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Seasonal occurrence and diversity of arthropods in *Bt* cotton ecosystem under Akola conditions of Maharashtra

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Abstract

Present investigation was carried out at Department of Entomology, Dr. PDKV Akola (MS) India during *kharif* 2016. It is revealed from the survey that, *Bt* cotton ecosystem harbored total 22 insect fauna out of which 14 insects were categorized as pests and 8 were natural enemies (NEs), besides eight species of predatory spiders were recorded. In *Bt* cotton ecosystem whiteflies, leafhoppers, aphids, mite, thrips, red cotton bugs were found in abundance during 34th, 35th, 36th SMW. Whereas, natural enemies *viz*: spiders, lady bird beetles, mallada, syrphid fly, ant and chrysopa were found predominantly during 35th, 36th, 37th and 38th SMW. The simple correlation studies indicated that rainfall had a significantly negative correlation with semilooper, whitefly, leafhopper population. However, positive significant association was noticed between maximum relative humidity with fruit borer, ash weevil, syrphid fly, white flies, chafer beetle and spider population. High percent abundance was recorded by aphids followed by leaf hoppers, whiteflies, mites, thrips and red cotton bugs with moderate to rich biodiversity of arthropod fauna was noticed in *Bt* cotton ($H' = 2.193$) crop ecosystem at Akola.

Keywords: *Kharif* crop ecosystem, *Bt* cotton, natural enemies, pests, spiders, biodiversity

1. Introduction

In India agriculture is currently suffers an annual loss about US\$ 36 billion due to insect pests. The last two decades have witnessed a remarkable progress in various bio-pesticide strategies including the development of transgenic crops. Such strategies should be utilized in IPM programme to reduce crop losses without affecting the quality of environment^[1]. This heavy crop loss causes the farmer to use huge amounts of pesticides^[2]. But, both the quantity of food loss due to pests and the cost of pest control in terms of money and human health are significant^[3].

Cotton is major *kharif* crop it is also called the king of fiber crops. Major pest of cotton is American bollworm, spotted bollworm, pink bollworm, and sucking pests like leafhopper, whitefly, thrips, aphids, etc. However, bollworm menace as been tackled by introducing *Bt* cotton. Predatory arthropods growing wildy in fields are one of the natural sources of pest management. When natural enemies are abundant in cotton field, higher pest levels can be tolerated for longer periods without pesticide use that means there is a saving of pest control cost. Predatory fauna including spiders play an important role crops pests management^[4].

India is one of the hotspots of arthropods biodiversity in the world. The diversity plays an important role in the functioning of an agro-ecosystem. At present, scanty information is available on the changing pest scenario and bio-agent insect fauna in *kharif* crop agro-ecosystem. Looking into the significance of major pest, bio-agent fauna the present study was undertaken to explore the insect pests and predatory fauna of an agro- ecosystem of Akola in relation to its diversity. This work aimed to emphasize the need for conservation of the diversity of predatory insect fauna found in a major *kharif* crop ecosystem for estimating the species diversity as well as the present status of insect pest fauna.

2. Materials and methods

The present study was carried out at Department of Entomology, Post Graduate Institute Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola, during 2016 - 17. Insects are generally inactive or less active in morning hours hence most of the collection was under taken during morning hours. Arthropods were searched on the *Bt* cotton crop.

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2.1 observations recorded

A weekly survey of *Bt* cotton recorded from each block. Wherever, adult stage occurred were collected and preserved for identification in the Taxonomy laboratory Department of Entomology. Immature stage of pests was brought to the Lab for further rearing. Collected fauna were identified at Biosystematics Lab., Department of Entomology Dr. P.D.K.V. Akola.

2.2 Correlation between meteorological parameters and pests/ natural enemies at Akola

The population of pests and natural enemies were correlated with various weather parameters. For correlation studies data of weather parameters of preceding week were considered by the population of pests and natural enemies of current week.

2.3 Shannon biodiversity index

Considering the occurrence of varied type of species of pests and natural enemies in *Bt* cotton ecosystems at Akola, the same data was used to estimate the diversity index for generic level / species level by following Shannon diversity index using following formula

$$H' = - \sum_{i=1}^s (P_i \ln P_i)$$

Pi = ni/N

ni = number of individuals of species "i"

N = total number of individuals of all species

pi = relative abundance of species "i"

S = total number of species

H' = Shannon Diversity Index

3. Results and Discussion

3.1 Arthropod fauna occurred in *Bt* cotton ecosystem:

During the *Kharif* season of 2016, total twenty three

arthropods (Insects and mites) were recorded (Table1). Out of them fourteen insects were categorized under pest and nine arthropod natural enemies were observed in the *Bt* cotton crop at Akola. Among fourteen insect pests six sap feeders viz; whitefly, leaf hoppers, aphids, thrips, mealy bug and mite, six chewers viz; blister beetle, chaffer beetle, grasshopper, ash weevil, *Spodoptera*, semilooper and one cotton bug i.e. red cotton bug and one bollworm i.e. pink bollworm were recorded. Among nine natural enemies lady bird beetle, spider, mallada, syrphid fly, chrysopa, ant, miridbug, mantid and dragonfly were recorded. Out of three bollworm only pink boll worm was recorded on *Bt* cotton.

In *Bt* cotton ecosystem eight predatory spiders were recorded beside insect and mites (Table1.1) namely *Argyrodes* sp., *Hyllus* sp., *Araneus* sp., *Thomisus* sp., *Telamonia* sp., *Oxyopes* sp., *Rhene* sp., *Clubiona* sp. Some of the previous researchers have also reported insect fauna from different parts of India. [5] have reported major predators in cotton ecosystem. These predators were coccinellids, mantid, syrphid fly and *chrysoperla* sp. They further reported that the sucking pests like aphids, jassids and thrips were effectively checked by these predators. Most of the insect - pests including mite were observed to be commonly recorded pests in this locality. However, among the predators miridbug was found active in *Bt* cotton ecosystem besides other common predators. Among the other arthropod predators spiders were active with diverged species and attempt was made first-time for identification of this important predatory arthropods. A total eight genera belonging to seven different families were recorded in *Bt* cotton ecosystem at Akola. reported four species of spiders in *kharif* agro-ecosystem in Akola district viz.; *Neoscona* sp., *Oxyopes* sp., *Thomisus* sp., *Pseusetia* sp. Out of which *Oxyopes* sp. and *Thomisus* sp. [4], same were also recorded during the present investigation endorsed the present findings.

Table 1: Arthropod fauna occurred in *Bt* cotton ecosystem during *Kharif* 2016 in Akola

Sr. No.	Common name of arthropods	Species	Family	Order	Pests / Natural enemies
1	Leafhopper	<i>Amrasca biguttula biguttula</i> (Ishida)	Cicadellidae	Hemiptera	Pest
2	Whitefly	<i>Bemisia tabaci</i> (Genn.)	Aleyrodoidae	Hemiptera	Pest
3	Aphid	<i>Aphis gossypii</i> (Glover)	Aphididae	Hemiptera	Pest
4	Spodoptera	<i>Spodoptera litura</i> (Fabricius)	Noctuidae	Lepidoptera	Pest
5	Thrips	<i>Thrips tabaci</i> (Lindeman)	Thripidae	Thysanoptera	Pest
6	Semilooper	<i>Anomis flava</i> (Fabricius)	Erebidae	Lepidoptera	Pest
7	Ashweevil	<i>Myloccerus dentifer</i> (Fabricius)	Curculionidae	Coleoptera	Pest
8	Mite	<i>Tetranychus</i> sp.	Tetranichidae	Trombidiformes	Pest
9	Mealybug	<i>Phenacoccus solenopsis</i> (Tinsley)	Pseudococcidae	Hemiptera	Pest
10	Grasshopper	<i>Hieroglyphus nigrorepletus</i> (Bolivar)	Acrididae	Orthoptera	Pest
11	Blister beetle	<i>Mylabris phalerata</i> (Pallas) / <i>M. pustulata</i> (Thunb.)	Meloidae	Coleoptera	Pest
12	RCB	<i>Dysdercus koenigii</i> (Fabricius)	Pyrrhocoridae	Hemiptera	Pest
13	Chafer beetle	<i>Oxycetonia versicolor</i> (Fabricius)	Scarabeidae	Coleoptera	Pest
14	PBW	<i>Pectinophora gossypiella</i> (Saunders)	Gelechiidae	Lepidoptera	Pest
15	LBB	<i>Cheilomenes sexmaculata</i> (Fabricius)	Coccinellidae	Coleoptera	Natural enemies
16	Syrphid fly	<i>Ischiodon scutellaris</i> (Fabricius)	Syrphidae	Diptera	Natural enemies
17	Spider	(List enclosed in separate Table)		Araneae	Natural enemies
18	Chrysopa	<i>Chrysoperla</i> sp.	Chrysopidae	Neuroptera	Natural enemies
19	Ant	-	Formicidae	Hymenoptera	Natural enemies
20	Mantid	<i>Mantis</i> sp.	Mantidae	Mantodea	Natural enemies
21	Mallada	<i>Mallada</i> sp.	Chrysopidae	Neuroptera	Natural enemies
22	Dragonfly	-	Aeshnidae	Odonata	Natural enemies
23	Miridbug	-	Miridae	Hemiptera	Natural enemies

Table 1.1: Spiders occurred in *Bt* cotton ecosystem during *Kharif* 2016 in Akola

Sr. No.	Name	Family	Order	Pests / Natural enemies
1.	<i>Argyrodes</i> sp.	Theridiidae	Araneae	Predator
2.	<i>Hyllus</i> sp.	Salticidae	Araneae	Predator
3.	<i>Araneus</i> sp.	Araneidae	Araneae	Predator
4.	<i>Thomisus</i> sp.	Thomisidae	Araneae	Predator
5.	<i>Clubiona</i> sp.	Clubionidae	Araneae	Predator
6.	<i>Telamonia</i> sp.	Salticidae	Araneae	Predator
7.	<i>Oxyopes</i> sp.	Oxyopidae	Araneae	Predator
8.	<i>Rhene</i> sp.	Salticidae	Araneae	Predator

3.2 Seasonal occurrence of pest of *Bt* cotton ecosystem

During the course of study, fourteen insect species *viz.*, leafhopper (*Amrasca biguttula biguttula*), whiteflies (*Bemisia tabaci*), aphids (*Aphis gossypii*), tobacco leaf eating caterpillar (*Spodoptera litura*), thrips (*Thrips tabaci*), green semilooper (*Anomis flava*), ashweevil (*Myllocerus dentifer*), mite (*Tetranychus* sp.), mealy bug (*Phenacoccus solenopsis*), grasshopper (*Hieroglyphus nigrorepletus*), blister beetle (*Mylabris phalerata* / *M. pustulata*), red cotton bug (*Dysdercus koenigii*), chafer beetle (*Oxyctonia versicolor*) and pink bollworm (*Pectinophora gossypiella*) were recorded (Fig. 1 & 2) under pest category on *Bt* cotton. The incidence of leafhoppers was noticed from 28th SMW to 49th SMW and peak incidence was recorded (11 leafhoppers / leaf) in 37th SMW. The whitefly infestation was initiated in 29th SMW increased upto 37th SMW and then decreased thereafter and peak was noticed during 37th SMW. The incidence of aphids was from 29th SMW to 52nd SMW and it was increased gradually and peak incidence recorded (22 / leaf) during 52nd SMW. The incidence of spodoptera was recorded from 29th SMW to 31st SMW but it was meager in *Bt* cotton. The incidence of thrips was initiated from 30th SMW to 52nd SMW, it was increased gradually and peak incidence was recorded (4.9 thrips / leaf) in 37th SMW. The incidence of green semilooper was recorded from 32nd SMW to 3th SMW but it was very meager. The incidence of ash weevil was recorded from 35th SMW to 48th SMW with peak population 0.8 per plant recorded in 38th, 39th, 43rd SMW. The incidence of mite was recorded from 37th SMW to 41st SMW and peak population was 14.6 mite per leaf during in 40th SMW. The incidence of mealy bug was noticed from 37th SMW to 42nd SMW. The incidence of grasshopper was recorded from 38th SMW to 47th SMW and peak population 0.6 per plant was recorded in 42nd SMW. The incidence of blister beetle was recorded from 39th SMW to 43rd SMW. The incidence of red cotton bug was noticed from 41st SMW to 52nd SMW and it was increased gradually and peak incidence was recorded during 48th SMW. The incidence of chaffer beetle was recorded from 41st SMW to 44th SMW. The infestation of pink boll worms was initiated from 44th SMW with peak population of 0.6 larvae per plant during 47th SMW. It means that, infestation of pink boll worm has initiated on *Bt* cotton at late season although it was low infestation. Extremely low larval population of pink bollworm in *Bt* cotton throughout the crop season [6].

Aphids incidence was noticed from 33rd SMW to till end of the season with some intermittent out breaks. Leafhopper incidence was also recorded from 33rd to 43rd SMW. In case of thrips peak was recorded in 35th SMW [7]. Thus, the present finding is in close proximity with the previous findings.

3.3 Seasonal occurrence of natural enemies in *Bt* cotton ecosystem

During the course of study, nine species, *viz.*, lady bird beetle (*Cheilomenes sexmaculata*), syrphid fly (*Ishiodon scutellaris*), spiders, chrysopa (*Chrysoperla* sp.), ant, mantid (*Mantis* sp.), mallada (*Mallada* sp.), dragonfly and mirid bug, were recorded (Fig.3) as the natural enemies in *Bt* cotton. The activity of LBB was noticed from 31st SMW to 51st SMW and it was increased gradually with a peak population during 37th SMW. The population of syrphid fly was recorded from 32nd SMW to 43rd SMW and it was increased gradually with a peak during 35th and 36th SMW. The activity of spiders was noticed from 33rd SMW to 52nd SMW and increased gradually to a peak population (0.8 /plant) recorded during 37th SMW. Chrysopa were active from 33rd SMW to 43rd SMW and peak population was recorded in 36th SMW. The occurrence of mantid was recorded from 34th SMW to 47th SMW. The activity of mallada was noticed from 37th SMW to 43rd SMW and it was increased gradually with a peak population (0.6 per plant) recorded in 39th SMW. The occurrence of the dragonfly was recorded from 37th SMW to 40th SMW. The population of mirid bug was recorded from 39th SMW to 50th SMW to a peak populations (3.2 bugs /plant) recorded in 44th SMW. In *Bt* cotton ecosystem seven species of spiders were found active in Akola for taking care of sucking pests beside other natural enemies need to be conserved.

Forty natural enemies per 50 plants of cotton were recorded in Integrated Pest Management module. The population of natural enemies was comprised of coccinellids, syrphid fly, chrysopa and spider had taken care of sucking pests [8]. Thus, the present investigation is in the tune to the previous finding.

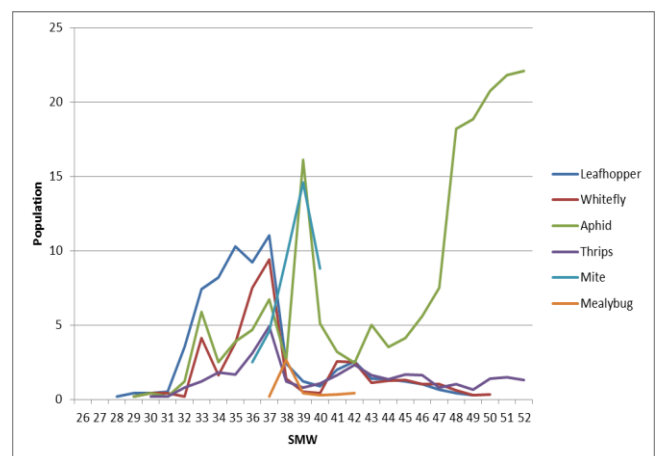


Fig 1: Seasonal occurrence of sucking pests in *Bt* cotton ecosystem during 2016-17

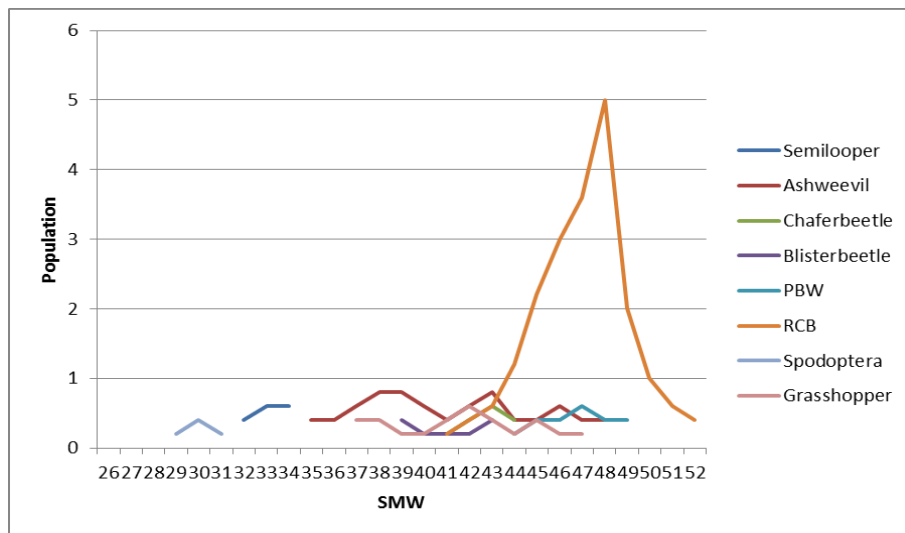


Fig 2: Seasonal occurrence of foliage feeders in *Bt* cotton ecosystem during 2016-17

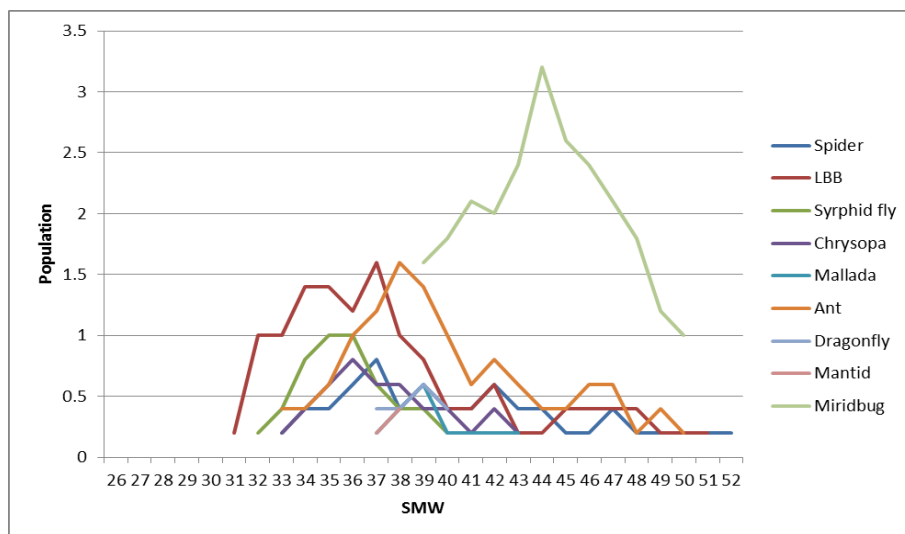


Fig 3: Seasonal occurrence of natural enemies in *Bt* cotton ecosystem during 2016-17

3.4 Correlation between insect population and weather parameters in *Bt* cotton ecosystem

The simple correlation studies recorded that there was a relationship between arthropod population and weather parameter in the *Bt* Cotton crop ecosystem (Table 2). Minimum temperature ($r = -0.730$), WS ($r = -0.548$) and RH II ($r = -0.547$) had a negative significant correlation with aphids population. Whereas, BSH showed a positive significant correlation ($r = 0.517$) with aphids population. Evaporation showed a positive significant correlation ($r = 0.587$) with thrips population. Maximum temperature ($r = 0.918$) and BSH ($r = 0.824$) showed positive significant correlation with semiloopers population. Whereas, RH I ($r = -0.910$), RH II ($r = -0.804$) and RF ($r = -0.989$) showed a negative significant correlation with semiloopers population. Minimum temperature ($r = -0.665$) and RH II ($r = -0.676$) showed negative significant correlation with population of mite. Whereas, BSH ($r = 0.647$) and evaporation ($r = 0.818$) had significantly positive correlation with mite population. Maximum temperature ($r = 0.496$) and minimum temperature ($r = 0.505$) had positive significant correlation with mealy bug population. Whereas, BSH ($r = -0.604$) showed significant negative correlation with mealy bug population. Maximum temperature showed positive significant correlation ($r = 0.612$) with blister beetle. Whereas, WS ($r = -0.536$) and RH II ($r = -0.547$) showed a significantly negative correlation

with blister beetles population. WS showed a negative significant correlation ($r = -0.533$) with red cotton bug population. Maximum temperature ($r = -0.871$), minimum temperature ($r = -0.540$), WS ($r = -0.704$) and evaporation showed a significantly negative correlation with population of pink boll worm. Minimum temperature ($r = 0.663$), WS ($r = 0.798$) and evaporation ($r = 0.496$) showed positive significant correlation with lady bird beetles population. RF ($r = -0.529$) showed negative correlation with syrphid flies population. Minimum temperature ($r = 0.663$), WS ($r = 0.798$) and RH II ($r = 0.491$) showed a significantly positive correlation with population of spider. Maximum temperature ($r = 0.767$) and BSH ($r = 0.571$) showed a positive significant correlation with population of chrysopa. Whereas, Minimum temperature ($r = -0.825$), WS ($r = -0.411$), RH I ($r = -0.598$) and RH II ($r = -0.870$) showed negative significant correlation with chrysopa population. RF ($r = 0.529$) showed significantly positive correlation with mallada population. Whereas, BSH ($r = -0.637$) showed negative significant correlation with mallada population. Minimum temperature ($r = 0.612$), RH II ($r = 0.504$) and RF ($r = 0.539$) showed positive significant correlation with ant population. RH I ($r = 0.740$), RH II ($r = 0.500$) and RF ($r = 0.852$) showed positive significant correlation with dragonfly population. Whereas, Maximum temperature ($r = -0.483$), WS ($r = -0.752$) and evaporation ($r = -0.652$) showed negative significant

correlation with dragonfly population. In *Bt* cotton genotypes, maximum and minimum temperature showed significant and positive effect on whitefly population, whereas the relative humidity exerted a negative effect during 2010 [9]. During 2011, the effect of all the factors was not noticed. On a cumulative basis, there was a positive non-significant correlation between population of whitefly and minimum temperature. During the present investigations also whitefly had non-significant weak correlations with abiotic factors

except evaporation (r 0.467). A weak but negative correlation was noticed with RH I which is in tune to the previous finding.

Rain fall had negative but weak correlation with whitefly. Whereas, minimum temperature, relative humidity and bright sunshine hour showing positive but weak correlation with whitefly population [10]. BSH had a weak negative correlation with leafhoppers which endorsed the present investigations.

Table 2: Correlation between arthropod population and weather parameters in *Bt*. cotton ecosystem in Akola during the *kharif* 2016

Insect	T MAX	T MIN	BSH	WS	RH I	RH II	Evap	RF
Leafhopper	0.026	0.397*	-0.026	0.351	-0.155	0.180	0.466*	-0.272
Whitefly	0.174	0.328	0.059	0.229	-0.133	0.101	0.467*	-0.249
Aphid	-0.072	-0.730**	0.517**	-0.548**	-0.064	-0.547**	-0.317	-0.361
Thrips	0.221	0.142	0.268	0.228	-0.145	-0.074	0.587**	-0.314
Semilooper	0.918**	-0.336	0.824**	0.334	-0.910**	-0.804**	0.479*	-0.989**
Ashweevil	0.417*	0.289	-0.220	0.262	0.198	0.124	0.124	0.316
Mite	0.277	-0.665**	0.647**	0.775*	0.063	-0.676**	0.818**	-0.138
Mealybug	0.496**	0.505**	-0.604**	0.161	-0.472*	-0.179	-0.105	-0.093
Grasshopper	0.045	0.339	0.004	0.230	0.107	0.164	0.179	0.081
Blisterbeetle	0.612**	-0.475*	0.144	-0.536**	-0.387*	-0.547**	-0.020	-0.184
RCB	0.122	-0.472*	0.373	-0.533**	-0.240	-0.451	-0.115	-0.407*
Chaffer beetle	0.917**	-0.737**	0.907**	-0.510**	-0.775**	-0.860**	0.744**	-0.857**
PBW	-0.871**	-0.540**	-0.109	-0.704**	0.365	-0.068	-0.701**	-
LBB	-0.054	0.663**	-0.402*	0.798**	0.043	0.471*	0.496**	-0.033
Syrphid fly	0.112	0.402*	-0.034	0.366	-0.392	-0.022	0.259	-0.529**
Spider	0.257	0.669**	-0.262	0.488**	0.394*	0.491**	0.448*	0.382*
Chrysopa	0.767**	-0.825**	0.571**	-0.411*	-0.598**	-0.870**	0.130	-0.456**
Ant	0.193	0.612**	-0.481*	0.351	0.380	0.504**	0.146	0.539**
Mallada	0.025	0.395*	-0.637**	-0.023	0.389*	0.316	-0.405*	0.529**
Dragonfly	-0.483**	0.269	-0.369	-0.752**	0.740**	0.500**	-0.652**	0.852**
Miridbug	0.433*	0.102	0.220	-0.160	-0.569**	-0.193	0.613**	-0.172

* Significant correlation at 5% ($r = 0.381$), ** Significant correlation at 1% ($r = 0.487$)

Table 3: Shannon biodiversity index of arthropod fauna in *Bt*. cotton ecosystem in Akola during the *kharif* 2016

Name of Species	Av.no. of insect recorded	Percent abundance	Pi	ln Pi	Pi ln Pi
Leafhopper	66.34	13.74	0.137	-1.985	-0.273
Whitefly	41.79	8.65	0.087	-2.447	-0.212
Aphid	182.60	37.81	0.378	-0.973	-0.368
Spodoptera	0.80	0.17	0.002	-6.403	-0.011
Thrips	33.63	6.96	0.070	-2.665	-0.186
Semilooper	1.60	0.33	0.003	-5.710	-0.019
Ashweevil	7.60	1.57	0.016	-4.152	-0.065
Mite	40.00	8.28	0.083	-2.491	-0.206
Mealybug	4.25	0.88	0.009	-4.733	-0.042
Grasshopper	3.60	0.75	0.007	-4.899	-0.037
Blisterbeetle	1.40	0.29	0.003	-5.844	-0.017
RCB	20.20	4.18	0.042	-3.174	-0.133
Chaferbeetle	1.60	0.33	0.003	-5.710	-0.019
PBW	2.40	0.50	0.005	-5.305	-0.026
LBB	13.60	2.82	0.028	-3.570	-0.101
Syrphid fly	5.60	1.16	0.012	-4.457	-0.052
Spider	7.40	1.53	0.015	-4.179	-0.064
Chrysopa	6.60	1.37	0.014	-4.293	-0.059
Ant	12.40	2.57	0.026	-3.662	-0.094
Mantid	1.60	0.33	0.003	-5.710	-0.019
Mallada	2.00	0.41	0.004	-5.487	-0.023
Dragonfly	1.80	0.37	0.004	-5.592	-0.021
Miridbug	24.20	5.01	0.050	-2.994	-0.150
Total	483.01			H' =	2.193

3.5 Shannon biodiversity index of arthropod fauna in *Bt* cotton crop ecosystem

Shannon diversity index (Table 3) revealed that the percent abundance of sucking pests *viz*; cotton aphids *Aphis gossypii* was 37.80 percent followed by leafhopper (13.74%),

whiteflies (8.6%), mite (8.28%) and thrips (6.96%) in descending order. Thus, the sucking pests complex shared more than 75 percent population of arthropod fauna. Red cotton bug; a stainer on cotton boll shared (4.18 percent). Population of the pink boll worm was meager (0.50

percent). Among the predators mirid bug showed 5.01 per cent, LBB (2.82%), ant (2.57%), syrphid fly (1.16%), chrysopa (1.37%) and mallada (0.41%). Spider shared (1.53%) abundance and had more species diversity. A rich Shannon diversity index ($H' = 2.193$) was recorded in *Bt* cotton ecosystem at Akola comprising twenty three different arthropods fauna.

5. Conclusions

Under Akola conditions of Maharashtra in the *Bt* cotton ecosystem no significant changing scenario is observed in terms of insect pests status. However, the population of predatory fauna seems to be declined. Activities of predatory spiders are a noteworthy. Abiotic factor plays an important role on the activities of both pests and predatory arthropods fauna. Biodiversity index of arthropods in Akola was moderate to rich.

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