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Toxicity of Biosal (Phytopesticide) and Permethrin (Pyrethroid) Against Common Carp, *Cyprinus carpio*

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Abstract.- The objective of this study was to compare the toxicity of locally produced phytopesticide (Biosal) and synthetic pyrethroid (permethrin) against the fresh water fish *Cyprinus carpio*. Fry of *Cyprinus carpio* was treated with five different concentrations of Biosal and permethrin, separately for 24 hours. Experiment was repeated 10 times with each concentration, and mortality count was made. Mortality curve was drawn using regression line equation (y=a+bx) from the statistically computed results. It was found that LC_{50} of Biosal is 42133ppm (4.21 mg/L aquarium water) and LC_{50} of permethrin is 35.37ppm (35 µg/L aquarium water), indicating that permethrin was found nearly 1000 times more toxic than Biosal against fish fry as a non-target species.

Key words: Biosal, *Cyprinus carpio*, LC_{50}, Permethrin, phytopesticide.

Although the toxic pesticides are designed to kill the unwanted organisms but a huge bulk of these pesticides is creating tremendous negative impact on the non-target species of the ecosystem. The pollution of water bodies with chemicals of anthropogenic origin may have adverse impacts on fish and other animal communities living in them (Glickman and Lech, 1982). Besides synthetic pesticides, IGRs (insect growth regulators) have been found toxic to fish (Kazmi *et al.,* 1985), although their toxicity is less than synthetic pesticides against fish fry (Kazmi *et al.,* 1991). Among the scores of pesticides, pyrethroids are widely used for their rapid, paralytic knockdown effect and very low mammalian toxicity (Naqvi *et al.,* 2007). Synthetic pyrethroids have been generally found to be highly toxic to fish (Balint *et al.,* 1995; Delistraty, 2000; Datta and Kaviraj, 2003). Pyrethroids have been shown to be neurotoxic and lethal to fish at concentrations 10-1000 times lower than the corresponding values for other animals and birds (Bradbury and Coats, 1989; Eells *et al*., 1993).

In the search for safer pesticides neem stands at the top, among pesticidal properties bearing plants, (Khan and Ahmed, 2000; Siddiqui *et al*., 2003). The most important property is that they pollute the atmosphere to a minimum level (Tabassum, 1995; Tabassum and Naqvi, 2001). Toxicity of synthetic pesticides and neem products has been determined and compared in many species (Naqvi *et al*., 1995, 2007). The objective of this study was to determine and compare the toxicity of neem based phytopesticide (Biosal) and pyrethroid (permethrin) against fry of common carp, *Cyprinus carpio*.

Materials and methods

Cyprinus carpio fry was collected from Fish Hatchery at Chillia District Thatta, Sindh. Fish fry having length including fins (4±0.3 cm) and weight (2±0.2 g) were selected for toxicity experiments.

Two insecticides, Biosal, a phytopesticide, and permethrin, a synthetic pesticide were used in this study. Biosal is an alcoholic extract of dried neem whole fruit. Biosal contains 0.32% azadirachtin as active ingredient. It was obtained from Dr. Beena S. Siddiqui, HEJ Research Institute of Chemistry, University of Karachi. Five different concentrations were prepared from 100% Biosal using 20% methanol as emulsifier, *i.e*., 30000ppm (3%), 35000ppm (3.5%), 40000ppm (4%), 45000ppm (4.5%) and 50000ppm (5%).

Stock solution of permethrin 0.05% (500ppm) was prepared by dissolving 0.2ml of 25EC (25*g a.i/l*) permethrin in 100ml of water. From this stock solution serial dilutions of permethrin 0.0025% (25ppm), 0.003% (30ppm), 0.0035% (35ppm), 0.004% (40ppm) and 0.0045% (45ppm) were prepared with double distilled water.

* This paper is based on the work of first author's PhD dissertation.

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After preliminary experiments fry of *Cyprinus carpio* was treated with the above mentioned concentrations for determination of toxicity of permethrin and Biosal. For each concentration 10 fish were taken and mortality was noted after 24 hours.

For the treatment of toxic compound, fish were kept in glass aquaria (30″x 22″x 23″) containing 4 litre of water. A constant volume of 4ml of permethrin and Biosal solution (1ml per litre of water) was added to each aquarium and was thoroughly mixed.

In case of permethrin 10 fish fry was taken for each concentration and was placed in separate aquaria, marked for each concentration. A group of 10 fish was kept in untreated aquarium as a control for the determination of environmental effects. Mortality counts were made after 24 hours. Each experiment was repeated 10 times. For the treatment of Biosal, same procedure was adopted. A batch of 10 fish fry was treated with methanol as check. Same number of fish fry was placed in separate aquaria marked for each concentration in addition to control group.

Corrected mortality was calculated employing Abbott's formula (Abbott, 1925) and mortality curve was drawn using regression line equation (y=a+bx) to find out LC_{50} for both compounds. Statistical analysis was also done.

Results

Figure 1 shows regression curves showing LC_{50}s of Biosal and Permethrin against *Cyprinus carpio.* LC_{50} was found to be 42133ppm (final concentration in aquarium 42.13 ppm or 4.21 mg/L) for Biosal with the regression equation y = -76.4+0.003 x and 35.37ppm for permethrin with the regression equation (final concentration in aquarium 0.035 ppm or 35 µg/L) y = 11.8+1.08 x.

Discussion

The present study shows that permethrin (pyrethroid) is nearly 1000 times more toxic than Biosal (neem based phytopesticide) against fry of common carp (*Cyprinus carpio).* Azmi *et al. (*1997) reported that deltamethrin (pyrethroid) is more toxic than neem product "shade dried seed-extract" (SDS) against the fish fry of *Cyprinus carpio*. LC_{50} of "SDS" against fish fry reported by Azmi *et al. (*1997) is 250ppm which is very low in comparison to the present report *i.e.*, LC_{50} of Biosal is 42133 ppm which may have been due to the different

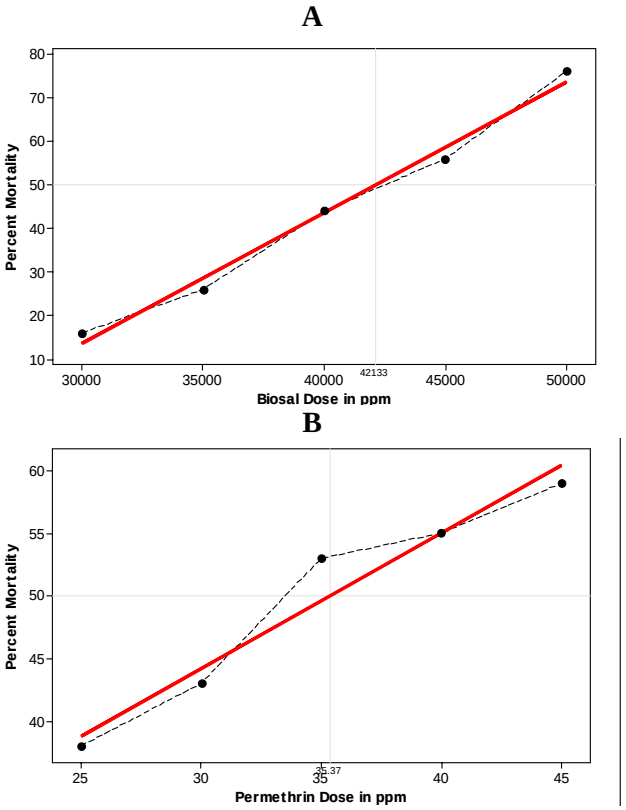

Fig. 1. Regression curves showing LC_{50} of Biosal (A) and Permethrin (B) against common carp, *Cyprinus carpio*.

formulations of SDS and Biosal. Azmi *et al.* (1997) also reported that LC_{50} of deltamethrin (pyrethroid) against fish fry was 21ppm while present study shows that LC_{50} of permethrin against fish fry was 35.37ppm. It depicts that permethrin is less toxic against *Cyprinus carpio* fry as compared to deltamethrin. Fernandez *et al.* (1992) tested the toxicity of various neem products such as aqueous neem seed kernel extract (NSKE) and neem oil against fingerlings of *Oreochromis niloticus* and *Cyprinus carpio*. Fernandez (1992) reported low LC_{50} value of neem extract against *Cyprinus carpio* as compared to the present result, which may be due to different formulations and variations in the content of active ingredients of plants of different ecotypes. During the present findings permethrin

(pyrethroid) is found much more toxic than Biosal against fish fry. It could be suggested here that Biosal as a pesticide is less hazardous to fish as a non-target species.

According to Zitko *et al. (*1977) the lethal threshold of permethrin for juvenile atlantic salmon is 9µg/L, while 24 hours LC_{50} of permethrin determined for *Cyprinus carpio* fry is 35µg/L (final concentration of aquarium water prepared by dissolving 1ml of 35ppm solution per litre of water) in the present experiment. It shows that *Cyprinus carpio* may be more resistant to permethrin as compared to the atlantic salmon that is nearly four times more sensitive to permethrin. Zitko *et al.* (1979) reported that synthetic pyrethroids have high toxicity to fishes during aqueous exposure. LC_{50} of permethrin after 72 hours has been reported as 54µg/L against *Oreochromis niloticus* by Al-Akel *et al.* (1995). Thus LC_{50} of permethrin against *Oreochromis niloticus* is far greater than that against *Cyprinus carpio*, which may be due to different levels of tolerance among different species. Sopinska *et al.* (1995) found that after 14 days LC_{50} of permethrin against carps K1 is 11µg/L. This lower concentration of permethrin as LC_{50} may be due to the longer period of exposure. David *et al.* (2003) observed that 96 hours LC_{50} of cypermethrin (pyrethroid) against another freshwater fish *Tilapia mossambica* is 4.79µg/L. According to estimation of Aydin *et al.* (2005), the 96 hours LC_{50} of cypermethrin for common carp larvae was 0.809µg/L. The lower concentration value of cypermethrin as LC_{50} than that in the present experiment may be either due to greater toxicity of cypermethrin to fish as compared to permethrin and/or due to longer exposure period. Investigations of Ural and Sağlam (2005) revealed that 24 hours LC_{50} of a synthetic pyrethroid, deltamethrin for fry of rainbow trout (*Oncorhynchus mykiss*) was 3.18µg/L, which is a smaller value than that in the current experiment and it may be due to higher toxicity of deltamethrin to fish.

Sultana *et al.* (1996) reported that toxicity of neem products is many times lower than that of organophosphate against *Cyprinus carpio* fry. Jahan *et al.* (1994) compared the toxicity of deltamethrin and neem extract "SDS" against *Barbus ticto* and reported that deltamethrin was 30 times more toxic than "SDS". These results are also in line with the present findings.

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New Records of *Eristalinus* (Syrphidae: Diptera) from Multan, Pakistan

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Abstract.- The genus *Eristalinus* is very important group of flies from view point of crop pollination. Four species were collected and identified from Multan region of which two species were recorded for the first time from Pakistan.

Key words: Syrphidae, Eristalinus, Pakistan.

The genus *Eristalinus* is cosmopolitan. It has "rat-tailed" maggots, which are aquatic, particularly in water bodies loaded with decaying vegetation, such as rot holes and ditches or drains. The adults are floral visitors of hundreds of flowering plant species (Tooker *et al.,* 2006), and many *Eristalinus* species have also been reported as efficient crop pollinators (Saeed *et al.,* 2008). The species are generally medium, and occasionally large, in size, *i.e.* 7-17 mm in length. The genus *Eristalinus* has already been recorded by previous workers in Pakistan. Saleem *et al.* (2001) identified two species *i.e. E. aeneus* Scopoli and *E. sepulchralis* Linnaeus from Peshawer division. In contrast, Brunetti (1923) described 29 species of genus *Eristalis* from India (which included present day Pakistan) and Barma from which *Eristalinus* was later separated. Only one (*E. taeniops*) of the 29 species he included was recorded from Pakistan.

Materials and methods

Adult *Eristalinus* specimens were collected from the Bahauddin Zakariya University (BZU) Multan Botanical Garden and the Cotton Research Station (CRS) Multan during March, 2008. We collected flies from the annual ornamental flowering plants in Botanical Garden at BZU, whereas at CRS, specimens were mostly from flowering carrot and onion. Flies were caught with an insect net and killed using Ethyl acetate vapour. They were then pinned and identified to species level. The specimens were deposited to the insect repository of Pakistan Museum of Natural History, Islamabad.

Results

Genus ERISTALINUS Rondani 1845

Head posteriorly less strongly concave so that pronotum is largely exposed; eyes punctate (with spots) or fasciate and punctate (with spots and bands) usually densely pilosed, holoptic to widely dichoptic in males; postpronotum pilose; anterior anepisternum bare; scutellum without marginal sulcus; metafemur at most very slightly thickened, not accurate; metatibia not carinate nor compressed ventrally; wings bare or sparsely microtrichose, cell r_{2+3} closed; vein R_{4+5} moderately to strongly sinuate; male abdomen with tergum 5 not visible dorsally.

1. *Eristalinus laetus* (Wiedemann, 1830)

Material examined

BZU, Multan, 3 males, 2 females, 20.iii.2008. New record for Pakistan.

2. *Eristalinus arvorum* (Fabricius, 1787)

Material examined

CRS, Multan, 1 male, 2 females, and 12.iii.2008. New record for Pakistan.

3. *Eristalinus taeniops* (Wiedemann, 1818)

Material examined

CRS, Multan, 2 males, 2 females, 20.iii.2008.

4. *Eristalinus aeneus* (Scopoli, 1763)

Material examined

BZU, Multan, 2 males, 2 females, 12.iii.2008.

The synonymy and description of important taxonomic characters is given by Brunetti (1923) and Knutson *et al*. (1975).

KEY TO THE SPECIES

1. Eyes with five longitudinal dark bands .....*taeniops*
- Eyes with dark spots 2
2. Abdomen entirely dark with a dull metallic green luster ..... *aeneus*
- Abdomen lacking metallic luster..... 3
3. Mesonotum with four dull metallic-green longitudinal stripes.....*laetus*
- Mesonotum with four shining black longitudinal stripes .....*arvorum*

Discussion

All four species were previously known from the different cities of neighboring India, but for Pakistan, *E. laetus* and *E. arvorum* are newly recorded. Out of the 29 *Eristalis* species described by Brunetti (1923), only 3 (*E. taphicus* Wied., *E. tabanoides* Jaenn. and *E. taeniops* Wied.) were recorded from different cities of Pakistan. Of these three previously known *Eristalis* species, only *E. taeniops* is currently placed in *Eristalinus*.

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New Record of Free Swimming Copepod Zooplankton *Tropocyclops prasinus* (Fischer, 1860) from Water Discharging Jamshoro Thermal Power Plant, Sindh, Pakistan

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Abstract.- The free swimming copepod zooplankton *Tropocyclops prasinus* (Fischer, 1860) is recorded for the fist time from Pakistan. The population was abundant among other zooplankton groups during November. Total of 34 specimen of male and females were found in the sample of zooplankton community.

Key words: Zooplankton, *Tropocyclops,* Jamshoro thermal power.

Jamshoro thermal station is located at the main Indus highway approximately 5 km north of

Jamshoro Deh Mohra Jabal Taluka Kotri District Jamshoro. (Latitude 25°.9" N. Longitude 68°.6" E). The distance between Jamshoro power plant and city of Hyderabad is approximately 18 km. It is one of the main power-generating units of Pakistan having the generating capacity of 880 MW and it consists of 4 units. The River Indus provides water to the power generating units as well as cooling power plant. Almost all industries, which use water for cooling purpose, contribute to the thermal pollution problem. Steam electric station (SES) requires huge amount of water to turn and cool the turbine used to generate electricity.

In the aquatic food chains, zooplankton serves as the connecting link between primary producers and secondary consumers. Studies on the long-term fluctuations in the abundance of plankton are therefore important in relation to the conservation of aquatic resources. The availability of zooplankton as food for larval fish is thought to be one of the key factors that determine year class strength of commercial fish (Kane, 1993).

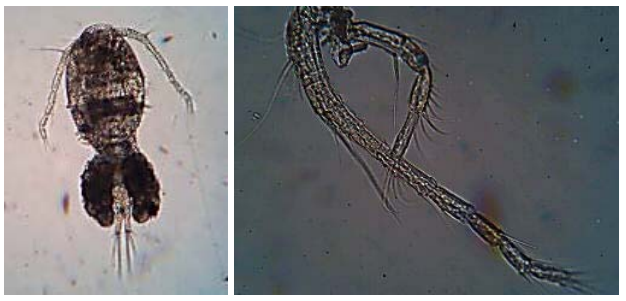
Very few studies have been carried out on freshwater copepod zooplankton in Pakistan. However, Baqai and Rehana (1973) published data on the seasonal fluctuation of freshwater copepods of Keenjhar Lake, Sindh and described a new species of calanoid copepod *Neodiaptomus keenjherensis*. Baqai *et al.* (1974a,b) reported limnological studies of Kalri and Haleji lakes. Mahoon and Zia (1985) carried out taxonomic studies of copepoda (Calanoida and Cyclopoida) from Lahore, Punjab. Chaudhari *et al*. (1986) recorded aquatic flora and fauna from Nullah Deg with new records of *Daphnia rosea*, *Macrocyclops albidus*, *Macrocyclops ater*, *Eucyclops macrurus* and *Paracyclops affinis*. *Tropocyclops prasinus* has not been previously reported from Pakistan. However, this species has been recorded from Japan (Mizuno and Takahashi, 1991), India (Battish, 1992) and China (Yunfang, 1995). This report shows the range of distribution of this species in water bodies of Pakistan.

Materials and methods

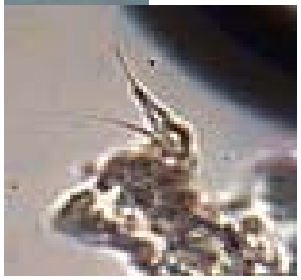
Zooplankton samples were collected with the help of plankton net No.25 (mesh size 55µ) during May-December 2006 at monthly intervals from Jamshoro thermal power plant. Specimen were preserved in 5% formalin solution and brought to the laboratory. Identification was done by taxonomic keys. Photographs of the specimens were made by a digital camera DCM35 (350 pixels, USB 1.0) with magnification of ×100 and ×400 under the Trinocular microscopes (Nikon Eclipse E-200 and Swift model 300-D).

Results and discussion

The colour of species is brownish. The body is short and ovoid in shape, total length of female specimen 0.56-0.62 mm and males about 0.55-0.59 mm (Fig.1A). Antennule of female was 12-segmented long reaching end of the metasoma; second antenna consisted of 4 segments (Fig.1A,B). The caudal rami short, about 3 times longer than wide and without bristles on the inner or outer margins (Fig. 1C). The 4th leg is longer and consists of 3 segments (Fig.1D). Leg 5th has 1 spine and 2 setae and small bristles near the base.



A **B**



C D E

Fig. 1. *Tropocyclops prasinus.* A, ventral view of female; B, antennule and 2nd antenna; C, caudal rami; D, leg 4th exopod and endopod; E, leg 5th .

Kazmi (2002) gave the status and the history of invertebrates found in Pakistan in which 19 species of free swimming cyclopoid copepod zooplankton were reported. This report provides the range of distribution of *Tropocyclops prasinus* from water bodies of Pakistan and record of this species from open channel of thermal power plant. This is also an addition to the already available information on freshwater free swimming copepod zooplankton species of Pakistan.

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Morphological Characters of Different Cotton Cultivars in Relation to Resistance against Tetranychid Mites

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Abstract.- The aim of present study was to evaluate resistance of five elite cotton cultivars *viz*., CIM-506, VH-145, NAIB-999, NIAB-111 and FH-900 against Tetranychidae mites infestation in relation to plant morphological characters in the farmer field trial at Multan. NIAB-999 was found to be the most resistant variety whereas, FH-900 was least resistant having over all mean populations of mites, 0.22 and 1.54 per leaf respectively. Regarding morphological characters of leaf, variety NIAB-999 showed the maximum hair density (504 cm^2) on leaf lamina, FH-900 possessed lowest number of gossypol glands (28 cm^2) on leaf lamina and minimum thickness of leaf lamina (0.023 mm) on top portion. It was concluded that cotton genotype NIAB-999 showed maximum resistance against mite population due to maximum hair density, medium gossypol glands and minimum hair length on leaf among the other tested genotypes.

Key words: Cotton cultivars, mites, plant morphological characters, resistance.

Cotton, *Gossypium hirsutum* L., the most important cash crop of Pakistan is planted over an area of 3.07 million hectares which produces over 12.8 million bales (Anonymous, 2007). The yield of seed cotton is low in Pakistan as compared to developed cotton growing countries of the world (Anonymous, 2004). This low yield in Pakistan is attributed to many factors, the important being the attack of insect pests. Cotton crop is attacked by 96 insect and four mite pests (Younas *et al*., 1980). The major cotton pests among the sucking group are jassid, *Amrasca biguttulla biguttulla* Ishida; whitefly, *Bemisia tabaci* (Gennadius.); spider mites *Tetranychus urticae* Koch and *T. telarius* L. As far the cotton mites are concerned, they are minute and microscopic creatures belonging to the order Acarina of sub class Acari. The families Tetranychidae, Tarsonomidae and Eriophidae are

phytophagous mites. At least 33 species of mites belonging to family Tetranychidae have been reported to be the pests of cotton and several of them are cosmopolitan such as *Tetranychus urticae* Koch and *T. telarius* L. (Leigh, 1985). Mites suck the cell sap of the plants, thus affecting the plant vigor which leads to reduced yield and inferior fibre and seed quality.

Insecticide/acaricides are used to control insect and mite pests. Since indiscriminate use of pesticides cause environmental contamination, besides development of resistance in the target insect (Georghiou and Langunes, 1991), resistant cotton cultivars are the most reliable method of pest control. In cotton the most important traits contributing resistance are hair density, gossypol glands, leaf area and smooth leaves etc. (Ali *et al*., 1995). Dariev *et al.* (1979) have reported that the leaves least attacked by the pest were those having large number of glands and hairs, and the types least attacked were with few hair and less number of glands. Cotton leaves were least infested by pests having thick hair covering after the study of 14 cotton varieties of 5 maturity groups (Pavlova and Egamberdiev, 1990). The main purpose of the present study was to investigate the role of morphological characters in the indigenous cotton cultivars that may impart comparative resistance against mite pests.

Materials and methods

Five cotton cultivars CIM-506, VH-145, NAIB-999, NIAB-111 and FH-900 from different research institutes were evaluated for their resistance to mite pest on the basis of morphological characters of plants. Experiment was conducted in the farmer's field at Kot Rabnawaz, Tehsil and District, Multan. Cotton varieties were sown in Randomized Complete Block Design, with three replications and plot size of 5 × 3m. Row to row and plant to plant distance was maintained as 30 and 12cm, respectively. No plant protection measures were applied throughout the season.

The morphological characteristics of the plant leaves were studied which included hair density on leaf lamina (per cm^2) on veins and midrib (per cm), number of gossypol glands on leaf lamina (per cm^2) on veins per cm and midrib (per cm). Hair density and gossypol glands counting were completed by using binocular meter. Hair length was measured from top, middle and bottom portions of leaves in millimeters by using binocular meter. Thickness of leaf at bottom portion of the leaves was measured in millimeters by using vernarier caliper. The mite population was counted under natural infestation from upper, middle and lower leaves from July to November. Fifteen leaves were taken from 5 randomly selected plants per replication of each variety and mite population data was recorded. Finally, the data on the population dynamics of mite and morphological traits of leaves as hair density, gossypol glands, hair length and thickness of leaf lamina were tabulated and analyzed statistically by using analysis of variance techniques with MSTAT-C software programme and compared with the help of Duncan's multiple range test (Steel *et al*., 1997).

Results

Table I shows the average population of Tetranychid mites as 1.54, 1.16, 0.93, 0.67 and 0.22 mites per leaf in FH-900, NIAB-111, CIM-506, VH-145 and NIAB-999, respectively. So the variety NIAB-999 showed maximum resistance against mites where as FH-900 was highly infested. This resistance was due to the leaf characters of plants as described below.

Table I.- Overall average population (per leaf) of *Tetranychidae* mite on cotton varieties.

S. No.	Varieties	Mean± SE
1	FH-900	1.54 ±0.57 a
2	NIAB-111	1.16 ±1.15 b
3	CIM-506	0.93 ±0.01 b
4	VH-145	0.67 ±0.01 c
5	NIAB-999	0.22 ±0.00 e

Figures sharing similar letters are non significant at P= 0.05 %

Hair density

Table II showed that hair density on leaf lamina (per cm^2 area) observed highest (504) on variety NIAB-999, while the lowest (298) were observed in variety NIAB-111. The hair density on leaf vein (per cm) showed that the highest number of hairs (223) was recorded on variety NIAB-111, while the lowest (123) on variety NIAB-999. CIM-506 and VH-145 possessed 155 and 147 number of

hairs on leaf vein respectively. Hairs density on leaf midrib was observed maximum (206) on FH-900 and the minimum (109) on NIAB-111.

Gossypol glands

In Table III the highest (96) number of gossypol glands per cm^2 area on leaf lamina was observed on VH-145, while significantly lowest number of gossypol glands (28.0) was recorded in variety FH-900. The varieties CIM-506 and NIAB-111 were having 47.0 and 63.0 gossypol glands. The gossypol glands on leaf vein (per cm area) ranged from 10 to 16 among the planted varieties (Table III). The number of gossypol glands on leaf midrib (per cm area) ranged from 13.3 (NIAB-999) to 18.00 (VH-145).

Table II.- Hair density on leaves of different cotton varieties.

Varieties	Hair density (Means± SE)		
	Leaf lamina (cm^2)	Vein (cm)	Midrib (cm)
FH-900	361.0 ±5.41 b	132.0±1.52 cd	206.0±4.58 b
NIAB-111	298.0 ±4.16 d	223.0±1.52 a	176.0±3.46 c
CIM -506	345.9±6.18 bc	155.0±2.89 b	224.0±2.31 a
VH -145	320.0±5.78 cd	147.0±3.51 bc	140.0±0.57 d
NIAB-999	504.0±2.31 a	123.0±1.73 d	109.0±4.93 e

Figures sharing similar letters are non significant at P= 0.05 %

Table III.- Gossypol glands on leaves of cotton varieties.

Varieties	No. of Gossypol glands (Mean± SE)		
	Leaf lamina (cm^2)	Vein (cm)	Midrib (cm)
FH-900	28.0 ±3.05 d	16.0 ±2.57 a	15.0 ± 0.57 c
NIAB-111	63.0 ±2.31 b	13.0 ± 0.57 bc	16.0 ±1.15 b
CIM -506	47.0 ±3.51 c	14.0 ±1.73 c	16.0 ±0.57 b
VH -145	96.0 ±2.51 a	13.3 ±2.33 b	18.0 ±0.00 a
NIAB-999	43.0 ±1.73 c	10.0 ±1.52 d	13.3 ±0.85 d

Figures sharing similar letters are non significant at P= 0.05 %

Hair length

The length of hairs (mm) on leaf lamina was observed highest (0.310) and lowest (0.175) in varieties VH-145 and NIAB-999 respectively. In other varieties FH-900, NIAB-111 and VH-145 the hair length on leaf lamina were recorded as 0.233, 0.206 and 0.310, respectively (Table IV). Hair length on leaf veins was observed maximum (0.243) and minimum (0.104) in varieties NIAB-111 and NIAB-999 respectively. CIM-506 and VH-145 possessed 0.145 and 0.119 hair length on leaf veins respectively. The maximum length of hairs on leaf midrib (0.124) was observed in CIM-506 while the minimum (0.101) on NIAB-111. The length of hairs on midrib was observed as 0.106, 0.120 and 0.107 in FH-900, VH-145 and NIAB-999, respectively.

Table IV.- Hair length on different cotton varieties.

Varieties	Hair length (Mean±SE)		
	Leaf lamina (mm)	Vein (mm)	Midrib (mm)
FH -900	0.233±0.01 b	0.122±0.00 c	0.106±0.00 c
NIAB-111	0.206±0.00 b	0.243±0.00 a	0.101±0.01 d
CIM -506	0.185±0.01 c	0.145±0.01 b	0.124±0.00 a
VH -145	0.310±0.00 a	0.119±0.01 d	0.120±0.01 b
NIAB-999	0.175 ±0.01 c	0.104±0.00 e	0.107±0.01 c

Figures sharing similar letters are non significant at P= 0.05 %

Table V.- Thickness of leaf lamina on different cotton varieties.

Varieties	Thickness of leaf lamina (Mean±SE)		
	Top (mm)	Middle (mm)	Bottom (mm)
FH -900	0.023±0.01 d	0.029±0.00 d	0.074±0.00 c
NIAB-111	0.027±0.02 c	0.040±0.00 c	0.080±0.00 b
CIM -506	0.031±0.00 a	0.041±0.00 c	0.068±0.01 d
VH -145	0.031±0.01 a	0.048±0.01 b	0.064±0.01 e
NIAB-999	0.029±0.00 b	0.052±0.01 a	0.087±0.00 a

Figures sharing similar letters are non significant at P= 0.05 %

Thickness of leaf lamina

The highest thickness of leaf lamina (mm) on top portion was observed as 0.031 in variety CIM-506 and VH-145, which differed significantly from the rest of the varieties (Table V). The thickness of leaf lamina on middle portion was recorded minimum (0.029) in variety FH-900 while maximum (0.052) in NIAB-999. Maximum (0.087) thickness on bottom portion was observed in NIAB-999. It was concluded from the present study that owing to dense hairs on leaf lamina, medium gossypol glands and hair length on leaf, the NIAB-999 was comparatively more resistant against

tetranychid mite pests while FH-900 was the least one.

Discussion

Hair density, hair length and gossypol glands on leaf lamina, vein and midrib while thickness of leaf lamina on all three portions of leaf *i.e.* top, middle and bottom are responsible for resistance against sucking pests of cotton. In our findings leaves of NIAB-999 cultivar possessed maximum hair density, minimum hair length on leaf lamina and medium number of gossypol glands as compared to other tested varieties which are the cause of less attack of mites. Present findings are in the line of Dariev *et al*. (1979) who reported that types least attacked by the pest were those whose leaves had large number of glands and hairs, and least resistant had leaves with few hair and less number of glands The length of hairs on leaf lamina of NIAB-999 in our findings was also the factor that caused resistance against mites. Similar results were attained by Dincer (1981) who reported that in Turkey, *Tetranychus cinnabarinus* (Boisd) appeared as a pest of cotton and has developed resistance. Younas *et al*. (1980) and Raza (2000) reported that the plant morphological characters responsible for insect resistance and results are in lines as we have got. By studying plant morphological characters of leaves in cotton cultivars showed that NIAB-999 as least susceptible while FH-900 the most susceptible against mite pests.

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