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# Biodiversity of winter crop pests and predators

**Dr. Kalpana Sharma**
Associate Professor,Department Of Zoology
Govt. College , Ajmer

## ABSTRACT

At each stage of their development, several insects and mites cause harm to winter crops. On sometimes, new pests will be discovered that are distinct from the pests that have been found in the past. The farming community is concerned about both common and novel insect pests because of the potential risk that these insects provide to agricultural and horticulture crops (Sorensen, 1988 and Burt et al. 2014). The Daucus carota L. carrot, which is primarily targeted by a number of different kinds of leafhoppers (Kenneth et al. 2001). The six-spotted leafhopper is the most common vector for the virus that causes aster yellows, a disease that affects carrots. Control of the leafhopper population in this region is vital if excellent carrots are to be produced. Leafhoppers are very little (their length is less than 1/8 of an inch) and light green in colour. When disturbed, the adults take to the air quickly, but the nymphs often migrate laterally as they travel on the leaves. From June through August, the most of the harm is done. The tips of plants that have been damaged by leafhoppers often become stunted and yellow. The roots are often coated with root hairs that are very fine and tough. Spiders and sucking complexes may be seen living in the leaves of the carrots (Stevenson and Chaput, 1998 and Webb, 2008). Spinach The Spinacia oleracea L. plant is a rich source of beta cortene, as well as vitamins C, E, and K, potassium, iron, sulphur, sodium, folic acid, and oxalic acid. It has a higher protein content than the majority of veggies. One of the vegetables with the greatest levels of chlorophyll, a fat-soluble component that promotes the formation of haemoglobin and red blood cells, spinach is one of those veggies. One of the most common insect pests of spinach is the green peach aphid, which gets its nourishment by syphoning juice off of the spinach plant. Aphid populations almost seldom reach levels high enough to cause a significant decrease in spinach production. The primary cause for worry arises with the discovery of aphids in the processed spinach product included inside the container (Holloway et al. 2003). In the autumn and spring, when aphid populations are at their peak, beneficial insects may have only a little impact on the situation. However, beneficial activity is significantly reduced over the majority of the chilly season, which is when spinach is cultivated (Sweeden and McLeod, 1997).

***Key Words**: Biodiversity, Insect Pests, Predators, Winter Crops*

## INTRODUCTION

An investigation of the diversity of insect pests and predators that feed on winter crops such carrots, spinach, radishes, and fennel was conducted at the experimental field of the Department of Plant Protection at Sindh Agriculture University in Tandojam during the academic year 2014-2014. We counted the populations of four insect pests (thrips, aphids, whiteflies, and spiders) as well as two insect predators (predatory beetles and predatory mites). On carrot, there was an increasing tendency of thrips, and the peak population was 3.0/plant on March 6th, averaging 1.66/plant; while whitefly was in the range of 0.07 and 1.40/plant reaching peak (1.40/plant) on February 20th, averaging 0.66/plant. On March 6th, the peak population of thrips was

3.0/plant. Aphid population was found to be scattered in the range of 0-0.42/plant, reaching at peak level on 27th Feb, and averaging 0.11/plant; spider population was found to be in the range of 0-0.42/plant, reaching at peak level on 27th Feb, and averaging 0.11/plant. Aphid population reached its peak on March 6th at 1.02/plant. The populations of predatory beetles and mites did not exhibit any consistency; the population of beetles ranged from 0.035 to 0.08 per plant on average, while the population of mites ranged from 0.030 to 0.06 per plant. On spinach, the thrips population was anywhere from 0.30 to 2.62 per plant, and it reached its peak on March 13th, averaging 1.19 per plant. Meanwhile, the whitefly population was anywhere from 0.15 to 1.07 per plant, and it reached its peak on February 20th, averaging 0.67 per plant.

The aphid population was anywhere from 0.07 to 0.20 per plant, and it reached its peak on February 6th, averaging 0.11.1 per plant. Predatory beetles showed consistency and were in the range of 0.05-0.20/plant, reaching peak level on the 16th of January, and averaging 0.11/plant; predatory mites were in the range of 0.07-0.20/plant, and they averaged 0.11/plant. Predatory beetles showed consistency and were in the range of 0.05-0.20/plant, and they averaged 0.11/plant. On radish, the thrips population ranged from 0.50 to 39.25 per plant, with an average of 1.39 per plant and a peak infestation of 3.25 per plant on January 4th. The aphid population, meanwhile, ranged from 0.50 to 39.25 per plant and reached its peak level on March 1st, with an average of 11.57 per plant. The whitefly population on radish ranged from 0.25 to 0.95 per plant and reached its height on January 4th, average 0.53 per plant. The spider population, however, ranged from 0 to 0.13 per plant and reached its peak on December 7th, averaging 0.06 per plant. The number of predatory beetles ranged from 0 to 0.25 per plant at its highest population on January 25 and averaged 0.10 per plant. On the other hand, the number of predatory mites ranged from 0 to 0.18 per plant and averaged 0.04 per plant.

On fennel, the whitefly population was in the range of 0.08-0.77/plant reaching peak on 18th Jan averaging 0.41/plant; and the spider population was in the range of 0-0.25/plant reaching peak on 25th Jan averaging 0.14/plant. Thrips population reached its peak level (2.37/plant) on 18th January, averaging 1.20/plant. Aphid population reached its peak level on 1st February, averaging 13.86/plant On the other hand, the population of predatory beetles ranged from 0 to 0.22 per plant and reached its peak on February 8th, averaging 0.06 per plant. Meanwhile, the population of predatory mites ranged from 0 to 0.10 per plant and averaged 0.01 per plant, indicating that almost none of these predators were present in the field.

Flea beetles are little insects that are glossy, hop quickly, and make small holes in the leaves of plants they feed on. Radishes are susceptible to assault by flea beetles. Planting too early should be avoided, and row coverings or rotenone dust should be used to suppress insects. Additionally, planting with companion plants that grow at a faster rate and are higher than the plants you want to protect can help disguise them from insects. Thrips, aphids, cabbage maggots, white flies, and black cutworm are the most prevalent types of pests that attack radishes. The pupal stage of the cabbage maggot spends the winter underground in the soil. At this point, infestations have the potential to affect one hundred percent of the radish acreage. In a given year, there are typically four generations of cabbage maggots that overlap one another (MacNab et al. 1983).

Fennel, also known as Foeniculum vulgare, is a plant that is native to the Mediterranean region and traditionally only flourished in locations that were bordered by the Mediterranean Sea. However, it is now widely grown in many temperate regions across the globe. Fennel is grown in practically every region of Pakistan, making it the country's most widely cultivated herb. The optimum temperature for the soil in which fennel plants are produced is between 15 and 18 degrees Celsius, which translates to around 60 and 65 degrees Fahrenheit. Plants should preferably be cultivated in this temperature range. Fennel plants are susceptible to a variety of insect pests, including aphids, thrips, and white flies, which are all capable of

causing significant damage to the herb. In addition to being susceptible to these pests, fennel is also susceptible to root rot, which is especially likely to occur if the soil is excessively moist or water logged (Banerji, 2000). Fennel crops are susceptible to damage from a variety of insect pests, including thrips, aphids, and whiteflies, among others (El- Bardai et al. 2001).

There are a variety of natural predators, such as ladybirds and lacewings, that will provide some degree of biological control. Sprays like dimethoate, imidacloprid, garlic extract, or maldison may be used to manage the problem if it has to be. In addition, soapy water and insecticidal soaps have the potential to lower populations (Burt et al. 2014). Caterpillars (such as corn earworms, imported cabbage worms, cabbage loopers, cutworms, and army worms), stink bugs, squash bug nymphs, beetle and fly larvae, and some true bugs and beetles are all susceptible to being parasitized by spiders and tachinoid flies, respectively. Adults measure between 0.3 and 0.5 inches in length. On the body of the host or on the surrounding vegetation, white eggs are laid (in the picture below, the tachinid fly is approaching the larvae of an elm leaf beetle). Larvae are a kind of parasite that feeds inside of the body of its host, draining its bodily fluids to the point where the host eventually dies (Banerji, 2000). The current research was conducted with the goal of determining the population sizes of various insect pests that feed on vegetables and medicinal plants like carrots, radishes, spinach, and fennel, as well as the economic significance of the various insect pests that feed on these crops. This evaluation of the populations of these insect pests and their natural enemies was carried out with these considerations in mind.

## MATERIALS AND METHODS

Experiments were carried out in the years 2014 and 2014 with the purpose of analysing the population increase of insect pests that feed on carrot, spinach, radish, and fennel crops as well as the predators that prey on those insects while the crops were in their growing stages.

### Experimental design

The experiment was organised using a method known as Randomized Completely Block Design (RCBD). The treatments for the experiment were insects and predators, and the replicates were observation dates. 13.5 square metres were devoted to the therapy. Ridges were created in the seedbed that was going to be used for seeding carrots, radishes, and fennel; on the other hand, a flat bed was prepared for spinach.

### Agronomic practises

### Carrot

After being broken up with a disc plough and then a disc harrow, the soil was subsequently planked and levelled to prepare it for cultivation. As a consequence of this, a fertile seedbed was created for planting the carrot crop. Before beginning the preparation of the ridges, a rate of two bags of DAP and two bags of urea per hectare were spread throughout the land. After preparing the ridges at a spacing of 45 centimetres apart, seed was spread, and then it was immediately blended into the soil and watered. The planting process was finished on October 14th, 2014.

### Spinach

Flat beds were constructed on the site after it was prepared according to agronomic suggestions so that

spinach could be grown there. Before planting the seed, an application of DAP at a rate of 2 bags ha-1 and an application of urea at a rate of 2 bags ha-1 were made. The planting took place on October 13th, 2014.

Radish The preparation of the land for growing radish followed a process quite similar to that used for carrot production. After the seedbed had been prepared properly, the dibbling technique was used to plant the seeds after the ridges had been formed. Before beginning the process of preparing the ridges, the appropriate amounts of DAP and urea were applied. The planting took place on October 15th, 2014.

**Fennel**

In order to get the area ready for planting fennel, a thorough ploughing operation was performed to break up the crusty top layer of the soil, which was then followed by a disc harrowing and levelling operation. Following the process of planking the soil, the ridges were prepared, and the dibbling technique of sowing fennel seed was carried out. Prior to the preparation of ridges, the appropriate amounts of DAP and urea were administered. This was done before the ridges were prepared. The planting took place on November 14th, 2014.

The gathering of information on the prevalence of insects Feeding on Other Animals (Thrips, Aphid, Whitefly)

The observations began 45 days following the planting, and weekly data were kept on each of the insect pest infestations. On the basis of five randomly chosen plants for each treatment, observations on sucking complexes such as whitefly, thrips, and jassids were recorded. On a per-plant basis, the typical infestation was treated and maintained spider mites The population count on the spider infestation on carrot, spinach, radish, and fennel crops was begun after 15 days after germination and were taken once in a week. This was done to ensure that there was no further spread of the infestation. Random selection was used to choose five plants from each treatment, and the results of the observations were recorded appropriately.

The population growth of predators, including predatory beetles and predatory mites, was also measured on carrot, spinach, radish, and fennel crops, with the first observation taking place 15 days following the germination of the seeds. These counts were performed once a week. Following the selection of five plants at random for each treatment, observations were made on the total number of predators found on all of the plants that were chosen, and an average was then calculated.

**A statistical look at the data**

The acquired data were then analysed using analysis of variance (ANOVA), and the means were differentiated using the LSD test at significance levels of 0.05 and 0.01 using the MSTAT-C statistical software (Michigan State University, 1982).

**RESULTS**

**Carrot**

Both the population of different insect pests and predators on carrots (F=26.7453; DF=5, 89; P0.01) and the population of different insect pests and predators on carrots (F=2.7798; DF=14, 89; P0.0.0025) differed significantly between observation dates, as shown by an analysis of variance of the data (Table-1).

The population on different insect pests of carrot and predators observed for 15 weeks is summarised in Table-1. This table reveals that the tendency of thrips population followed a gradual increase, and the peak population of the insect was recorded on the last observation (6th March, 2014), showing an average population of 1.66/plant. The populations of other insect pests of carrot are also summarised in Table-1. The thrips population was less than one per plant in the first six weeks of the crop, but it rose to more than one by the ninth week, more than two by the 12th week, and more than three per plant in the crop's last three weeks. Between 0.15 and 3.0 insects were found living on each plant at the same time. The whitefly population trend showed very little variation over the thrips population, which ranged from 0.07 to 1.40/plant and reached its highest population of 1.40/plant on February 20th, 2014. The whitefly population averaged 0.66/plant during the course of the study. The whitefly population stayed below one per plant for the first 11 weeks of monitoring, then rose to above one during weeks 12-14, and then fell back down to below one per plant in the last week.

The aphid population was found to be anywhere from 0 to 1.02/plant, with the highest population occurring on March 6th at 1.02/plant and the average population being 0.22/plant. The bug population stayed below one per plant for the first 14 weeks of monitoring but then rose to more than one in the last week. The spider population fluctuated during the time from 0 to 0.42/plant, with the peak population occurring on February 27th, averaging 0.11/plant. The population reached its highest point on that day. During the whole time of observation, which lasted for 15 weeks, the bug population never rose over 1/plant. The population of predatory beetles varied from 0.0 to 0.35 per plant, with 0.08 being the average number, while the population of predatory mites ranged from 0.0 to 0.30 per plant, with 0.06 being the average number. The predatory population on carrot stayed at less than one per plant during the whole 15-week research period.

**Table 1 shows the populations of insects that feed on carrots as well as those that eat them.**

| Obs. Date | Insect pests | | | | Predators | |
|---|---|---|---|---|---|---|
| | Thrips | Whitefly | Aphid | Spider mites | Predatory beetles | Predatory mites |
| 28.11. 14 | 0.15 | 0.07 | 0 | 0 | 0 | 0 |
| 05.12. 14 | 0.60 | 0.27 | 0.05 | 0.02 | 0 | 0 |
| 12.12. 14 | 0.57 | 0.27 | 0 | 0.02 | 0.02 | 0 |
| 19.12. 14 | 0.67 | 0.17 | 0.07 | 0 | 0 | 0 |
| 26.12. 14 | 0.70 | 0.15 | 0.02 | 0 | 0.12 | 0 |
| 02.01.15 | 0.80 | 0.57 | 0.07 | 0.10 | 0.12 | 0 |
| 09.01.15 | 1.02 | 0.62 | 0.32 | 0.17 | 0.32 | 0 |
| 16.01.15 | 1.17 | 0.65 | 0.10 | 0 | 0.02 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 23.01.15 | 1.67 | 0.90 | 0.07 | 0.15 | 0.10 | 0.22 |
| 30.01.15 | 2.12 | 0.70 | 0.52 | 0 | 0 | 0.20 |
| 06.02.15 | 2.07 | 0.82 | 0.30 | 0.02 | 0.10 | 0.05 |
| 13.02.15 | 2.65 | 1.25 | 0.27 | 0.25 | 0 | 0 |
| 20.02.15 | 3.37 | 1.40 | 0.20 | 0.25 | 0 | 0.30 |
| 27.02.15 | 3.60 | 1.25 | 0.32 | 0.42 | 0 | 0.20 |
| 06.03.15 | 3.80 | 0.80 | 1.02 | 0.30 | 0.35 | 0 |
| Total | 24.96 | 9.89 | 3.33 | 1.70 | 1.15 | 0.97 |
| Avg | 1.66 a | 0.66 b | 0.22 c | 0.11 c | 0.08 c | 0.06 c |

Analysis of variance for

| Source of variation | d.f. | Sum of squares | Mean squares | F. Ratio | Prob/ Remarks |
|---|---|---|---|---|---|
| Obs. Dates | 14 | 8.669 | 0.619 | 2.7798 | 0.0025** |
| Insects | 5 | 29.778 | 5.958 | 26.7453 | 0.0000** |
| Error | 70 | 15.593 | 0.223 | - | - |
| Total | 89 | 54.050 | - | - | - |

Table-2. Insect pests and predators population per leaf on spinach

| Obs. Date | Insect pests | | | Predators | |
|---|---|---|---|---|---|
| | Thrips | Whitefly | Aphid | Predatory beetles | Predatory mites |
| 28.11.14 | 0.32 | 0.17 | 0.10 | 0.15 | 0.07 |
| 05.12. 14 | 0.30 | 0.15 | 0.07 | 0.10 | 0.12 |
| 12.12. 14 | 0.60 | 0.35 | 0.10 | 0.15 | 0.10 |
| 19.12. 14 | 0.60 | 0.30 | 0.15 | 0.05 | 0.10 |
| 26.12. 14 | 0.60 | 0.37 | 0.10 | 0.12 | 0.10 |

| | | | | | |
|---|---|---|---|---|---|
| 02.01.15 | 0.97 | 0.60 | 0.10 | 0.12 | 0.10 |
| 09.01.15 | 1.00 | 0.65 | 0.10 | 0.10 | 0.10 |
| 16.01.15 | 1.20 | 0.60 | 0.15 | 0.20 | 0.15 |
| 23.01.15 | 1.00 | 0.65 | 0.10 | 0.10 | 0.10 |
| 30.01.15 | 1.22 | 0.90 | 0.10 | 0.10 | 0.10 |
| 06.02.15 | 1.40 | 0.85 | 0.20 | 0.12 | 0.12 |
| 13.02.15 | 1.45 | 0.97 | 0.10 | 0.10 | 0.10 |
| 20.02.15 | 1.57 | 1.07 | 0.10 | 0.10 | 0.20 |
| 27.02.15 | 1.90 | 1.07 | 0.15 | 0.10 | 0.10 |
| 06.03.15 | 2.30 | 1.00 | 0.10 | 0.10 | 0.10 |
| 13.03.15 | 2.62 | 1.00 | 0.10 | 0.10 | 0.10 |
| Total | 19.05 | 10.70 | 1.82 | 1.81 | 1.76 |
| Avg | 1.19 a | 0.67 b | 0.11 c | 0.11 c | 0.11 c |

Analysis of variance

| Source of variation | d.f. | Sum of squares | Mean squares | F. Ratio | Prob/ Remarks |
|---|---|---|---|---|---|
| Obs. Dates | 15 | 2.874 | 0.192 | 2.0919 | 0.0227* |
| Insects | 4 | 15.007 | 3.752 | 40.9630 | 0.0000** |
| Error | 60 | 5.495 | 0.097 | - | - |
| Total | 79 | 23.377 | - | - | - |

Table-3.Insect pests and predators population per leaf on radish

| Obs. Date | Insect pests | | | | Predators | |
|---|---|---|---|---|---|---|
| | Thrips | Aphid | Whitefly | Spiders | Predatory beetles | Predatory mites |
| 30.11.14 | 0.70 | 0.50 | 0.58 | 0.05 | 0 | 0 |
| 07.12.14 | 0.90 | 0.73 | 0.63 | 0.13 | 0 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 14.12.14 | 1.73 | 0.43 | 0.75 | 0.05 | 0 | 0 |
| 21.12.14 | 2.03 | 0.80 | 0.68 | 0 | 0.13 | 0 |
| 28.12.14 | 2.23 | 0.55 | 0.68 | 0.13 | 0.06 | 0 |
| 04.01.15 | 3.25 | 1.40 | 0.95 | 0.08 | 0.08 | 0 |
| 11.01.15 | 1.80 | 3.45 | 0.65 | 0.05 | 0.05 | 0.03 |
| 18.01.15 | 1.78 | 3.15 | 0.35 | 0 | 0.18 | 0 |
| 25.01.15 | 1.48 | 5.13 | 0.38 | 0.08 | 0.25 | 0.05 |
| 01.02.15 | 1.13 | 11.73 | 0.25 | 0 | 0.23 | 0.10 |
| 08.02.15 | 0.58 | 16.18 | 0.38 | 0.10 | 0.10 | 0 |
| 15.02.15 | 0.50 | 21.63 | 0.38 | 0.10 | 0.13 | 0.10 |
| 22.02.15 | 0.70 | 29.65 | 0.48 | 0 | 0.15 | 0.10 |
| 01.03.15 | 0.63 | 39.25 | 0.48 | 0.05 | 0.13 | 0.18 |
| 02.03.15 | 1.45 | 38.78 | 0.40 | 0.03 | 0.05 | 0 |
| Total | 20.85 | 173.52 | 7.98 | 0.83 | 1.53 | 0.55 |
| Avg | 1.39 b | 11.57 a | 0.53 b | 0.06 b | 0.10 b | 0.04 b |

Analysis of variance

| Source of variation | d.f. | Sum of squares | Mean squares | F. Ratio | Prob/ Remarks |
|---|---|---|---|---|---|
| Obs. Dates | 14 | 446.581 | 31.899 | 0.9278 | 0.1342 |
| Insect species | 5 | 1574.813 | 314.963 | 9.1609 | 0.0000** |
| Error | 70 | 2406.688 | 34.381 | - | - |
| Total | 89 | 4428.082 | - | - | - |

Table-4 Insect pests and predators population per leaf on fennel

| Obs. Date | Insect pests | | | | Predators | |
|---|---|---|---|---|---|---|
| | Thrips | Aphid | Whitefly | Spiders | Predatory beetles | Predatory mites |

| | | | | | | |
|---|---|---|---|---|---|---|
| 28.12.14 | 0.62 | 2.10 | 0.50 | 0.02 | 0.02 | 0 |
| 04.01.15 | 0.97 | 6.72 | 0.08 | 0.07 | 0 | 0 |
| 11.01.15 | 1.02 | 9.75 | 0.22 | 0.07 | 0 | 0 |
| 18.01.15 | 2.37 | 16.90 | 0.77 | 0.17 | 0.05 | 0 |
| 25.01.15 | 1.17 | 18.15 | 0.65 | 0.25 | 0.05 | 0 |
| 01.02.15 | 0.92 | 19.57 | 0.32 | 0.02 | 0.02 | 0 |
| 08.02.15 | 0.90 | 19.50 | 0.47 | 0.05 | 0.22 | 0.10 |
| 15.02.15 | 1.00 | 16.82 | 0.32 | 0.05 | 0.15 | 0 |
| 22.02.15 | 1.37 | 16.32 | 0.17 | 0.05 | 0.06 | 0 |
| 01.03.15 | 1.67 | 12.72 | 0.60 | 0.02 | 0.07 | 0 |
| Total | 12.01 | 138.55 | 4.095 | 1.40 | 0.63 | 0.10 |
| Avg | 1.20 a | 13.86 a | 0.41 b | 0.14 b | 0.06 b | 0.01 b |

Analysis of variance

| Source of variation | d.f. | Sum of squares | Mean squares | F. Ratio | Prob/ Remarks |
|---|---|---|---|---|---|
| Obs. Dates | 9 | 58.224 | 6.469 | 1.1244 | 0.3659 |
| Insect species | 5 | 1529.383 | 305.877 | 53.1601 | 0.0000** |
| Error | 45 | 258.924 | 5.754 | - | - |
| Total | 59 | 1846.532 | - | - | - |

Spinach

The analysis of variance (Table-2) indicated that there was significant difference in the population on different insect pests and predators on spinach (F=40.9630; DF=4, 79; P<0.01) as well as between observation dates (F=2.0919; DF=15, 79; P<0.0.0227).

Population of different spinach insect pests and predators recorded for 16 weeks (Table- 23) showed that the trend of thrips population followed a gradual increase and peak population of the insect was recordedin the last week (13th March) indicating an average population of 1.19/plant. Thrips population during first six

weeks was <1/plant, which increased to >1 upto 14thweek, >2 during last two weeks of crop. Thepopulation of insect was in the range of 0.30 and 2.62/plant. The whitefly population on spinach was in the range of 0.15 and 1.07/plant reaching its peak population on20th February averaging 0.67/plant. Theinsect population remined <1/plant upto first12 weeks, increased to >1 during rest of the crop period. Aphid population was found in the range of 0.07 and 0.20/plant reaching its peak population on 6th February, averaging 0.11/plant. The insect population remained

<1/plant upto throughout the observation period. However, no significant population fluctuation was noted during the studyperiod of 16 weeks. Predatory beetles showed consistency on spinach and remained in the spinach field for whole crop period in the range of 0.05 to 0.20/plant,reaching its peak population on 16th January,averaging 0.11/plant. The predator population remained <1/plant throughout theobservation period of 16 weeks. The population of predatory mites also showed consistency during 16 weeks study period on spinach. The population of predatory mites ranged between 0.07 and 0.20/plant, averaging 0.11/plant.

**Radish**

The analysis of variance (Table-3) indicated a significant difference in the population of different insect pests and predators on radish($F=9.1609$; $DF=5, 89$; $P<0.01$), while non-significant between observation dates ($F=0.9278$; $DF=14, 89$; $P<0.0.1342$). High coefficient of variation (256.77%) inversely impacted the significance of differences. Population of different insect pests and predators recorded on radish crop for 15 weeks (Table-3) showed no linear trend and thrips population was quite uneven duringthe period of 15 weeks of study. However, the thrips population reached its peak infestation (3.25/plant) on 4th January, while the minimum population (0.5/plant on 15th February, having an average infestation of 1.39/plant. Thrips population reached >3/plant after 6th week of study and laterdecreased. The whitefly population on radish was in the range of 0.25 and 0.95/plant reaching its peak population on 4th January averaging 0.53/plant. The insect population remained <1/plant throughout the crop growth period of radish. The spiderpopulation on radish was in the range of 0 and 0.13/plant reaching its peak population on 7th December averaging 0.06/plant. The insect population remained <1/plant throughout the growth period of radish. No consistency and no linear trend of populationbuildup was found in case of predatory beetles and predatory mites on radish. Predatory beetle population was in the range of 0-0.25/plant reaching its peak population on 25th January, averaging 0.10/plant. The predator population remained <1/plant throughout the study period. The population of predatory mites ranged between 0.0 and 0.18/plant, averaging 0.04/plant, indicating the predator population remained scattered and <1/plant throughout the growth period of radish.

**Fennel**

The analysis of variance (Table-4) showed that the differences in the population of different insect pests and predators on fennel was significant ($F=53.1601$; $DF=5, 59$; $P<0.01$), while non-significant between observation dates ($F=1.1244$; $DF=9, 59$; $P=0.3659$). The coefficient of variation was relatively higher (92.16%) inversely affectedthe significance of differences between observation dates. Population of different insect pests and predators recorded on fennelcrop for 10 weeks (Table-4) showed yet no linear trend and thrips population was quite uneven during the period of 10 weeks ofstudy. However, the thrips population reached its peak infestation (2.37/plant) on 18th January, while the minimum population (0.62/plant) on 28th December, having an average infestation of 1.20/plant. Thripspopulation reached >2/plant in 4th week of study and later decreased and againincreased in the last 2 weeks. Aphid population on fennel was found in

the range of 2.10 and 19.57/plant reaching its peak population on 1st February, averaging13.86/plant. The insect population linearlydeveloped in the development of growth period and after reaching peak population, the aphid count started reducing gradually and this trend continued upto the last observation on 1st March. The whitefly population on fennel was in the range of

0.08 and 0.77/plant reaching its peak population on 18th January averaging0.41/plant. The spider population on fennel was in the range of 0 and 0.25/plant reachingits peak population on 25th January averaging 0.14/plant. The insect population remained <1/plant throughout the growth period of fennel. Inconsistent population development was noted in case of predatory beetles and predatory mites on fennel. Predatory beetle population was in the range of 0-0.22/plant reaching its peak population on 8th February, averaging 0.06/plant. The predator population remained <1/plant throughout the study period. The population of predatory mites ranged between 0.0 and 0.10/plant, averaging 0.01/plant, indicatingthe predator population was almost absent exception only a minor population on 8th February.

## DISCUSSION

Winter crops like carrot, spinach, radish, fennel etc. are always left unsprayed against insect pests and in result the production level of these crops is far less in the country as compared to advanced agricultural countries of the world. Various insect pests and predators damage winter vegetables at allstages of growth. The present study was the study on the assessment of insect pests and predators diversify on some winter crops (carrot, spinach, radish, fennel). The results showed that on carrot increasing tendency ofthrips and peak population was 3.0/plant (6th March) averaging 1.66/plant; whilewhitefly was in the range of 0.07 and 1.40/plant reaching peak (1.40/plant) on20th Feb. averaging 0.66/plant. Aphid population was in the range of 0-1.02/plant reaching at peak (1.02/plant) on 6th March, averaging 0.22/plant; while spider population found scattered in the range of 0- 0.42/plant, reaching at peak level on 27thFeb, averaging 0.11/plant. Predatory beetles and mites showed no consistency; population of beetles was in the range of 0-

0.35 averaging 0.08/plant and mites 0-0.30/plant averaging 0.06/plant. In a similar investigation Stevenson and Chaput (1998); Webb (2008) have reported infestation ofsucking complex and spiders on the carrot leaves. Similar results have also been reported by Stevenson and Chaput (1998). Furthermore, Brunke *et al.* (2014) described the beetles predating carrot insect pests.Present study indicated that on spinachthrips population was in the range of 0.30- 2.62/plant, reaching peak on 13th March, averaging 1.19/plant; while whitefly was in the range of 0.15-1.07/plant reaching its peak on 20th Feb averaging 0.67/plant; and aphid population was in the range of 0.07- 0.20/plant reaching peak level on 6th Feb, averaging 0.11/plant. Predatory beetlesshowed consistency, were in the range of0.05-0.20/plant, reaching peak level on 16th Jan, averaging 0.11/plant; while predatorymites were in the range of 0.07-0.20/plant, averaging 0.11/plant. These results are further supported by Mound and Kuo (1996)who have reported thrips infestation on spinach. Nuessly and Webb (2014) studied the insect pests of leafy vegetables includingspinach and concluded that damage to leafy vegetables results from holes chewed in leaves by caterpillars and beetles, leaf mining by fly larvae and diseasetransmission and head contamination by piercing sucking insects. Major pests of these crops are beet and southern armyworms, cutworms, cabbage loopers,dipterous leaf-miners, aphids, cucumber beetles and wireworms. Less common pests of leafy vegetables include seed corn maggot, seed corn beetle and corn earworm. In another study, Palumbo (2000) reported aphid and thrip population dynamics in spinach. Aslam *et al.* (2004) reported aphid, *Lipaphis erysimi* Kalt. on leafy vegetables.

In addition, it was discovered that the thrips population on radish ranged from 0.50 to 39.25 per plant, with the infestation reaching its peak level (3.25 per plant) on January 4th and averaging 1.39 per plant. Meanwhile, the aphid population ranged from 0.50 to 39.25 per plant and reached its peak level on March 1st, with an average of 11.57 per plant. The whitefly population on radish ranged from 0.25 to 0.95 per plant and reached its height on January 4th, average 0.53 per plant. The spider population, however, ranged from 0 to 0.13 per plant and reached its peak on December 7th, averaging 0.06 per plant. The number of predatory beetles ranged from 0 to 0.25 per plant at its highest population on January 25 and averaged 0.10 per plant. On the other hand, the number of predatory mites ranged from 0 to 0.18 per plant and averaged 0.04 per plant.

According to the findings that were presented by Eastman et al. (1995), the researchers came to the conclusion that radish leaves were extensively damaged by thrips and aphids. After doing research on the prevalence of thrips in radish, Buntin and Beshear (1995) came to the conclusion that among thrips, Limothrips cerealium and Frankliniella fusca were the two most common species, accounting for more than 89 percent of the adult thrips collected from both crops. Alumbo (1997) came to the conclusion that thrips, much like aphids, have the potential to move into radish crops at any moment. The findings showed that the whitefly population on fennel was in the range of 0.08-0.77/plant reaching peak on 18th Jan averaging 0.41/plant, while the spider population was in the range of 0-0.25/plant reaching peak on 25th Jan averaging 0.14/plant. Thrips on fennel reached peak level (2.37/plant) on 18th Jan, averaging 1.20/plant. Aphid population was in the range of 2.10-19.57/ The population of predatory beetles, on the other hand, ranged from 0.01-0.22 per plant and reached its peak on February 8th, averaging 0.06 per plant. The population of predatory mites, on the other hand, ranged from 0.01-0.10 per plant and averaged 0.01, indicating that almost none of these predators were present in the field. Banerji (2000) reported that aphids followed by thrips and other insect pests such as the white fly can cause serious damage to fennel plants and that the herb is susceptible to such pests; the fennel is also susceptible to being affected by root rot especially if the soil is too moist or water logged. These results are further supported by Banerji (2000), who reported that aphids followed by thrips and other insect pests such as Fennel crops are susceptible to damage from a variety of insect pests, including thrips, aphids, and whiteflies, among others (El-Bardai et al. 2001).

## CONCLUSION

On carrot, the population of thrips was significantly higher in comparison to that of other insect pests; on the other hand, the population of predators was unreliable, and there were significant differences in the population buildup of various insect species based on the observation dates (P 0.05). The population of thrips was similarly greater on spinach, whereas the population of predators remained the same. There were statistically significant variations in the population growth of different insect species and observation dates (P 0.05). On radish, the aphid population was manifold greater than that of other insect pests, while the population of predator insects was inconsistent. Differences in population growth between observation dates were significant (P 0.05) and non-significant (P > 0.05) depending on the insect species. Aphid population on fennel was several times larger than that of other insect pests; inconsistent population of predators; changes in population growth between observation dates were significant (P 0.05) and non-significant (P > 0.05) depending on the insect species.

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