EFFECT OF MIX CROPPING OF MUSTARD AND SUNFLOWER ON INSECT DIVERSITY

Abdul Ghani Lanjar*, Abdul Waheed Solangi *, Sajjad Ali khuhro * and Riaz Hussain Jiskani*
Aslam bukero*, and Mehar Ul Nissa Rais,**
*Department of Entomology, Sindh Agriculture University, Tandojam.
**Department of Agriculture Economics, Sindh Agriculture University, Tandojam
Corresponding author: solangiwaheed@gmail.com Ph. #. +92-306-3587142

ABSTRACT: *The studies on insect diversity were carried in the experimental field, Entomology section, Agriculture Research Institute Tandojam from November, 2011 to February, 2012. Three crops were sown as mustard alone, sunflower alone and under mix cropping on an area of ½ acre each. The collection of insect and non-insect species was done once a week. Data were collected by examining 15 plants and were analyzed statistically, using Shannon diversity index. Results showed that the total specimens 2991 belonging to 30 species were collected from mustard crop. Among them 31 species were pests while 4 and 5 species were predators and pollinator, respectively. The highest diversity ($H^{/}$), diversity maximum ($H^{/}_{max}$), and richness (D) were recorded as (1.77), (1.41) and (0.25) on 15-01 2012 and evenness ($J^{/}$ =1.00**)** on 24-12-2011. Total specimens 2288 of 22 species were collected from sunflower crop. Fifteen species of them were pests while 2 and 5 were predators and pollinators, respectively. The highest ($H^{/}$) was recorded as (1.23) on 16-11 2011, while ($H^{/}$max), ($J^{/}$) and (D) were recorded as (1.30), (0.94) and (.06), respectively. A total of 3844 specimens of 32 species were collected from mustard and sunflower mix crop. Twenty three species of them were insects while 4 and 5 were predators and pollinator, respectively. The highest ($H^{/}$) was recorded twice as (1.39) on 16-11 2011 and 30.11.2011, while ($H^{/}$max) were recorded as (1.44). The maximum ($J^{/}$ = 0.98) was also recorded twice on 03-12-2011 and 29-01-2012, respectively, while the maximum richness (D= 0.046) was recorded on 26-11-2011. Over all impact of temperature and RH indicated that the most of the insects showed negative correlation with temperature and relative humidity on all crops, but highly significant impact whether negative or positive was recoded for a few insects .*

Key words: Insects, Diversity indices, Mustard, Sunflower, mix crop.

INTRODUCTION

Insects are the most commonly occurring herbivores, carnivores, scavengers and pollinators of many agricultural and horticultural crops [1]. An emerging idea in ecology is that the function and stability of multitrophic communities in natural ecosystems are directly affected by plant biodiversity [2]. Plant species diversity can have strong effects on the abundances and distributions of other organisms, with increases in the number of plant species promoting a higher diversity of individual herbivorous and predatory arthropod species [3; 4]. Species richness provides an extremely useful measurement of diversity where a complete catalogue of species in the community is obtained [5]. Biodiversity entails all forms of biological entities inhabiting the Earth-including prokaryotes and eukaryotes, wild plants and animals and cultivated plants and even genetic material like seeds and germplasm [6]. Insects have great potential for understanding ecosystem and the limitation of resources increase the difficulty of work on insect biodiversity [7].

The sunflower (*Helianthus annuus* L.) is one of the most important oil crops globally and is grown on over 22 million hectares worldwide, with a production of 26 million tones [8]. Sunflower (*H. annuus*) belongs to family Asteraceae. *H. annuus* is cultivated for edible seed [9]. As an oil seed crop, sunflower was introduced in Pakistan during 1960 with the object of bridging the gap between production and consumption of edible oil in the country [10]. Over 150 phytophagous insect species have been reported from cultivated and native sunflower. However, only a few insect species have adapted to cultivated sunflower and have become economic pests [11]. The key insect pests attacking the sunflower head include the sunflower moths, red sunflower seed weevil, and midge [12]. Cutworms, Green stink bug, American bollworm, aphids, cabbage semi-looper, melon fly, whitefly, thrips termites and beetle [13; 10]. Rape and mustard oil seed crops are the most important sources of vegetable oil grown during the winter season. The area and production level of rape and mustard in Pakistan during 2002-03 were about 649x103 acres, 217x103 tons oil seeds and 69x103 tons oil [14]. The activities of insect pests, predator and parasitoids such as aphids, leaf miner, leaf folder, ladybird beetles, Syrphids, *Diaretialla*, *Aponteles* were recorded on mustard from sowing till maturity of the crop [15]. Insect pollinators also play a vital role in crop plant [16]. Many insect species are seen as active pollinators on flowers of plants [17].

Environmental factors also play a vital role in the biodiversity of insect pests in a particular agro ecosystem. [18] there are numerous factors which affect the speedy increase and decrease of insects population. Both the physical and biological factors are much vital causing the variations in the densities of insects (REF) aphid population. The present research was conducted to estimate the biodiversity of insects associated with mustard and sunflower crop cultivated alone and mix crops.

MATERALS AND METHODS

The experiment on "Effect of mixed cropping of sunflower and mustard on insect diversity" was carried out in the field of Entomology section, Agriculture Research Tandojam during winter season 2011. To determine insect biodiversity mustard and sunflower crops were cultivated alone and mixed with each other. For this purpose, three plots of ½ acre were reserved and each one was cultivated as, i. mustard alone ii. sunflower alone and iii. mustard and sunflower as mixed crop. After germination, each crop was examined for insect biodiversity. *In situ* method of sampling was used from 1st week of October, 2011 to February, 2012. At each observation 75 leaves from 15 randomly selected plants and soil surface were examined for specimens by walking diagonally in every portion of the area for 30-40 minutes. The collected specimens were brought to department of Entomology, Sindh agriculture university Tandojam for identification purpose. The insects were killed with ethyl acetate. The killed insects were spread over the table for identification. Identification was made under the supervision of teachers of department of Entomology, Sindh agriculture university Tandojam. The collected specimens were separated out to determine their families and orders. Mustard and sunflower serves as a reservoir for many insect species, hence, the present studies were carried out to determine diversity maximum, species richness and species evenness and by using the Shannon diversity index.

The following diversity indices were used:

$$\text{i) } H' = \frac{n \log n - \sum_{i}^{K} fi \log fi}{n} \quad \textit{(Diversity)}$$

ii) H' max = log K (Max. Diversity)

iii) $J' = H'/H'$ max (Evenness)

iv) D = 1- J' (Richness)

Where H' is the diversity index of total number of collected specimens; fi is the proportion of ith species, H' max is the maximum diversity, k is the total number of species in the entire crop area, j' is the evenness, D represents the dominance of species and n is the number of species per observation.

RESULT

The results of the experiments showed that insect biodiversity varied with cropping pattern. A total 31 species of insects were recorded from November, 2011 to February, 2012 in mustard crop. Among them, 22 species were pests while 4 and 5 species were predators and pollinator, respectively. The collected insects were belonging to insect orders Homoptera, Thysanoptera, Lepidoptera, Odonata, Coleoptera, Orthoptera, Hymenoptera and Diptera. During the course of study the whitefly, *Bemisia tabaci* was the most abundance species (216) while the abundance of other insect species was recorded in descending order as *Lipaphis erysimi* (206) < *lugens Amrasca devastan* < *Spodoptera litura* (146) < *Bagrada cruciferarum* (141) < *Eristalis sp.* (141) < *Acheta domesticus* (132) < *Athalia proxima* (132) < *Pieris brassicae* (130) < *Myzus persicae* (127) < *Thrips tabaci* (125) <*Stenolophus lecontei* (120) <*Coccinella septempunctata* (115) <*Earias vittella* (108) < *Apis florae*(101) <*Amrasca devastans*(69) <*Hagna aspersa* (99) < *Pieris brassicae* (92) < *Megachile sp.* (89) < *Llasioglossum sp.* (85) < *Andrena Sp.*(81) <*Plusia sp* (78) <*Gryllus bimaculatus* (78) <*Euproctis sp* (61) <*Danaus plexippus* (61) <*C. Carnya* (61) <*Chrotogonus trachypterus* (51) <*Sminthurus viridis* (47) < *Phaulacridium vittatum* (42) < *Xylocopa collaris* (35) < *Attractomorpha acutipennis* (22).

SHANNON-WEINER DIVERSITY INDEX

A total of 2991 specimens was recorded on mustard during 13 observations. Diversity, diversity maximum, species richness and species evenness were calculated weekly by using Shannon-Weiner diversity index. Fig. 1 showed that the highest diversity (H') was recorded 1.77 on 15-01 2012, while the minimum diversity was recorded 1.22 on 12-11-2011. The diversity maximum (H'max) 1.41 was constant for 4 consecutive weeks i.e. from 24.12.11 to 15.01.12. However, the lowest (H'_{max}) 1.20 was observed during the last week on 06.02.12. The maximum evenness (J') was recorded as (1.00) on 24-12-2011 and minimum J' was recorded as 0.75 on 15-01 2012. However, Maximum species richness (D= 0.25) was recorded on 15-01-12 and the lowest richness (D= 0.4) was recorded twice on 17.12.11 and 01.01.12, respectively, i.e. 6th and 8th week of observation in mustard crop when grown alone.

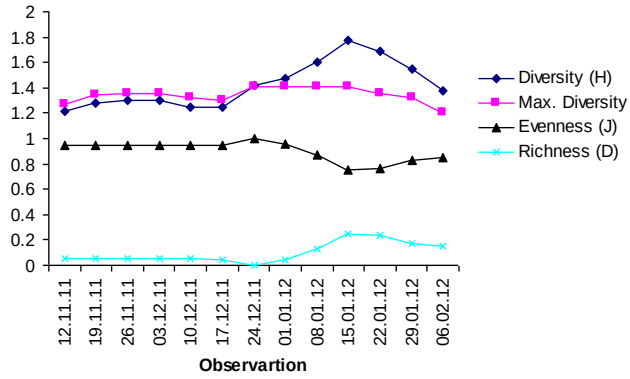

Fig. 01. Biodiversity of arthropods on mustard crop grown alone.

BIODIVERSITY ON SUNFLOWER CROP

A total 22 species of insects were recorded from November, 2011 to February, 2012 in sunflower crop. Among them 15 species were pests while 2 species of predators and 5 species pollinator were recorded, respectively. The collected insects were belonging to insect orders Homoptera, Thysanoptera, Lepidoptera, Odonata, Isoptera Coleoptera, Orthoptera, Hymenoptera, and Diptera, Araneae, Neurroptera. The most abundant was white ant,, *Microtermes obesi* (230) while the abundance of other insect species was recorded in descending order as *Bemisia tabaci* (180) < *Eristalis sp.* (168) < *Acheta domesticus* (132)<*Spodoptera litura* (128)<*Bedellia somnlentella* (126)<*Bagrada cruciferarum* (122)<*Apis florae* (118)< *Smicronyx sorididuss*(115)<

Megachile sp.(108) *Llasioglossum sp.*(97)*<Thrips tabaci* (97)< *Hagna aspersa* (94)< *Amrasca devastans(*83) *<Gryllus bimaculatus*(77)*<Andrena Sp.*(75) *Euproctissp*(71)*<Plusia sp*(66)*<Chrotogonus trachypterus* (62) *<Danaus plexippus (59)< Attractomorpha acutipennis* (42)< *Xylocopa collaris* (36).

Shannon-Weiner diversity index

The population counts of different insects and related arthropods indicated that a total of 2288 specimens were recorded during 13 observations. Twenty two species were belonging to different insect orders and classes of arthropoda. Shannon-Weiner diversity index was used to calculate Diversity ($H^{/}$), diversity maximum ($H^{/}$max), species richness ($J^{/}$**)** and species evenness (D) at weekly intervals. During the observation, the highest diversity was recorded as (1.23) on 16-11 2011, while ($H^{/}$max), ($J^{/}$) and (D) were recorded as (1.30), (0.94) and (.06), respectively. However, minimum biodiversity ($H^{/}$**=0.99) was** observed on 28.12.2011, while ($H^{/}$max), ($J^{/}$) and (D) were recorded as (1.04), (0.95) and (.05), respectively on sunflower grown alone.

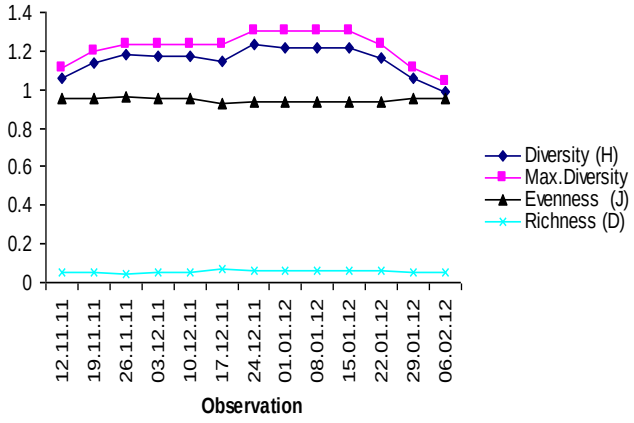

Fig. 02. Biodiversity of arthropods on alone sunflower crop.

BIODIVERSITY ON MUSTARD AND SUNFLOWER MIX CROP

A total of 32 species of insects were recorded. Among them 23 species were pests while 4 and 5 species were predators and pollinator, respectively. The collected insects were belonging to insect orders Homoptera, Thysanoptera, Lepidoptera, Isoearptera, Neuroptera, Odonata, Coleoptera, Orthoptera, Hymenoptera and Diptera. During the course of study the whitefly, *Bemisia tabaci* was the most abundant species (290) while the abundance of other insect species was recorded in descending order as , *Microtermes obesi* (218)< *Lipaphis erysimi* (192) < *Eristalis sp.* (184)< *Bagrada cruciferarum*(168)< *Spodoptera litura* (163) < *Thrips tabaci* (157) < *Amrasca devastans* (150) *Acheta domesticus* (147) < *Hagna aspersa* (139)< *Pieris brassicae* (133)< *Athalia proxima* (126) < *Apis florae*(119)< *Myzus persicae* (114)< *Smicronyx soridius* (114) *<Plusia sp* (111)< *Euproctis sp*(109)*<Coccinella septempunctata* (108) *<Earias vittella* (107)< *Gryllus bimaculatus* (104) *<Megachile sp* (95) < *Lasioglossum sp.* (94)< *Pieris Brassicae* (94) < *Bedellia somnulentella* (93) *<Andrena Sp.*(90)< *Danaus plexippus* (88) < *Phaulacridium vittatum* (70)< *C. Carnya* (68) *Sminthurus viridis* (62)< *Chrotogonus trachypterus* (49)< *Attractomorpha acutipennis* (45) < *Xylocopa collaris(*43).

SHANNON-WEINER DIVERSITY INDEX

A Total of 3844 specimens were recorded on 15 randomly selected plants of mustard and sunflower mixed crop for 13 observations. Thirty two species were collected belonging to different insect orders and classes of arthropod. Diversity ($H^{/}$), diversity maximum ($H^{/}$max), species richness ($J^{/}$**)** and species evenness (D) were calculated weekly by using Shannon-Weiner diversity index. During the observation, the highest diversity ($H^{/}$=1.39) was recorded twice, 1st in the 7th week and second in 9th weeks of observations i.e. on 16.11.2011 and 30.11.2011, respectively, while the minimum ($H^{/}$=1.27) was recorded on 05.10.2011. The highest ($H^{/}$max) 1.44 was observed on 7th to 9th week during the observation, on other hand the lowest (H max) 1.32 was recorded in the 1st week, however, in last couple of weeks during the observations. The maximum evenness ($J^{/}$=0.98) was the same during 4th and 12th week of observations, and minimum evenness $J^{/}$=0.95 was recorded during the 5th and 8th week of observations. The maximum richness (D= 0.046) was recorded on 26-11-2011, while the lowest richness D 0.018 was recorded on 26-10-2011on sunflower and mustard mixed cropping

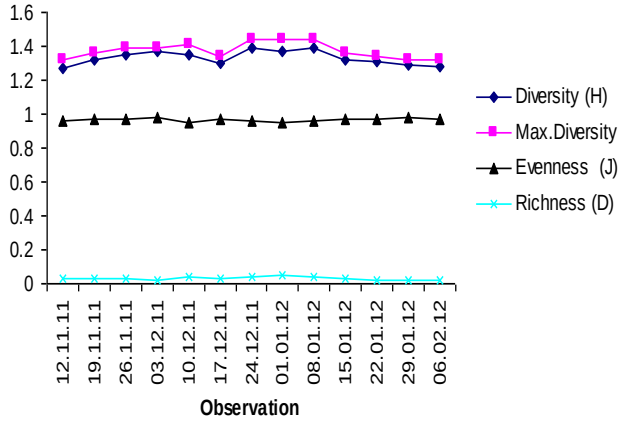

Fig. 03. Biodiversity of arthropods on mustard and sunflower mixing cropping.

Table 1. Over all biodiversity alone and mix of Shannon-Weiner diversity index.

Biodiversity Components	Mustard	Sunflower	Mustard and Sunflower mix
Diversity (H)	**1.62**	**1.30**	**1.78**
Max. Diversity	**2.46**	**2.33**	**2.49**
Evenness (J')	**0.68**	**0.55**	**0.71**
Richness (D)	**0.32**	**0.45**	**0.29**

The data in Table -1 indicates that **t**he value of diversity ($H^{/}$= 1.78) was maximum in mustard and sunflower mix cropping and minimum (1.30) in the sunflower crop when grown alone. Maximum diversity **(**$H^{/}$max=2.49) was recorded in mix crop and minimum ($H^{/}$max =2.33) in sunflower grown alone. Similarly Evenness (J'= 0.71) was the highest in mix cropping while minimum (J'= 0.55) sunflower alone. The maximum richness (D=0.45) was recorded in the field of sunflower, minimum (D=0.29) in mix cropping.

EFFECT OF A BIOTIC FACTORS

Table 2 showed that the population of white fly jassids, thrips, hairy caterpillar, semilooper were negatively correlated with temperature. The correlation values were non-significant on all the crops. However, significant negative correlation computed (0.513) between population of mustard aphid and temperature on mixed cropping. The population of painted by was positively correlation (0.208 NS) with temperature and negatively correlated (-0.429) with RH in mixed cropping. Highly significant correlations (0.730**), (0.779**),

(0.707**), (.7349**) were computed between the populations of wingless grass hopper, surface grass hopper, green grass hopper, lucerne flea on mix cropping. Among predator, the seven spotted beetle showed highly significant negative correlation (-0.714**) in mixed cropping. Whereas negative correlation (-0.638*) was recoded on mustard alone. Over all impact of temperature and RH indicated that most of the insects showed negative correlation with temperature and relative humidity on all crops but highly significant impact whether negative or positive was recoded for a few insects .

DISCUSSION

A total of 32 insects species (pests, predators and pollinators) belonging to insect orders Homoptera, Thysanoptera, Lepidoptera, Isoearptera, Neuroptera, Odonata, Coleoptera, Orthoptera, Hymenoptera and Diptera were recorded when sunflower and mustard were sown as mix crops. Among such insect species a total of 22 species were recorded on sunflower and 30 on mustard crop when grown alone. [19] and [20] mentioned most of the species on sunflower, which were recorded during present investigation. [21] reported over 50 species of insects visited flowers of 17 different species of selected crops during flowering periods. [22] mentioned that at least 19 species of insects pollinated the mustard. [15] recorded the activities of more than a dozen insects on mustard as pests, predators, parasitoids and pollinators. [23] found 19 insect species of natural enemies belonging to 4 orders and 6 families and 2 entomopathogenic fungi were found associated with the insect pests. [24] monitored 17 different predators such as 6 birds,, 3 species of spiders, 3 syrphids, 2 ants, 2 coccinellids and 1 dragonfly were also found to predate on different life stages of *Plutella xylostella*. During present investigation, maximum specimens were collected from the field of sunflower and mustard mixed crop. Similarly, highest insect biodiversity, diversity maximum, evenness and richness were computed in sunflower and mustard mix cropping. Authors in [7] reported that insects have great potential for understanding ecosystem as measures of ecosystem health. In [6], they mentioned that biodiversity entails all forms of biological entities inhabiting the Earth-including prokaryotes and eukaryotes. Zahoor *et al*. [25], compared the diversity in forest and crop agro-ecosystem and concluded that the Noctuidae was more diverse over forest area than crop area. Similarly, [26] in another investigation concluded the coccinellidae was the most diverse in the forest area than crop area. [27] studied A total of 11720 specimens belonging to different insect orders were captured in three localities. About 117 species associated with sugarcane were identified. The diversity, maximum diversity, species richness and species evenness in three localities were 1.55, 2.0, 0.22 & 0.77 and 1.66, 2.0, 0.17 & 0.83 and 1.75, 2.0, 0.13 & 0.87, respectively. [2] while analyzing the agro-ecosystem of cauliflower recorded 13 species of insects with a diversity value (0.54), diversity maximum (1.11), evenness (0.48) and species richness (0.51), respectively.

CONCLUSION

The result showed that 30, 22 and 32 insect species of different orders was recorded on mustard, sunflower and mixed crop, respectively. Maximum specimens were collected from the field of sunflower and mustard mixed crop. Similarly, highest insect biodiversity, diversity maximum, evenness and richness were computed in sunflower and mustard mix cropping.

LITERATURE CITED

[1] Partap, U. and Verma, L. R., Floral biology and foraging behaviour of Apis cerana on lettuce crop and its impact on seed production. *Progressive Horticulture*, **24**: 42-47, 1992.

[2] Memon. I. A. Insect diversity in cauliflower agro- eco-system at Tandojam. A *M.Sc thesis* submitted to Department of Entomology, Sindh agriculture University Tandojam. Total pages- 80, 2011.

[3] Siemann, E., D. Tilman, J. Haarstad and M. Ritchie, Experimental tests of the dependence of arthropod diversity on plant diversity. *Am Nat.*, **152**:738–750, 1998.

[4] Haddad, N.M., D. Tilman, J. Haarstad, M, Ritchie, J. M. H. Knops. Contrasting effects of plant richness and composition on insect communities: a field experiment. *Am Nat.*. **158**:17–35, 2001..

[5] Magurran, A.E., Ecological Diversity and Measurement. Princeton University Press, Princeton. In: Schowalter, T.D. (ed.). Insect Ecology: *An Ecosystem Approach*, pp: 221–47. Academic Press, USA, 1988.

[6] Kothari, A., The Biodiversity Convension: *an Indian viewpoint. Sanctuary*, **12**: 34-4, 1992.

[7] Williamson, M. *Species diversity in Ecological communities* . Pp. 325- 336, 1995.

Table 2. Correlation between insects population and a biotic factors on mustard and Sunflower grown alone and in mixed crop during winter 2011-2012.

Insect	Mustard and Sunflower mixed crop		Mustard alone		Sunflower alone	
	Temp.	R. H	Temp.	R. H	Temp.	R. H
Whitefly	-0.126	-0.002	-0.288	0.128	-0.291	0.121
Jassid	-0.427	0.221	-0.287	0.036	-0.480	0.251
Aphid 1	-0.519	0.209	-0.486	0.275		
Thrips	-0.356	0.179	-0.372	0.295	-0.190	0.019
Hairy caterpillar	-0.163	-0.143	-0.281	-0.006	-0.199	0.007
Semi Looper	-0.128	-0.104	-0.238	0.258	-0.094	-0.111
White ant	-0.143	0.031			-0.144	0.024
D B M	-0.321	0.221	-0.349	0.161		
Spider	0.013	-0.211	-0.360	0.137	-0.274	0.041
Painted bug	0.208	-0.429	-0.069	-0.151	0.108	-0.285
Gray weevil	0.279	-0.480			0.140	-0.354
Butter fly	-0.070	-0.195	-0.381	0.270	-0.229	0.072
Hoverfly	0.016	-0.179	-0.162	-0.095	-0.139	-0.170
Saw fly	-0.202	-0.017	-0.291	0.088		
winless grasshopper	0.730	-0.591	0.755	-0.478		
Surface grass hopper	0.779	-0.566	0.746	-0.584	0.650	-0.694
Green grass hopper	0.707	-0.534	0.771	-0.653	0.532	-0.613
Army worm	0.563	-0.616	0.358	-0.542	0.398	-0.570
Spotted boll worm	0.520	-0.650	0.347	-0.569		
Aphid 2	-0.251	0.118	-0.249	0.014		
Cabbage butter fly	0.026	-0.221	-0.112	-0.097		
Black headed cricket	0.489	-0.654	0.415	-0.591	0.386	-0.424
House cricket	0.524	-0.658	0.300	-0.558	0.439	-0.649
Leaf minor	0.484	-0.601			0.301	-0.529
Lucern flea	0.739	-0.514	0.781	-0.454		
Seven spotted beetle	-0.714	0.619	-0.638	0.538		
Chrysopa	-0.647	0.625	-0.654	0.601		
Honey bee	-0.444	0.404	-0.589	0.555	-0.490	0.458
Bumble bee	-0.473	0.473	-0.653	0.582	-0.554	0.561
Solitary bee	-0.450	0.477	-0.564	0.543	-0.519	0.459
Andrena	-0.458	0.466	-0.626	0.583	-0.502	0.458
Leaf cutter bee	-0.434	0.397	-0.562	0.523	-0.515	0.450

[8] Skoric, D., Jocic, S., Lecic, N. and Sakac, Z. Development of sunflower hybrids with different oil quality. *Helia*., **30**:205-212, 2007.

[9] Khan, S. N., Ayub, N., Ahmad, I., Shehzad, I. and Asad., 2007. Effect of climatic conditions on life cycle of charcoal rot infected sunflower plant. *Pakistan Journal of Botany*, **39**:2657-2662.

[10] Ashfaq, M. and Aslam, M., Resistance of Different sunflower (*Helianthus annu* L.) Genotypes against the attack of *Lipaphis erysimi* Glover, *Nezara viridula* (L.) and *Thrips tabaci* Lind, in Field. Journal of *Biological Sciences*, **1**: 941-945, 2001..

[11] Charlet, L. D. and P. A. Glogoza, 2004. Insect problems in the sunflower production regions based on the 2003 sunflower crop survey and comparisons with the 2002 survey. Proc. 26th Sunflower Research Workshop, Natl.Sunflower Assoc., Fargo, ND, 14-15 January 2004.

[12] Rogers, C. E., Insect pests and strategies for their management in cultivated sunflower. *Field Crops Res*., 30:301-332, 1992.

[13] Aslam, M., Suleman, N., Riaz, A. Rehman, A. and Zia, Q., Insect Pests found on *Helianthus annuus* L.(Compositae) in the Potohar Region of Pakistan. *Pakistan Journal of Biological Sciences*, **3**: 963-964, 2000.

[14] Anonymous, Economic survey, Government of Pakistan, Finance Division,Islamabad. pp. 19, 2013.

[15] Hugar P. G., Anandhi P., Varma S. S. L. Seasonal incidence of important insect pests of mustard and their natural enemies in relation to weather parameters, in Allahabad region Department of Plant Protection, AAI-DU, Allahabad - 211 007, U.P, India, 2008.

[16] Müller, A., Diener, S., Schnyder, S., Stutz, K., Sedivy, C., Dorn, S., Quantitative pollen requirements of solitary bees: implications for bee conservation and the evolution of bee-flower relationships. *Bio. Conservation*. **130**:604-615, 2006.

[17] De Grandi-Hoffman.G and Chambers., M. Effects of honey bee Hymenoptera: Apidae)foraging on seed set in self-fertile sunflowers Helianthus annuus, 2006.

[18] Aheer, G. M., K. J. Ahmad and A. Ali., Impact of weather factors on population of wheat aphids at Mandi Baha-ud-din District. *J. Agric. Res*., **45**(1): 61-68, 2007.

[19] Sattar, A., Ullah, K. and Yousaf, M., Insect pest of sun flower in NWFP , Pakistan. *Pakistan Journal of Agriculture Resources*, **5**: 239-240, 1984.

[20] Kakakhel, S. A., Islam, N. Amjad, N. and Malik, M.A. 2000. Insect Pests Complex of sunflower (*Helianthus annuus* L.). *Pakistan Journal of Biological Sciences*, **3**: 669-671, 2006.

[21] Thapa, R. B., Honeybees and other Insect Pollinators of Cultivated Plants: *J.Inst. Agric. Anim. Sci*. 27:1-23,2006

[22] Atmowid, T., D. Buchori., S. M. B. Suryobroto and P. Hidayat, Diversity of Pollinator Insects in Relation to Seed Set of Mustard (Brassica rapa L.:Cruciferae) HAYATI *Journal of Biosciences*,**14**(4):155-161, 2007.

[23] Devjani, P . and T . K. Singh ., insect pest and natural enemy complex of cauliflower in the agro-ecosystem of Manipur. *Indian journal of entomology*, **64**(3): 275-278, 2002.

[24] Hemchandra, O. and T . K. Singh., Natural enemy complex of *Plutella xylostella*(Linn.)on cauliflower . Advances in Indian Entomology : *Productivity and Health* (a Silver Jubilee, Supplement No. 3, Volume **11**; Insect Environment). 85-95, 2006.

[25] Zahoor, M. K., A.Suhail, J.Iqbal, Z . Zulfaqar and M . Anwar., Biodiversity of Noctuidae (Lepidoptera) in Agro- Forest Area of Faisalabad. *Int.. J . of Agri. and Biol* . **5**(4) : 555-563, 2003.

[26] Zahoor, M.K., A. Suhail, J.Iqbal, Z . Zulfaqar and M. Anwar., Biodiversity of Predaceous Coccinellids and Their role as bioindicators in an agro- ecosystem. *Int.. J. of Agri. and Biol*., **5**(4): 555-559, 2003(b).

[27] Adnan A., A. Suhail, Z. Abdin, S. Iftikhar and K. Zahoor. Biodiversity of insect associated with sugarcane crop in Faisalabad. *Pak. Entomol*., **26**(1): 65-69, 2004.