		0.00 \pm 0.00
1/6/02	0.00	0.00	0.00		0.00 \pm 0.00
15/6/02	0.00	0.20	1.00		0.07 \pm 0.07
1/7/02	0.09	0.21	0.98		0.43 \pm 0.29
15/7/02	0.25	0.24	0.75		0.49 \pm 0.25
1/8/02	0.09	0.25	0.27		0.36 \pm 0.20
15/8/02	0.71	0.00	0.31		0.33 \pm 0.21
1/9/02	0.09	0.11	0.00		0.17 \pm 0.07
15/9/02	0.08	0.05	0.00		0.04 \pm 0.02
1/10/02	0.02	0.17	0.00		0.09 \pm 0.05
15/10/02	0.00	0.00	0.00		0.00 \pm 0.00
1/11/02	0.00	0.00	0.00		0.00 \pm 0.00
15/11/02	0.00	0.00	0.00		0.00 \pm 0.00
1/12/02	0.00	0.00	0.00		0.00 \pm 0.00
15/12/02	0.00	0.00	0.00		0.00 \pm 0.00

Location effect

Mean \pm SEM 1.18 0.05 0.54
 \pm 0.09 \pm 0.01 \pm 0.11

SEM Standard error of means

Citrus Psylla

Table II indicates that citrus psylla population at three sites started from January 1st and onward built up when there was enough fresh flush on trees. In palai citrus psylla were present till October 15th and maximum (5.5 adults per leaf) was recorded on June 1st and then its population leveled at zero till end of December. In Charbagh citrus psylla became zero on February 15th again noticed on March 1st but was zero in mid March. From April 1st new attack was started and prevailed till August 1st and dropped down to zero in mid August. Citrus psylla was again active during first half of September, the highest population (1 adult per leaf) was observed on January 1st in Charbagh. In Khanpur citrus psylla population fluctuated five times, i.e January 1st to mid February, March 1st to April 1st, May 1st to July 1st, August 1st to mid September and last time from mid October to mid November and then totally eliminated during December. Maximum number of (12.90 adults per leaf) was recorded on June 1st. Citrus psyllids are present more or less throughout the year, it is also common in all three locations that number of adults per leaf decreased during January and June and was totally absent in December. Here our findings are in close conformity with Divender *et al.* (2000) and Arora *et al.* (1997) who reported that citrus psyllids were active throughout the year except December. Divender *et al.* (2000) also reported that psyllids remained active more or less throughout the year only a few adults were present during January and June.

Table II Population trend of citrus psylla in Khyber Pukhtunkhwa

	Palai	Charbagh	Khanpur	Data interval effect Mean \pm SEM
1/1/02	0.80	1.00	1.80	1.20 \pm 0.31
15/1/02	0.40	0.40	1.70	0.80 \pm 0.43
1/2/02	0.10	0.50	0.00	0.20 \pm 0.15
15/2/02	0.10	0.00	0.00	0.03 \pm 0.03
1/3/02	0.10	0.60	0.70	0.47 \pm 0.91
15/3/02	0.60	0.00	1.30	0.63 \pm 0.38
1/4/02	2.10	0.20	5.50	2.60 \pm 1.55
15/4/02	3.90	0.20	0.00	1.37 \pm 1.27
1/5/02	4.80	0.60	33.90	13.10 \pm 10.47
15/5/02	3.80	0.40	20.10	8.10 \pm 6.08
1/6/02	5.50	0.50	12.90	6.30 \pm 3.60
15/6/02	1.70	0.20	3.50	1.80 \pm 0.95
1/7/02	1.30	0.30	6.00	2.53 \pm 1.76
15/7/02	0.90	0.60	0.00	0.50 \pm 0.26
1/8/02	0.60	0.70	6.00	2.43 \pm 1.78
15/8/02	0.30	0.00	0.00	0.10 \pm 0.10
1/9/02	0.30	0.10	6.90	2.43 \pm 2.23
15/9/02	0.00	0.20	6.30	2.17 \pm 2.07
1/10/02	0.20	0.00	0.00	0.07 \pm 0.07
15/10/02	0.30	0.00	2.80	1.03 \pm 0.89
1/11/02	0.00	0.00	2.30	0.77 \pm 0.77
15/11/02	0.00	0.00	2.80	0.93 \pm 0.93
1/12/02	0.00	0.00	0.00	0.00 \pm 0.00
15/12/02	0.00	0.00	0.00	0.00 \pm 0.00

Location effect

Mean \pm SEM	1.16	0.30	4.77
	\pm 0.34	\pm 0.05	\pm 1.60

SEM Standard error of means

Citrus Aphids

Table III shows population of citrus aphids started from January, but reached to its highest peak in different times. In Palai (29% shoots infestation) was recorded on mid March, in Charbagh (35.5% shoots infestation) was noted on November 1st while in Khanpur (38.5% shoots infestation) was observed in mid January. Population of citrus aphids fluctuated twice while in Palai and Charbagh fluctuated four times. (Sonya, 2007) reported peak activity time from February to March and then from September to December and also observed 25% or more leaf flush infestation in citrus with aphids.

Leaf Miner

Table IV shows that leaf miner attack started from mid January in Palai and Charbagh while in Khanpur its attack started from February 1st. The highest number (49%) was found on fresh leaves infested in Palai on October 1st. In Charbagh it was on (55%) fresh shoots in mid September. Zero fresh attack of leaf miner was recorded at all three sites from mid December till first half of January also during first half of March. Zero infestation was recorded in Charbagh and Khanpur from July 1st till mid August. In Palai fresh attack of leaf miner was found through out the year except mid March to first half of April.

Table III Population trend of citrus aphids in Khyber Pukhtunkhwa

	Palai	Charbagh	Khanpur	Data interval effect Mean \pm SEM
1/1/02	2.90	20.00	12.00	11.63 \pm 4.94
15/1/02	0.00	22.00	38.50	20.17 \pm 11.15
1/2/02	0.00	25.30	25.30	16.87 \pm 8.43
15/2/02	0.00	0.00	0.00	0.00 \pm 0.00
1/3/02	0.00	0.00	0.00	0.00 \pm 0.00
15/3/02	29.00	20.00	4.40	17.80 \pm 7.19
1/4/02	3.9	0.00	1.90	1.93 \pm 1.13
15/4/02	0.00	0.00	0.00	0.00 \pm 0.00
1/5/02	0.00	0.00	0.00	0.00 \pm 0.00
15/5/02	0.00	0.70	0.00	0.00 \pm 0.23
1/6/02	0.00	2.70	0.00	0.00 \pm 0.90
15/6/02	0.00	0.00	0.00	0.00 \pm 0.00
1/7/02	0.00	0.00	0.00	0.00 \pm 0.00
15/7/02	0.00	0.00	0.00	0.00 \pm 0.00
1/8/02	0.00	0.00	0.00	0.00 \pm 0.00
15/8/02	0.00	0.00	0.00	0.00 \pm 0.00
1/9/02	2.00	2.00	0.00	1.13 \pm 0.67
15/9/02	0.00	7.70	0.00	2.57 \pm 2.57
1/10/02	7.70	16.00	0.00	7.90 \pm 4.62
15/10/02	5.00	4.70	0.00	3.23 \pm 1.62
1/11/02	9.70	35.5	0.00	15.00 \pm 10.53
15/11/02	17.00	26.70	0.00	14.57 \pm 7.80
1/12/02	2.00	9.00	0.00	3.67 \pm 2.73
15/12/02	8.7	8.00	0.00	5.57 \pm 2.79
Location effect				
Mean \pm SEM	3.66	8.34	3.42	
	\pm 1.41	\pm 2.22	\pm 1.91	
SEM Standard error of means				

Table IV Population trend of citrus leaf miner in Khyber Pukhtun Khawa

	Palai	Charbagh	Khanpur	Data interval effect Mean \pm SEM
1/1/02	0.00	0.00	0.00	0.00 \pm 0.00
15/1/02	13.00	11.00	0.00	8.00 \pm 4.04
1/2/02	16.00	23.00	5.00	14.67 \pm 5.24
15/2/02	15.00	15.00	3.00	11.00 \pm 4.00
1/3/02	0.00	1.00	2.00	1.00 \pm 0.58
15/3/02	0.00	0.00	0.00	0.00 \pm 0.00
1/4/02	0.00	0.60	0.00	0.20 \pm 0.20
15/4/02	7.00	33.00	0.00	13.33 \pm 10.04
1/5/02	10.00	27.00	27.00	21.20 \pm 5.60
15/5/02	3.00	15.00	0.00	6.00 \pm 4.58
1/6/02	5.00	12.00	0.00	5.67 \pm 3.48
15/6/02	2.00	17.00	0.00	6.33 \pm 5.36
1/7/02	9.00	0.00	0.00	3.00 \pm 3.00
15/7/02	9.00	0.00	0.00	3.11 \pm 3.11
1/8/02	10.00	0.00	0.00	3.33 \pm 3.33
15/8/02	15.00	0.00	0.00	5.00 \pm 5.00
1/9/02	33.00	18.00	12.00	21.00 \pm 6.25
15/9/02	35.00	16.00	29.00	26.67 \pm 5.61
1/10/02	49.00	42.00	25.00	38.67 \pm 7.13
15/10/02	27.00	55.00	23.00	35.00 \pm 10.07
1/11/02	10.00	22.00	18.00	16.67 \pm 3.53
15/11/02	6.00	32.00	6.00	14.67 \pm 8.67
1/12/02	2.00	22.00	0.00	8.00 \pm 7.02
15/12/02	0.00	0.00	0.00	0.00 \pm 0.00
Location effect				
Mean \pm SEM	11.51	15.07	6.23	
	\pm 2.60	\pm 3.09	\pm 2.05	
SEM Standard error of means				

Bhumannar and Singh (1983) noted leaf miner attack through out the year especially on fresh growth and Singh and Azam (1986) also reported that leaf miner remained active throughout the year. We found that total leaf damage ranged from 2% to 55% but (Lara et al., 1998) reported leaves damage as 12~85%.

Population Dynamics of Natural Enemies

Tables V and VI show different species of spider and ladybird beetles recorded in our target sites. Our study showed that eight different species of spiders occur on citrus throughout the year. At the same time eight predatory

ladybird beetles were also found on citrus plantation in these areas. The ladybird beetles species included *Menochilus sexmaculata*, *Micraspis* sp, *Illeis confusa*, *Oenopia sauzeti*, and *Coccinella septempunctata*. Four other ladybird beetles were not identified. (Divender *et al.*, 2000) reported four species of ladybird beetles in citrus including *Leis dimidiata*, *Menochilus sexmaculatus*, *Micraspis cardoni* and *Coccinella septempunctata*. They observed the ladybird beetles feeding on nymphs during the spring season. The occurrence of ladybird beetles on citrus plants at the studied locations is a good sign because these beetles play important role in the natural control of citrus pests as stated by Divender *et al.* (2000). Additionally, the presence of these beetles show that the citrus environment is suitable for these natural enemies, therefore they can be reared and released for the biological control of citrus pests. Green lace wings and syrphid flies were present only at Charbagh.

Table VI Population trend of Spiders in Khyber Pukhtunkhwa

	Palai	Charbagh	Khanpur	Data interval effect Mean \pm SEM
1/1/02	0.00	0.00	0.00	0.00 \pm 0.00
15/1/02	0.10	0.25	0.20	0.18 \pm 0.04
1/2/02	0.20	0.17	0.00	0.12 \pm 0.06
15/2/02	0.10	0.00	0.00	0.03 \pm 0.03
1/3/02	0.00	0.25	1.30	0.52 \pm 0.40
15/3/02	0.30	0.00	1.00	0.43 \pm 0.30
1/4/02	0.10	0.00	0.30	0.13 \pm 0.09
15/4/02	0.20	0.40	0.00	0.20 \pm 0.12
1/5/02	0.20	0.20	0.00	0.13 \pm 0.07
15/5/02	0.40	0.80	0.00	0.40 \pm 0.23
1/6/02	0.80	0.80	0.00	0.53 \pm 0.27
15/6/02	0.60	0.70	0.00	0.43 \pm 0.22
1/7/02	0.40	0.60	0.00	0.33 \pm 0.18
15/7/02	0.80	0.60	0.40	0.40 \pm 0.12
1/8/02	0.60	0.50	0.40	0.33 \pm 0.12
15/8/02	0.40	1.10	0.50	0.40 \pm 0.26
1/9/02	0.20	1.70	0.60	0.33 \pm 0.85
15/9/02	0.10	2.30	0.30	0.60 \pm 0.58
1/10/02	0.20	2.30	0.40	1.93 \pm 0.56
15/10/02	3.50	0.00	0.50	1.27 \pm 0.17
1/11/02	1.20	0.00	0.20	1.23 \pm 0.09
15/11/02	1.00	0.00	0.00	0.33 \pm 0.00
1/12/02	0.50	0.00	0.00	0.00 \pm 0.00
15/12/02	0.30	0.00	0.00	0.00 \pm 0.00

Location effect

Mean \pm SEM 0.43 0.53 0.25
 \pm 0.15 \pm 0.14 \pm 0.07

SEM Standard error of means

Table V Population trend of Lady bird beetles in Khyber Pukhtun Khawa

	Palai	Charbagh	Khanpur	Data interval effect Mean \pm SEM
1/1/02	0.00	0.50	0.30	0.27 \pm 0.15
15/1/02	0.00	0.25	0.30	0.18 \pm 0.09
1/2/02	0.00	0.00	0.00	0.00 \pm 0.00
15/2/02	0.00	0.00	0.00	0.00 \pm 0.00
1/3/02	0.00	0.25	0.50	0.25 \pm 0.14
15/3/02	1.30	0.80	2.70	1.60 \pm 0.57
1/4/02	1.20	0.20	8.30	3.23 \pm 2.55
15/4/02	0.00	0.00	0.00	0.00 \pm 0.00
1/5/02	0.00	0.00	0.00	0.00 \pm 0.00
15/5/02	0.00	0.00	0.00	0.00 \pm 0.00
1/6/02	0.00	0.00	0.00	0.00 \pm 0.00
15/6/02	0.00	0.00	0.00	0.00 \pm 0.00
1/7/02	0.00	0.00	0.90	0.30 \pm 0.30
15/7/02	0.20	0.00	0.20	0.13 \pm 0.07
1/8/02	0.40	0.00	0.00	1.13 \pm 0.13
15/8/02	4.12	0.20	0.50	1.61 \pm 1.26
1/9/02	2.00	0.30	0.30	1.10 \pm 0.49
15/9/02	1.10	0.20	0.50	0.53 \pm 0.28
1/10/02	1.30	1.5	0.70	1.10 \pm 0.31
15/10/02	2.30	0.2	0.30	1.07 \pm 0.63
1/11/02	0.00	0.3	0.30	0.20 \pm 0.10
15/11/02	0.00	0.2	0.00	0.17 \pm 0.09
1/12/02	0.00	0.00	0.00	0.00 \pm 0.00
15/12/02	0.00	0.00	0.00	0.00 \pm 0.00

Location effect

Mean \pm SEM 0.58 0.20 0.70
 \pm 0.21 \pm 0.07 \pm 0.35; SEM Standard error of means

At Palai and Charbagh 14.7% and 13.1% parasitism was recorded from leaf miner and citrus psylla respectively. At Khanpur, leaf miner parasitism was only 1.1%. From citrus psylla nymphs more than 31% parasitism was recorded both at Khanpur and Palai, which was only 17% at Charbagh. At Khanpur 31% parasitism was recorded in aphids, which was only 2% at Palai while at Charbagh no parasitoid emerged from aphids. Aphid's parasitoid identified as *Binodoxys shillongensis* has also been recorded by Ahmad and Inayatullah (2006) who stated that if encouraged, this species could be a useful parasitoid against citrus aphids. Citrus psylla parasitoid was identified as *Allocaerastichus obscurus*. Though this parasitoid is not so efficient under natural conditions, however by proper protection and rearing, the efficiency can be increased. No parasitoid was recorded from whiteflies in the present studies.

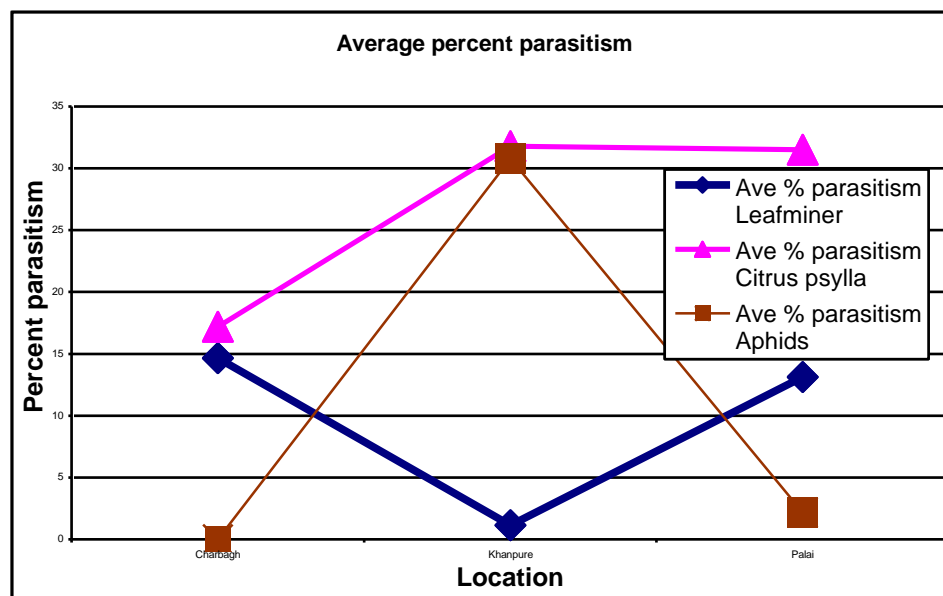


Fig. 1. Percent Parasitism of different parasitoids at Palai, Charbagh and Khanpur areas of Khyber Pakhtunkhwa

CONCLUSION AND RECOMMENDATION

Farmers mostly rely on pesticides to control citrus pests with out knowing the ill effect of these chemicals. Therefore these pests should be regularly monitored to know their abundance and peak time of activity. It will help in reducing spray application and in decision making for the management of these pests. The occurrence of biocontrol agents in citrus is good sign because they play important role in natural control of citrus pests. Further work is needed to study the effect of environmental factors on these pests and rearing and release of efficient biocontrol agents for these pests.

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