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DIVERSITY AND ABUNDANCE OF BENEFICIAL AND HARMFUL ARTHROPODS IN BELL PEPPER

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Abstract

The study was conducted in the Entomology Research Field of Sylhet Agricultural University (SAU) campus, Sylhet and in the farmer's field of Sreemangal, Moulvibazarduring October 2017 to April 2018 to determine the abundance and diversity of beneficial and harmful arthropod communities in bell pepper. In SAU campus, 822 beneficial arthropods of 9 insect species (ladybird beetle, ground beetle, ant, damselfly, preying mantid, long legged fly, hoverfly, ichneumonid wasp, braconid wasp) and 3 spider species (lynx spider, wolf spider and jumping spider) and 715 harmful arthropods of 6 insect species (aphid, jassid, common cutworm, thrips, flea beetle, sting bugs) and 2 mite species (broad mite and white mite) were found. In Sreemangal, 616 beneficial arthropods of 7 insect species (ladybird beetle, ground beetle, damselfly, ant, hoverfly, ichneumonid wasp, braconid wasp) and 2 spider species (lynx spider, wolf spider) and 740 harmful arthropods of 10 insect species (aphid, jassid, common cutworm, thrips, European corn borer, flea beetle, pepper weevil, leafminer, sting bug, whitefly) and 3 mite species (white mite, two spotted spider mite, broad mite) were found. Higher diversity index and richness of beneficial arthropods was found in SAU campus whereas, higher diversity index and richness of harmful arthropods was found in Sreemangal. The results clearly indicated that bell pepper habitat of research station is more suitable than those of farmer's field.

***Keywords*:** *Capsicum*, ecosystem, insect, spider, mite.

Introduction

Bell pepper (*Capsicum annuum* L.),being a member of the family Solanaceae,is also known as sweet pepper, capsicum, pepper,chilli or paprika. It is a minor but valuable spice crop in Bangladesh. Because it is a vulnerable crop to high night temperature, the production of bell pepper has been facing many production challenges (Rylski and Spigelman, 1982). Apart from environmental extremities, the occurrence of insect and mite pests has also been reported as major production limiting factors of bell pepper in many countries of the world (ACIAR, 2013). For example, chilli thrips (*Scirtothrips dorsalis* Hood), cotton aphid (*Aphis gossypii*), cotton leafhopper (*Amrasca devastans*), silverleaf, whitefly (*Bemisia tabaci*), papaya mealybug (*Paracoccus marginatus*), green vegetable bug (*Nezara viridula*), common cutworm (*Spodoptera litura* Fab.), gall fly (*Asphondylia capsici*), agromyzid leafminers, wireworm and weevils have been found to attack bell pepper (ACIAR, 2013). Several mite species viz., bean spider mite (*Tetranychus ludeni*), two-spotted spider mite (*T. urticae*) and broad mite (*Polyphagotarsonemus latus*) have also been recorded as the pests of bell pepper (ACIAR, 2013). Besides harmful arthropods, several beneficial insect and spider species have been reported from the world over. For example, ladybird beetles, predatory ground beetles, rove beetles, predatory bugs such as pirate bug (*Orius* spp.) feeds on thrips, caterpillar eggs and very small larvae, big-eyed bug (*Geocoris lubra*) fast-moving, daytime hunter of soft-bodied insects, caterpillar eggs and very small larvae, predatory shield bug (*Oechalia schellenbergii*) feeds mainly on caterpillars and can prey on quite large caterpillars. In addition, lacewings like green lacewing (*Malladas ignata*) and brown lacewing (*Micromus tasmaniae*) have been found in bell pepper field. Predatory thrips (*Haplothrips victoriensis*, *Scolothrips rhagebianus*), wasps, earwigs, ants and preying mantids have also been found in chili field (ACIAR, 2013).The farmers of Bangladesh often improperly use toxic insecticides like cypermethrin, lambda-cyhalothrin, dimethoate, chlorpyrifos, and mixture of thiamethoxam and chlorantranili prolein order to manage various pests of high-value vegetable crops. As a result, many pests have developed resistance against toxic insecticides (Rahman *et al*., 2013).

This adverse situation has prompted researchers to find out some alternative solutions to traditional toxic pesticides. The use of biocontrol and bio-rational management techniques could be achieved through reducing application frequency of toxic pesticides and conserving beneficial insect and spider species in agro-ecosystem. As such, sex-

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pheromone and other bio-rational management practices like soaps, oils, botanical extracts, parasitoids and natural enemies, etc. have been used as effective techniques against eggplant shoot and fruit borer pest (Mazumder *et al*., 2010). Trichogrammatid wasps (*Trichogramma* spp.) have been used to control the lepidopteran insect pests worldwide. The members of the genus *Trichogramma* are egg parasitoids which have been extensively used as inundative release organism in biocontrol program worldwide (Miranda *et al*., 2011). These egg parasitoids have been used to parasitize the eggs of cotton bollworm, codling moth, light brown apple moth and European corn borer (Knutson, 1998). *Bracon hebetor* is a larval parasitoid of many lepidopteran pests. This larval parasitoid paralyzes the late instar larvae of Indian meal moth, *Plodia interpunctella*; Mediterranean flour moth, *Ephestia kuehniella* and almond moth, *Cadra cautella* (Alam *et al*., 2014). In order to develop environment friendly pest management options, abundance and diversity of both beneficial and harmful arthropods dwelling in bell pepper ecosystem needs to be determined. Keeping these in view point, an attempt was made to determine the abundance and diversity of beneficial and harmful arthropods inresearch field and farmer's field of bell pepper, respectively in Sylhet and Moulvibazar.

Materials and Methods

Study sites

The experiment was conducted in the Entomology Research Field of Sylhet Agricultural University (SAU) campus and farmer's field of Sreemangal, Moulvibazar during October 2017 to April 2018. The hybrid variety 'Omaxe' of bell pepper were used to grow bell pepper. Seeds were purchased from the local market of Sylhet. SAU campus is located on north-east corner of Bangladesh lying between 23°57′ to 25°13′ North latitude and 90°56′ to 92°21′ East longitude. Soil pH is 5.47. Sreemangal site is located between 24°08' and 24°28' North latitude and between 91°36'and 91°48' East longitude. The soil texture of the experimental field is sandy loam. Soil of the Sreemangal site is deep brown with highly acidic (Rahman and Khondoker, 2001). The climate of both the experimental sites falls under the sub-tropical climate which is characterized by high temperature, high humidity and heavy rainfall.

Sampling and identification of arthropods

Arthropod individuals were sampled from bell pepper field in SAU campus at 9.00 am and farmer's field in Sreemangal at 11.00 am. Nylon sweep net (30 cm dia.) were used to sample arthropods. In each plot, 25 complete sweeps were made to collect one sample and sampling was done at seedling stage, vegetative stage and fruiting stage of bell pepper. The collected samples were brought to the Laboratory of Entomology, Faculty of Agriculture, SAU, Sylhet for sorting and identification of the arthropod specimens. The specimens were identified to common name, family and order using photos and keys described in Lawrence *et al*. (1999), Goulet and Huber (1993), Hamasaki *et al*. (2008) and Chapman (2013). In case of borer pests, data were collected from randomly selected five plants from each plot and the average was calculated. The first data were collected at 20 days after transplanting (DAT) of seedlings in the main research fields and continued up to the end of cropping season at 20-day intervals.

Total number of beneficial and harmful arthropods

Total number of beneficial and harmful arthropods was calculated by adding the individuals collected from seedling, vegetative and fruiting stages of the crop.

Abundance of beneficial and harmful arthropods

The abundance of beneficial and harmful arthropods was calculated using the following formula:

$$\text{Abundance} = \frac{\text{Total no. of individuals in each species}}{\text{Total no. of replication}}$$

Relative abundance of beneficial and harmful arthropods

The relative abundance of beneficial and harmful arthropods was calculated using the following formula:

$$\text{Relative abundance (\%)} = \frac{\text{Total no. of individuals of each species}}{\text{Total no. of individuals of all species}} \times 100$$

Shannon-Weaver Diversity Index

Shannon-Weaver Diversity Index (H′) was used to measure the diversity of beneficial and harmful arthropods (Shannon & Weaver, 1963).The H′ is the direct method of determining the diversity of different pest and beneficial insect between two locations. The H' ranges from 0 to 1, where 1 indicates the maximum diversity. Jamago (2000) classified the diversity of mungbean based on morphological characters as high (H′=>0.750), moderate (H′= 0.50-0.75) and low (H′ = <0.50). The higher the diversity index, the more is the diverse the population. Shannon-Weaver Diversity Index is defined by the formula (Li *et al*., 1996).

$$H' = -\sum_{i=1}^{n} Pi * \log_2 (Pi)/\log_2 (n)$$

Where, P_i is the proportion of the total number of entries belonging to the ith species and n is the number of natural enemies. The relative frequencies for the different species were used to calculate the diversity index. The H′ for each of the species was calculated using Microsoft Excel.

Species richness

To provide a cohesive overview of species richness, Margalef's Index was also calculated along with S (actual number of species collected). Margalef's index (Margalef, 1958) assumes a theoretical relationship between the number of individuals (N) and the number of species (S) in a sample and is expressed as follows:

$$\text{M.I.} = \frac{S-1}{\log_e N}$$

The index logarithmically scales the value of S, and hence provides a means of comparison between stations with different ratios of S and N.

Equitability or Evenness

Equitability is considered a component of diversity, in that it provides an idea about the evenness of species distribution at a given site. Usually a positive correlation exists between diversity and equitabilityi.e. a high equitability would indicate a high diversity and probably a healthy condition of a fauna. Pielou's (1966) method of measuring equitability is mostly used. The computational formula is below:

$$J = \frac{H}{\log_e S}$$

Where, H = Shannon's index, S = Total species

Results and Discussion

Abundance of beneficial arthropods

The list of total number of beneficial insect and spider species collected and identified from the seedling, vegetative and fruiting stages of bell pepper in SAU campus and Sreemangal site is presented in Table 1.

Table 1. Total number of beneficial arthropods in SAU campus and Sreemangal during October 2017 to April 2018

Sl No.	Beneficial arthropods	SAU campus				Beneficial arthropods	Sreemangal			
		Seedling Stage	Vegetative Stage	Fruiting Stage	Total		Seedling Stage	Vegetative Stage	Fruiting Stage	Total
1	Ant	20	33	49	102	Ant	23	42	19	84
2	Braconid wasp	2	5	40	47	Braconid wasp	3	9	45	57
3	Damselfly	7	20	31	58	Damselfly	2	30	64	96
4	Ground beetle	11	10	9	30	Ground beetle	7	13	16	36
5	Hoverfly	6	18	33	57	Hover fly	12	13	27	52
6	Ladybird beetle	17	53	71	141	Ichneumonid wasp	1	1	22	24
7	Long legged fly	11	57	83	151	Ladybird beetle	2	47	62	111
8	Ichneumonid wasp	3	8	15	26	Lynax spider	3	26	22	51
9	Preying mantid	10	15	15	40	Wolf spider	1	38	66	105
10	Lynx spider	5	17	36	58	-	-	-	-	-
11	Wolf spider	7	12	40	59	-	-	-	-	-
12	Jumping spider	11	14	28	53	-	-	-	-	-
	Total	110	262	450	822		54	219	343	616

The total number of beneficial insect and spider species in SAU campus of three growth stages was ranked as fruiting stage (450)> vegetative stage (262)> seedling stage (110). The total number of individual beneficial insect and spider species were recorded in SAU campus which was ranked as long legged fly (151)> ladybird beetle (141)> ant (102)> wolf spider (59)> lynax spider (58)> damselfly (58)> hoverfly (57)> jumping spider (53)> braconid wasp (47)> preying mantid (40)> ground beetle (30)> ichneumonid wasp (26). The total number of beneficial insect and spider species in Sreemangal of three growth stages was ranked as fruiting stage (343)> vegetative stage (219)> seedling stage (54). The total individual number of beneficial insects and spider species was ranked as ladybird beetle (111)> wolf

spider (105)> damselfly (96)> ant (84)> hoverfly (52)> lynax spider (51)> ground beetle (36)> ichneumonid wasp (24). The total number of pest insect and mite species of three growth stages was ranked as fruiting stage (574)> vegetative stage (184)> seedling stage (18).

Abundance of harmful arthropods

The list of total number of harmful insect and mite species collected and identified from the seedling, vegetative and fruiting stages of bell pepper in SAU campus and Sreemangal site is presented in Table 2. The total number of harmful insect and mite species of three growth stages was ranked as fruiting stage (516)> vegetative stage (194)> seedling stage (5) in SAU campus. The total individual number of harmful insect and mite species found in SAU site was ranked as aphid (293)> jassid (102)> white mite (84)> thrips (80)> broad mite (56)> common cutworm (55)> flea beetle (32)> sting bug (13).The total number of harmful insect and mite species in Sreemangal of three growth stages was ranked as fruiting stage (519)> vegetative stage (203)> seedling stage (18). The total individual number of harmful insects and mite species was ranked as aphid (286)> common cutworm (113)> jassid (105)> white mite (57)> sting bug (49)> thrips (38)> European corn borer (36)> leafminer (15)> two spotted spider mite (14)> flea beetle (12)> broad mite (6)> pepper weevil (6) and whitefly (3).

Table 2.Total number of harmful arthropods in SAU campus and Sreemangal during October 2017 to April 2018

Sl No.	Harmful arthropods	SAU campus				Harmful arthropods	Sreemangal			
		Seedling Stage	Vegetative Stage	Fruiting Stage	Total		Seedling Stage	Vegetative Stage	Fruiting Stage	Total
1	Aphid	0	91	202	293	Aphid	0	76	210	286
2	Thrips	0	8	72	80	Common cutworm	0	27	86	113
3	Jassid	0	26	76	102	European corn borer	0	24	12	36
4	Common cutworm	0	10	45	55	Flea beetle	3	3	6	12
5	Sting bug	2	8	3	13	Jassid	0	30	75	105
6	Flea beetle	3	17	12	32	Leaf miner	7	2	6	15
7	Broad mite	0	0	56	56	Pepper weevil	0	3	3	6
8	White mite	0	34	50	84	Sting bug	3	2	44	49
9	-	-	-	-	-	Thrips	4	14	20	38
10	-	-	-	-	-	Whitefly	0	1	2	3
11	-	-	-	-	-	Broad mite	0	0	6	6
12	-	-	-	-	-	Two spotted spider mite	1	3	10	14
13	-	-	-	-	-	White mite	0	18	39	57
	Total	5	194	516	715		18	203	519	740

Relative abundance of beneficial arthropods

The relative abundance of beneficial arthropods in SAU campus was ranked as long legged fly (18.37%)> ladybird beetle (17.15%)> ant (12.41%)> wolf spider (7.18%)> lynx spider (7.06%) and damsel fly (7.06%)> hoverfly (6.93%)> jumping spider (6.45%)> braconid wasp (5.72%)> preying mantid (4.87%) > ground beetle (3.65%)> ichneumonid wasp (3.16%). The relative abundance of beneficial insect and spider species in Sreemangal site was ranked as ladybird beetle (18.02%)> wolf spider (17.05%)> damsel fly (15.58%)> ant (13.64%)> braconid wasp (9.25%)> hoverfly (8.44%)> lynx spider (8.28%)> ground beetle (5.84%)> ichneumonid wasp (3.90%).

Relative abundance of harmful arthropods

The relative abundance of harmful arthropods in SAU campus was ranked as aphid (40.98%)> jassid (14.27%) > white mite (11.75%) > thrips (11.19%) > broad mite (7.83%)> common cutworm (7.69%)> flea beetle (4.48%)> sting bug (1.82%). The harmful insect and mite species in Sreemangal was ranked as aphid (38.65%) > common cutworm (15.27%) >jassid (14.19%) > white mite (7.70%) > sting bug(6.62%)> thrips (5.14%)> European corn borer (4.86%) > leafminer (2.03%) > two spotted spider mite (1.89%)> flea beetle (1.62%)> pepper weevil (0.81%)> broad mite (0.81%)> whitefly (0.41%) .

Diversity indices of beneficial arthropods

The diversity indices of beneficial insect and spider species as per order in SAU campus and Sreemangal are presented in Table 3. The diversity of beneficial insect and spider varied from low to high between SAU campus and Sreemangal (0.30 - 0.71).

Table 3. Diversity indices of beneficial arthropods as per order in SAU campusand Sreemangalduring October 2017 to April 2018

Sl No.	Order	SAU campus			Order	Sreemangal		
		Diversity Index(H′)	Evenness (J)	Richness (M.I.)		Diversity index(H′)	Evenness (J)	Richness (M.I.)
1	Araneae	0.50	0.47	0.67	Araneae	0.30	0.32	0.67
2	Coleoptera	0.61	0.56	0.65	Coleoptera	0.68	0.72	1.2
3	Diptera	0.71	0.66	0.62	Hymenoptera	0.50	0.52	0.83
4	Dictyoptera	0.0	0.0	0.0	Isoptera	0.0	0.0	0.0-
5	Hymenoptera	0.39	0.36	0.85	Odonata	0.0	0.0	0.0
6	Isoptera	0.0	0.0	0.0	-	-	-	-
7	Odonata	0.0	0.0	0.0	-	-	-	-

Diversity indices of harmful arthropods

The diversity indices of harmful insect and mite species as per order are presented in Table 4. The diversity of harmful insect and mite species varied from low to high between SAU campus and Sreemangal (0.15 - 0.65).

Table 4. Diversity indices of harmful arthropods as per order in SAU campus and Sreemangal during October 2017 to April 2018

Sl No.	Order	SAU campus			Order	Sreemangal		
		Diversity Index(H′)	Evenness (J)	Richness (M.I.)		Diversity index(H′)	Evenness (J)	Richness (M.I.)
1	Araneae	0.65	0.72	0.69	Araneae	0.29	0.26	1.72
2	Coleoptera	0.0	0.0	0.0	Coleoptera	0.15	0.14	1.70
3	Hemiptera	0.51	0.56	0.65	Diptera	0.0	0.0	0.0
4	Homoptera	0.0	0.0	0.0	Hemiptera	0.41	0.38	0.67
5	Lepidoptera	0.0	0.0	0.0	Homoptera	0.56	0.50	0.56
6	Thysanoptera	0.0	0.0	0.0	Lepioptera	0.51	0.46	1.40
7	-	-	-	-	Thysanoptera	0.0	0.0	0.0

Diversity indices of arthropods in two sites

Higher diversity index (0.93) and richness (3.77) of beneficial arthropods was found in SAU campus than diversity index (0.86) and richness (2.87) found in the farmer's field of Sreemangal site. Beneficial arthropods were more equitable in the farmer's field of Sreemangal (0.91) than in the SAU campus (0.85). In contrast to beneficial arthropods, higher diversity index (0.69) and richness (4.18) of harmful arthropods was found in Sreemangal than diversity index (0.55) and richness (2.45) found in SAU campus. Harmful arthropods were equally equitable (0.69) in two sites.

Relative abundance of arthropods in two sites

The relative abundance of beneficial species was higher in SAU campus (54%) than in the farmer's field of Sreemangal (45%). Conversely, the relative abundance of harmful species was higher in the farmer's field of Sreemangal (55%) than in the SAU campus (46%). Diversity as a community ecological concept refers to the heterogeneity in a community or assemblage of different organisms (Menzies *et al*.,1973). Thus diversity is dependent upon the number of species present (Species richness, S) and the distribution of all individuals among the species (Equitability or evenness) (Khan, 2013). It is generally accepted that more diverse and complex ecosystem in respect of more heterogeneous habitat attributes support more diverse and higher abundant arthropod community assemblage (Maleque *et al*., 2009). In the present study, the results showed that bell pepper ecosystem of SAU campus supported more abundant and diverse beneficial arthropods compared to those of the farmer's field in Sreemangal. This variation in arthropod abundance and diversity between SAU campus and Sreemangal might have caused due to the prevalence of differential landscape patterns between the two study sites. SAU campus is surrounded by Eco Park, tea gardens, hillocks and flat land ecosystems and thus it is more complex and heterogeneous habitat compared to that of the farmer's field in Sreemangal site. This may be one reason of more abundant arthropods prevailing in the bell pepper ecosystem of SAU campus. On the other hand, the landscape pattern of the farmer's field in Sreemangal is flat and less heterogeneous. As a result, this site supports less abundant arthropods. In respect of relative abundance of beneficial and harmful arthropods, bell pepper ecosystem of SAU campus supports more abundant beneficial arthropods. In contrast, bell pepper ecosystem of Sreemangal supports more abundant harmful arthropods. Higher abundance of harmful arthropods in the farmer's field of Sreemangal happens possibly due to more frequent application of pesticides by the local farmers. The probable indiscriminate use of pesticides in Sreemangal site could have reduced the number of beneficial arthropods. Thus, higher abundance of harmfularthropods exists there due to a lack of naturally pest regulating biocontrol arthropod species. Conversely, SAU campus and surrounding areas are most protected and application frequency of synthetic pesticides is minimal. This could be another reason of higher relative abundance of beneficial arthropods in SAU campus than those of Sreemangal site.

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