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Research Article

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Studies on Insect Fauna of Amaranthus and Loss Estimation Due to Major Defoliators

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ABSTRACT

The studies conducted at the College of Horticulture, UHS Bagalkot on amaranthus resulted in exploring 42 phytophagous species, 12 natural enemies and four pollinators from the ecosystem. Out of the phytophagous species, Spoladea (=Hymenia) recurvalis (Fabricius), Erectomocera impectella (Walker), Psara bassalis Walker, Helicoverpa armigera (Hubner), Spodoptera litura (Fabricius), Agrotis segetum (Denis and Schiffermuller) and Agrotis sp. and Spilarctia obliqua (Walker) were predominant defoliators. Lady bird beetles were the major predators while bees were the predominant pollinators when the crop was grown for seed purpose. The crop loss estimation due to Agrotis segetum (Denis and Schiffermuller) and Spoladea (=Hymenia) recurvalis (Fabricius) on Amaranthus, foliage damage and yield loss were assessed by comparing the different treatments like insecticide treated plot, net covered and untreated (open plot) plot. The least foliage damage (9.50 ± 7.40%) and higher leaf yields (23.78 ± 1.63 t/ha) were recorded in insecticide treated plot followed by net protected plot (with 12.50 ± 10.17% leaf damage, 21.82 ± 1.02 t/ha yield), and maximum foliage damage (34.25 ± 13.15%) and least yield (13.78 ± 2.12) were noticed in untreated plot).

Key words: *Amaranthus, Agrotis segetum, Spodolea recurvalis, Leaf damage and Foliage damage.*

INTRODUCTION

The Indian sub continent is the bowl of many vegetable crops. The leafy vegetables are the most important group under vegetable crops widely grown in India around the year and cultivated as minor crops in many parts of the world (Mexico, Guatemala, Peru, India, Nepal, *etc*.,). In India, leafy vegetables are grown mostly in Himachal Pradesh, Gujarat, Maharashtra, Punjab, West Bengal, Haryana, Madhya Pradesh, Delhi, Bihar, Uttar Pradesh and Karnataka[6]. These leafy vegetables are short duration crops with high productivity. The most important leafy vegetables are amaranthus (*Amaranthus tricolor* L.), fenugreek (*Trigonella foenum-graecum* L.) and palak (*Beta vulgaris* var. *bengalensis* Hort.). There are several species under the genus *Amaranthus* which belongs to the family Amaranthaceae. During the past one decade, there has been a sharp rise in the demand and consumption of amaranthus[5].

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This can be attributed to increased awareness about the importance as a valuable source of food, medicine and income for all small-scale farmers[17,20]. Popularity of amaranthus is due to its early maturity, palatability and high nutritive value, as this is a good source of vitamins and minerals, being exceptionally rich in calcium, magnesium, iron, phosphorus, β-carotene and folic acid containing higher grain protein (13-19%), with high lysine (6.09/100g protein) and other sulphur containing amino acids (4.4%) which are limiting factors in the conventional food grains[13].

Hence, daily inclusion of amaranthus in the diet of children can help to alleviate the blood haemoglobin level. Amaranth grain has 6 to 10 per cent of oil, which is found in the germ[10]. Predominantly, it is unsaturated oil (76%) and linoleic acid is in high quantity, which is very much essential for human nutrition. Therefore, the regular consumption of amaranthus reduces the blood pressure, cholesterol levels and improves the body's antioxidant status and immunity[16]. Amaranthus is a crop with multiple uses; its tender leaves are used as vegetable, while grain is being used in different culinary preparation and elaborately in various bakery products and lysine rich baby foods. It has great potential for application in high quality plastics, cosmetics, pharmaceuticals and natural dyes. Tribals of India use grain for treatment of measles and snake bites as well as for foot and mouth diseases in animals[13]. In amaranthus, beet worm and weevils cause significant damage and reduce the yield drastically up to 94 and 92 per cent[10]. Insect pests are the major constraints in the cultivation of amaranthus. As the detailed studies on insects infesting amaranthus were lacking, so the present study was initiated.

MATERIAL AND METHODS

The experiments were studied during the year 2013- 2014 at College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka by conducting the roving survey on and off the campus farmers fields in and around Bagalkot throughout the year. The insect pests, pollinators and natural enemies were collected from the amaranthus at regular interval of 10 days. Slow moving and sedentary insects were collected by hand using the poison bottle. The plants were searched visually for possible insect pests and encountered specimens were collected in vials containing 70 per cent alcohol (immature and soft bodied insects), labelled and taken to the laboratory. Beating sheets were used to collect camouflaged or hidden insect pests, where in a small sheet was placed beneath the plants and the insect pests were knocked down by shaking the plants on to the sheet. Then the insects were picked up from the sheet with aid of a hand lens (for minute insects) and forceps and placed into vials. Flying insects were collected using aerial nets. Insect pests were preserved for identification, after confirming their feeding habit by following standard Entomological tools and techniques. At the same time, the natural enemies noticed were also recorded and preserved. The insect specimens so collected were got identified by Dr. C. A. Viraktamath, Principal investigator, Network Project on Biosystematics, Department of Entomology, GKVK, UAS, Bangalore. To find out the extent of loss due to major defoliators on amaranthus. The crop was grown over an area of 300 m^2 and size of each plot was 3m × 2m. Each field was divided in to three equal plots. Each plot was replicated four times, in each field 12 plots were maintained. After randomization, four plots were treated with fipronil 5% SC @ 1ml/l of water by using knapsack sprayer after 15 days and 30 days of sowing. Four plots were covered with shade net with the help of pegs and strings. In addition, four plots were fully exposed to the environment, without any control measures. In each plot, 10 plants were randomly selected to record percentage of foliage damage inflicted by the defoliators. Percentage of foliage damage was also recorded before and after spray as follows:

Grade 0 - No damage
Grade 1 - 1 to 20 per cent damage
Grade 2- 21 to 40 per cent damage

Grade 3 - 41 to 60 per cent damage
Grade 4- 61 to 80 per cent damage
Grade 5 - 81 to 100 per cent damage

After harvesting of leaf, biomass (fresh leaf weight) was recorded. Based on the market price, extent of monitory loss was calculated. The data collected were analyzed statistically using paired t-test.

RESULTS AND DISCUSSION

Observations made on amaranthus during 2013-14 at an interval of 10 days revealed totally 42 species of insect pests, 12 natural enemies and four pollinators belonging to the orders Lepidoptera (14 species), Coleoptera (11 species), Orthoptera (6 species), Hemiptera (16 species), Hymenoptera (5 species), Mantodea (2 species), Diptera (1 species), Thysanoptera (1species) and Odonata (1 species) were noticed. The whole complex of faunistic diversity of amaranthus is presented in Table 1.

Insect defoliators

i. Amaranthus leaf webber, *Spoladea* (=*Hymenia*) *recurvalis* (Fabricius): Adult is a dark brownish black moth with white markings on the wings. The female laid spherical white eggs in groups on veins and under surface of the leaves under field conditions. Caterpillars are greenish in colour with whitish wavy lines and black crescents on thorax below lateral line. Larvae scraped the epidermal tissues of leaves, webbed the leaves with the silken threads resulting in drying of webbed leaves. A fully grown up larva pupated in the web or soil. *S. recurvalis* has been reported to feed on the amaranthus by several workers *viz.*, Batra and Bhattachargee[4], David and Kumarswamy[8], Bose *et al*[6]., Rao *et al*[22]., Shirai[24], Srivastava and Butani[25], James *et al*[12]., Parvathareddy[21], Garcia *et al*[10]., Oliveira *et al*[19]., Aderolu *et al*[1]., and Kagali *et al*[14].

ii. Leaf folder, *Erectomocera impectella* (Walker): Adult moth is small blackish with prominent yellow spots on the fore wings. Fully grown up caterpillars are cylindrical, brownish grey in colour. Caterpillars webbed the leaves of amaranthus with silken threads and remained hidden in folds feeding from inside. This has been reported on amaranthus by earlier workers[3,10].

iii. Leaf webber, *Psara bassalis* Walker: Adults are small with yellowish, white thorax and abdomen with brownish red fore wings and dark brown hind wings. Fully fed caterpillar is greenish in colour. Larvae scraped the epidermal tissues on amaranthus leaves, webbed them together with silken threads resulting in drying of webbed leaves. The leaf webber, *Psara bassalis* (Walker) has been reported on amaranthus by Srivastava and Butani[25], Garcia *et al*[10]., and Aderlou *et al*[1].

iv. Tomato fruit borer, *Helicoverpa armigera* (Hubner): Moth is medium sized, creamy yellow in colour with two black spots on the fore wings. Female laid eggs on under surface of the leaves in groups, after hatching the larvae scraped the surface of the leaf and grown up ones defoliated on amaranthus. Larvae become light greenish in colour when fully fed and pupation takes place in soil as well as plant debris and pupae are brownish in colour.

v. Tobacco cut worm, *Spodoptera litura* (Fabricius): The adult moths are medium sized with greyish brown forewings patterned with wavy markings and the hind wings are transparent with brown narrow band along the outer margins. Larvae become green to black in colour as they grow with two lateral bands. They were found defoliating on amaranthus throughout the cropping period and also reported by earlier workers[1,7,9,18,23,26] .

vi. Cutworms, *Agrotis segetum* (Denis and Schiffermuller) and *Agrotis* sp.: The moths are medium sized greyish in colour. Female laid eggs on under surface of the leaves in groups as well as singly. After hatching, the larvae started scrapping the ventral surface of the leaf and later acted as defoliator on amaranthus. Larvae become greenish to black grey in colour as they grow. Fully fed caterpillar pupated in the soil as well as in plant debris. Pupae are brown in colour. This pest has not been reported by earlier workers; hence it is placed as new record on

amaranthus. Further biological studies need to be conducted.

vii. Bihar hairy caterpillar, *Spilarctia obliqua* (Walker): Adult moth is medium sized with reddish brown spots on the wings. Female laid around 50 to 100 eggs on lower surface of the leaves. Larvae are brown coloured with red head with transverse band and tuft of yellow hairs at both the ends. Early instars of caterpillars scraped the chlorophyll content of leaf, later instars defoliated plants completely. The infested field looks like goat or cattle grazed. Grown up larvae form a thin silken cocoon with interwoven shed hairs of the larvae and pupate inside. Aderlou *et al*[1]., reported it on amaranthus.

viii. Legume pod borer, *Maruca vitrata* (Fabricius): The adult moth has light brown fore wings, with white patches and white hind wings with an irregular brown boarder. It often rests with the wings spread out; the wings are brownish black with clear markings. The caterpillars are pale green in colour and they are defoliators on amaranthus. Aderlou *et al*[1]., reported the pod borer on amaranthus.

ix. White migrant, *Catopsilia pyranthe* (Linnaeus): During the present study, *C. pyranthe* was noticed on amaranthus. Caterpillar is bright velvety-green in colour and it was found to defoliate. Adults are whitish in colour. This pest has not been reported by earlier workers and further studies need to be made.

x. Tiger moth, *Amata passalis* (Fabricius): The caterpillars were found to feed on leaves on amaranthus. Caterpillars were dusty coloured with greenish tinge and hairs on the body. The moths are brilliantly coloured. The pest has not been reported by earlier workers; hence further investigations need to be conducted.

xi. Hairy caterpillar, Lymantridae: Lepidoptera: A species of hairy caterpillar, *Euproctis* sp. was observed on amaranthus, fenugreek and palak. Larvae fed on leaves. They were solitary in nature. During present investigation, Hairy caterpillar, *Euproctis* sp. was observed on amaranthus and its acts as defoliator. The ploy phagous hairy caterpillars are recorded to feed on leafy vegetables for the first time and the detailed studies need to be undertaken.

xii. Grasshoppers: The following six species of grasshoppers *viz*., *Cyrtacanthacris tartarica* (Linnaeus) *Attractomorpha* sp., *Pyrgomorpha* sp., *Dittopternis* sp. and two unidentified species were observed on amaranthus. Both adults and nymphs were found to feed on leaves and cut the tender shoots. They are green to brown in colour. During present study, six species of grasshoppers, *Cyrtocanthacris tartarica* (Linnaeus), *Attractomorpha* sp. *Pyrgomorpha* sp. *Dittopternis* sp. and two unidentified species were recorded to feed on foliage of amaranthus. Both nymphs and adults were found to feed on foliage and shoots. *A. crenulata crenulata* has been reported on amaranthus[10].

xiii. Leaf miner, *Liriomyza* sp.: During the present investigation, amaranthus was infested by a species of leaf miner. Its infestation was more in the early stage of the crop compared to later stage. The maggots made mines on the leaves and such leaves become unfit for consumption. Kalra *et al*[15]., Balikai[2], Garcia *et al*[10]., and Aderlou *et al*[1]., observed *Melanogramyza* sp., *Amarauromyza abnormalis* (Mollach) and *Liriomyza brassicae* (Riley) on amaranthus.

xiv. Weevils, *Hypolyxius truncatullus* Fabricius, *Myllocerus viridanus* (Fabricius) *Myllocerus discolor* Boheman and Clerid beetle: The adults which were greenish white to grey in colour, which are fed on the leaves of amaranthus and made semicircular notches on the margin of leaves in 'U' shaped manner and results in decreased market value of the leafy vegetable**.**

xv. Leaf beetles, *Aulocophora foevicollis* Lucas, *Cryptocephalus sehestedti* Fabricius and *Altica* sp.: The adults which were shiny beetles fed on the leaves of amaranthus and made small holes resulting in decreased market value of the leafy vegetable.

Sucking pests

i. Aphids, *Aphis* sp.: The nymphs of *Aphis* sp. which are small brown in colour, were

observed on leaves and stems of amaranthus and fenugreek. Both nymphs and adults sucked the sap and caused yellowing and drying of leaves. They were found, congregating on under surface of the leaves and succulent stems of amaranthus, which conforms to the earlier reports of Srivastava and Butani[25].

ii. Thrips, ***Thrips* sp.:** During the present study, a species of thrips was noticed on amaranthus. The nymphs and adults sucked the sap from the terminal portion of the leaves as well as flowers by lacerating the tissues of amaranthus. These results are in agreement with David and Kumarswamy[8], Srivastava and Butani[25] and Aderlou *et al*[1].

iii. Red cotton bug, *Dystricius similis* (Freeman): During the present study larvae of *D. similis* were noticed to feed on amaranthus. Reddish bugs with white bands on the abdomen and black markings on the wings, were observed amaranthus during the present study. Nymphs and adults sucked the sap from the leaves and inflorescence, which is an agreement with Garcia *et al*[10].

iv. Plant bug, *Nezara virudula* Linnaeus: The bugs are green in colour. Both nymphs and adults used to insert their long stylets in to the leaves and tender shoots and sucked the sap on all the three hosts. Garcia *et al*[10]., also reported it on amaranthus.

v. Jewel bug, *Chrysocoris stolli* Wolf: The bugs are brilliantly coloured with extended scutellum over the hemielytra. Nymphs and adults used to insert their long stylets in to the leaves and tender shoots and suck the sap.

vi. White spotted stink bug, *Eysarcoris ventralis* (Westwood): The bugs are dark green coloured with extended scutellum over the hemielytra. They are small in size, both nymphs and adults used to insert their long stylets in to the leaves and tender shoots of and sucked the sap.

vii. Horned coreid bug, *Cletus* sp.: The bugs are small in size and were found sucking the sap on amaranthus. Both nymphs and adults used to insert their long stylets in to the leaves, tender shoots and flowers and sucked the sap.

viii. Painted bug, *Bagrada hilaris* (Burmeister): The bugs are black coloured with white markings on the hemielytra. Both nymphs and adults used to insert their long stylets in to the leaves, tender shoots and flowers and suck the sap. There are no earlier reports about this pest particularly occurring on amaranthus. Further studies need to be taken up especially on its breeding, feeding habit and habitations.

Natural enemies

During the period of investigation, totally 13 natural enemies were recorded in amaranthus ecosystem. A Dragonfly, three species of Preying mantids, a Tettigonid, a Reduvid bug, Assassin bug, Green lace wing, four species of Lady bird beetles, a Potter wasp were found in the amaranthus, out of which 12 were new records. There are no records regarding natural enemy complex in amaranthus except green lacewing.

Pollinators

During the present study, when a portion of crop was left for seed formation, different pollinators were noticed on leafy vegetables during the flowering stage. Totally three Hymenopterans and one Dipteran insect were recorded on the flowers of amaranthus, *viz*., Syrphid fly, (Diptera: Syrphidae), Rock bee, *Apis dorsata* Fabricius, Little bee, *Apis florea* Fabricius, Indian bee, *Apis cerana indica* Fabricius (Hymenoptera: Apidae).

The data on the foliage damage in three treatments were collected and subjected to paired t- test analysis. Foliage damage, yield and yield loss were assessed by comparing three different treatments *viz*., insecticide treated plot (fipronil 5% SC @ 1 ml/l of water), netted plot (plot was covered by net) and open plot (the whole plot was left as it is and no plant protection measures were taken). Among the three plots, significantly maximum per cent foliage damage of 34.54±13.15 was recorded in the open field and 12.50±10.17 per cent leaf damage was recorded in net protected plot. The least per cent leaf damage of 9.50±7.40 was recorded in the plots treated with fipronil 5% SC @ 1 ml/l of water (Table 2). The differences with respect to foliage

damage between chemical treated plot *v/s* open plot and net protected plot *v/s* open plots were statistically significant, while there was no significant difference with respect to foliage damage between chemical treated plot and net protected plot.

Highest foliage yield was recorded in the case of plots treated with fipronil 5% SC @ 1 ml/l of water (23.78±1.63 t/ha) followed by net protected plot (21.83±1.02 t/ha). Significantly lowest (13.78±2.12 t/ha) foliage yield was noticed in open plot (Table 3). The differences with respect to foliage yield between insecticide treated plot *v/s* open plot and chemical treated plot *v/s* open plots were statistically significant. Whereas, there was no significant difference with respect to foliage yield between chemical treated plot and net protected plot. The additional foliage yield in the plots treated with fipronil 5% SC @ 1ml/l of water was 10.00±2.67 tonnes per hectare over open plot, and in net protected plot it was 8.00±2.15 tonnes per hectare over open plot (fig. 1).

The highest per cent yield loss of 42.06±9.64 was recorded in open plot followed by net protected plot (8.63±2.78%). The differences with respect to per cent loss between chemical treated plot *v/s* open plot and insecticide treated plot *v/s* open plots were statistically significant. Whereas, there was no significant difference with regard to the per cent yield loss between chemical treated plot and net protected plot. Garcia *et al*[11]., who conducted field trial to find out the extent of loss due to defoliators on amaranthus, reported that cucurlionid, *H. truncatullus*, Noctuids, *S. exigua*, *H. catullus* and the Scaraboid, *P. crucicatca*, caused damage to the tune of 92, 94, 57 and 45 per cent, respectively.

Table 1: Insect pests, their natural enemies and pollinators observed on the amaranthus, during 2013-14

SI. No.	Insect pests	Scientific name	Order and family	Remarks
A. Defoliators				
1.	Amaranthus leaf webber	*Hymenia* (=*Spoladea*) *recurvalis* (Fabricius)	Lepidoptera: Crambidae	
2.	Turnip moth	*Agrotis segetum* (Denis and Schiffermueller)	Lepidoptera: Noctuidae	*
3.	Leaf webber	*Psara bassalis* (Walker)	Lepidoptera: Crambidae	
4.	Leaf webber	*Erectomocera impectella* (Walker)	Lepidoptera: Helionidae	
5.	Bean pod borer	*Maruca vitrata* (Fabricius)	Lepidoptera: Crambidae	
6.	Tobacco cutworm	*Spodoptera litura* (Fabricius)	Lepidoptera: Noctuidae	
7.	Cutworm	*Agrotis* sp.	Lepidoptera: Noctuidae	*
8.	Bihar hairy caterpillar	*Spilarctia obliqua* (Walker)	Lepidoptera: Arctiidae	
9.	White migrant	*Catapsilia pyranthe* (Linnaeus)	Lepidoptera: Pieridae	*
10.	Crimson speckled foot man	*Utetheisa pulchelloides* Hampson	Lepidoptera: Noctuidae	*
11.	Tiger moth	*Amata passalis* (Fabricius)	Lepidoptera: Arctiidae	*
12.	Tomato fruit borer	*Helicoverpa armigera* (Hubner)	Lepidoptera: Noctuidae	
13.	Hairy caterpillar	*Euproctis* sp.	Lepidoptera: Lymantridae	*
14.	Migratory bird locust	*Cyrtacanthacris tatarica* (Linnaeus)	Orthoptera: Arcididae	*
15.	Grasshopper	*Dittopternis* sp.	Orthoptera: Arcididae	*
16.	Slant faced grasshopper	*Attractomorpha* sp.	Orthoptera: Pyrgomrphidae	
17.	Grasshopper	*Pyrgomorpha* sp.	Orthoptera: Pyrgomorphidae	*

18.	Grasshopper	Unidentified	Orthoptera: Acrididae	*
19.	Grasshopper	Unidentified	Orthoptera: Acrididae	*
20.	Amaranthus stem weevil	*Hypolyxius truncatulus* Fabricius	Coleoptera: Curcurlionidae	
21.	Beetle	Unidentified	Coleoptera: Cleridae	
22.	Ash weevil	*Myllocerus viridanus* (Fabricius)	Coleoptera: Curcurlionidae	*
23.	Ash weevil	*Myllocerus discolor* Boheman	Coleoptera: Curcurlionidae	*
24.	Red pumpkin beetle	*Aulocophora foevicollis* Lucas	Coleoptera: Chrysomelidae	*
25.	Flea beetle	*Altica* sp.	Coleoptera: Chrysomelidae	*
26.	Flea beetle	*Cryptocephalus sehestedti* Fabricius	Coleoptera: Chrysomelidae	*
B. Sucking pests				
27.	Southern green stink bug	*Nezara virudula* (Linnaeus)	Hemiptera: Pentatomidae	
28.	Painted bug/ Bagrada bug	*Bagrada hilaris* (Brumeister)	Hemiptera: Pentatomidae	*
29.	White spotted stinck bug	*Eysarcoris ventralis* (Westwood)	Hemiptera: Pentatomidae	*
30.	Milk weed bug	*Spilostethus hospes* (Fabricius)	Hemiptera: Lygaeidae	*
31.	Swarming bug	*Graptostethus servus* (Fabricius)	Hemiptera: Lygaeidae	*
32.	Bug	*Nysius* sp.	Hemiptera: Lygaeidae	
33.	False cinch bug	*Pylorgus* sp.	Hemiptera:Lygaeidae	*
34.	Jewel bug	*Chrysocoris stolli* Wolf	Hemiptera: Scutellaridae	*
35.	Red cotton bug	*Dysdercus similis* (Freeman)	Hemiptera: Pyrrocoridae	*
36.	Lygaeid bug	*Spilostethus pandurus* (Scopoli)	Hemiptera: Lygaeidae	*
37.	Bug	*Antilochus* sp.	Hemiptera: Pyrrochoridae	*
38.	Horned coreid bug	*Cletus* sp.	Hemiptera: Coridae	
39.	Tree hopper	Unidentifed	Hemiptera:Membracidae	*
40.	Serpentine leaf miner	*Liriomyza* sp.	Diptera : Agromyzidae	
41.	Aphids	*Aphis* sp.	Hemiptera: Aphididae	
42.	Thrips	*Thrips* sp.	Thysanoptera: Thripidae	
C. **Natural enemies**				
1.	Dragonfly	Unidentified	Odonota: Libeullidae	*
2.	Preying mantid	*Mantis religiosa* (Linnaeus)	Mantodea: Mantidae	*

3.	Preying mantid	*Hierodula tenuidentata* Saussure	Mantodea: Mantidae	*
4.	Tettigonid	*Conocephalus* sp.	Orthoptera: Tettigonidae	*
5.	Three striped lady beetle	*Brumoides suturalis* (Fabricius)	Coleoptera: Coccinellidae	*
6.	Lady bird beetle	*Cheliomenes sexmaculata* (Fabricius)	Coleoptera: Coccinellidae	*
7.	Lady bird beetle	*Illieis cincta* (Fabricius)	Coleoptera: Coccinellidae	*
8.	Transverse lady beetle	*Coccinella transversalis* (Fabricius)	Coleoptera: Coccinellidae	*
9.	Potter wasp	*Rophalidia* sp.	Hymenoptera: Vespidae	*
10.	Reduvid bug	*Rhinocoris marginatus* Fabricius	Hemiptera: Reduvidae	*
11.	Assassin bug	*Rhinocoris* sp.	Hemiptera: Reduviidae	*
12.	Green lace wing	*Chrysoperla zastrowi sillemi*	Neuroptrea: Chrysopidae	
D. Pollinators				
1.	Flower fly	*Phytomia* sp.	Diptera: Syrphidae	
2.	Rock bee	*Apis dorsata* Fabricius	Hymenoptera: Apidae	
3.	Indian hive bee	*Apis cerena indica* Fabricius	Hymenoptera: Apidae	
4.	Little bee	*Apis florea* Fabricius	Hymenoptera: Apidae	

* - New record

Table 2: Comparative leaf damage and yield loss due to *Agrotis segetum* and *Spoladea recurvalis* in protected and open fields of amaranthus

SI. No.	Treatments	Per cent of leaf damage (Mean ± SD)	Test of significance (Paired t -test) (t @ 5%)	Leaf yield (t/ha) (Mean ± SD)	Test of significance (Paired t -test) (t @ 5%)	Per cent leaf yield loss (Mean ± SD)	Test of significance (Paired t -test) (t@5%)
1.	Insecticide treated plot *v/s*	9.50 ± 7.40	NS	23.68 ± 1.63	NS	00	-
	Netted plot	12.50 ± 10.17		21.82 ± 1.02		8.63 ± 2.78	
2.	Insecticide treated plot *v/s*	9.50 ± 7.40	2.203	23.33 ± 1.63	2.447	00	3.182
	Open plot	34.25 ± 13.15		23.33 ± 2.12		42.06 ± 9.64	
3.	Netted plot *v/s*	12.50 ± 10.17	2.023	21.82 ± 1.02	2.447	8.63 ± 2.78	
	Open plot	34.25 ±13.15		13.78 ± 2.12		42.06 ± 9.64	

Each value is the mean of four replications ; SD- Standard deviation

Table 3: Extent of leaf damage and yield loss due to *Agrotis segetum* and *Spoladea recurvalis* on amaranthus

SI. No.	Treatments	Per cent of leaf damage (Mean ± SD)	Damage range (%)	Leaf yield (t/ ha) (Mean ± SD)	Additional leaf yield over open plot (t/ha)	Per cent leaf yield loss over insecticide treated plots (Mean ± SD)
1.	Insecticide treated plot	9.50 ± 7.40	0-20	23.78 ± 1.63	10.00 ± 2.67	00
2.	Netted plot	12.50 ± 10.17	0-30	21.82 ± 1.02	8.04 ± 2.15	8.63±2.78
3.	Open plot	34.25 ± 13.15	10-50	13.78 ± 2.12	00	42.06±9.64

Each value is the mean of four replications ; SD- Standard deviation

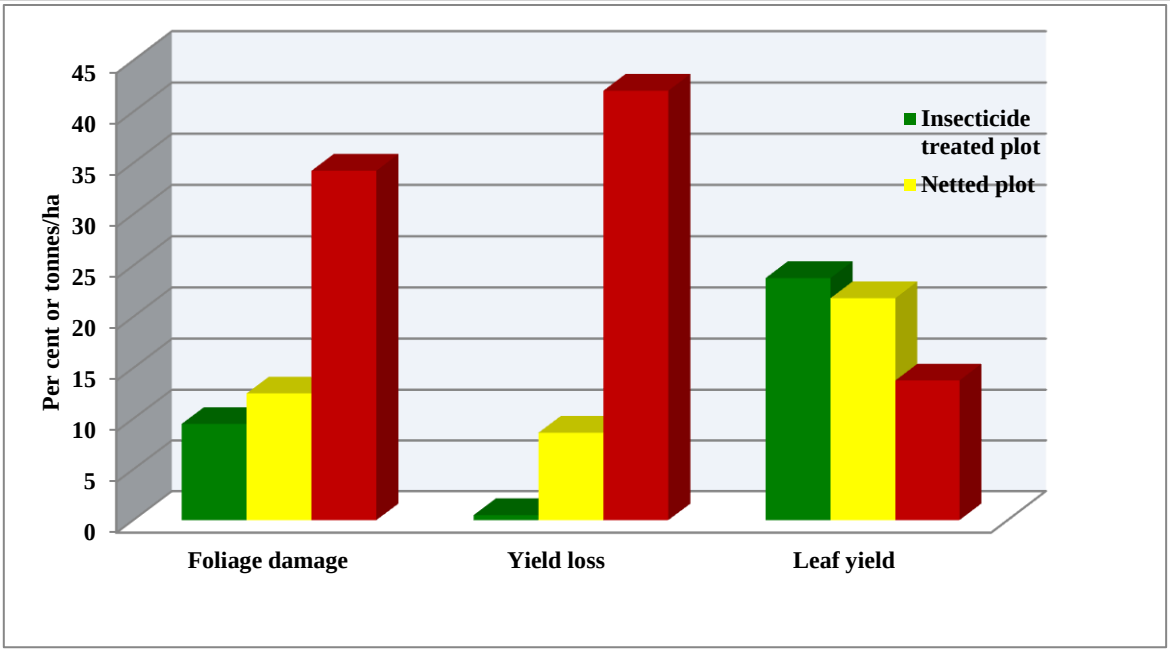

Fig. 1: Leaf damage, loss in foliage and leaf yield due to *Agrotis segetum* and *Spoladea recurvalis* on Amaranthus

CONCLUSION

During the present study, amaranthus was prone to attack by 42 species of insects, belonging to Lepidoptera, Coleoptera, Orthoptera and Hemiptera, out of which 27 were new records on amaranthus. Thirteen lepidopterous defoliators *viz*., *Spoladea* (=*Hymenia*) *recurvalis* (Fab.), *Spodoptera litura* Fab., *Agrotis segetum* (Denis and Schiffermuller), *Agrotis* sp. *Psara bassalis* Walker, *Maruca vitrata* (Fabricius), White migrant, *Catopsilia pyranthe* (Linnaeus). *Erectomocera impectella* (Walker), Tomato fruit borer, *Helicoverpa armigera* (Hubner), Bihar hairy caterpillar, *Spilarctia obliqua* (Walker), Tiger moth, *Amata passalis* (Fabricius), *Utethesia pulchelloides* Hampson, Hairy caterpillar, *Euproctis* sp. were noticed throughout the period of investigation. Six insect species *viz*., *A. segetum*, *C. pyranthe*, *U. pulchelloides*, *A. passalis*, *Euproctis* sp. were recorded for the first time on amranthus. Four species of bugs, *Chrysocoris stolli* Wolf, Red cotton bug, *Dysdercus similis*, White spotted stinck bug, *Eysarcoris ventralis* and painted bug, *Bagrada hilaris* (Burmeister) were noticed for the first time on amaranthus. Four species of lady bird beetles, *Brumoides suturalis*, *Cheliomenes sexmaculata*, *Illieis cincta* and *Coccinella transversalis*, species of preying mantids, *Mantis reliogosa* (Linnaeus) and *Hierodula tenuidentata* Sassure, a paper wasp, a dragonfly and tettigonid insect, were noticed in amaranthus ecosystem. Further detailed studies regarding the biology and extent of damage caused by the phytophagous species, the role of natural enemies in suppressing them need to be done.

Foliage damage and yield loss were assessed by comparing the different treatments like insecticide treated plot, net covered and untreated (open plot) plot. Higher leaf yields were recorded in insecticide treated plot and net protected plot. The least foliage damage was noticed in the insecticide treated plot followed by net protected plot, and maximum foliage damage was noticed in the untreated plot. Higher yield loss was recorded from the open plot compared to insecticide treated plot and net protected plot, indicating the economic loss and necessity to protect the crop.

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