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Spatial distribution of alfalfa weevil, *Hypera postica* Gyllenhal (Coleoptera: Curculionidae) in cold arid region (Ladakh) of Jammu and Kashmir

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Abstract

Spatial distribution of alfalfa weevil, *Hypera postica* Gyllenhal in alfalfa crop was studied during the cropping seasons of 2005-06, 2006-07, 2007-08 and 2008-09 at Regional Agriculture Research Sub Station Kargil, Jammu and Kashmir, India. The various parameters of dispersion *viz.,* variance mean ratio, exponent k, common k (Kc), Lloyd's index of mean crowding (x*), patchiness index (x* / x) and Taylor's power law were applied to determine the nature of distribution of *H. postica*. In the pursuance of various index, it was observed that the alfalfa weevil exhibits aggregate or contagious pattern of distribution in the field. The value of Taylor's aggregation index (b), *i.e.* 1.5279, 0.2378, 1.2941 and 1.1869 during the year 2005-06, 06-07 and 08-09, respectively, was greater than one (>1) which indicates aggregated nature of distribution of alfalfa weevil. In Iwao m* - m relationship contagiousness coefficient value (β = 1.3817, 1.1991, 1.1523 and 1.3092, respectively) was found to be > 1 which also justify that weevil populations approached aggregate or negative binomial distribution pattern. The intercept (5.8296, 2.4226, 2.3361 and 2.2460) also justify that alfalfa weevil followed contagion nature of distribution instead of dispersion.

Keywords: Alfalfa, Biotic stress, Distribution, Fodder, *Hypera,* Insect, Lucerne*,* Spatial

Introduction

Alfalfa or Lucerne, *Medicago sativa* L. is one of the extremely adapted perennial forage crop cultivated world wide including cold arid region (Ladakh) of Jammu and Kashmir. The crop is attacked by a large number of insect pests including alfalfa weevil *Hypera postica* Gyllenhal which is most destructive pest of alfalfa (Metcalf and Lukman, 1994). Adult and grub stage of this pest is voracious feeder on terminal foliage and new crown shoots of alfalfa. Adult and larval stages of this pest cause damage to this crop but 3rd and 4th instars grubs inflict severe damage resulting in appearance of silver or white colour field as most of the leaves become skeletonised.

Estimating population densities of alfalfa weevil damaging alfalfa crop is the most important part of basic research in agricultural ecosystems and one of the main components in pest management programmes of this pest. A reliable sampling programme to estimate density should include a proper sampling time, sampling unit and sampling size in which the determination of spatial distribution is fundamental (Southwood and Henderson, 2000). Sampling programmes can be used in assessing crop loss (Hughes, 1996), studying the population dynamics of pests (Jarosik *et al.*, 2003) and determination of levels of pest infestation in order to apply control measures (Arnaldo and Torres, 2005). The development of a sampling procedure requires knowledge of the spatial distribution of the populations which is important in understanding the biology and ecology of a species and the basis for the development of sampling protocols. It provides reliable information of field population density which is the prerequisite for the pest management programme. It also helps in monitoring and to take the right decision about pest control interventions for pest management. Keeping in view the immense importance and the ardent need of the work, the present investigation was carried out to quest the distribution pattern of alfalfa weevil in cold arid region (Ladakh) of Jammu and Kashmir.

Materials and Methods

The present experiment was carried out at Regional Agriculture Research Sub Station, Kargil to study the spatial distribution of alfalfa weevil (grub) *Hypera postica*. Five alfalfa fields of about one hectare area each, located

2 to 5 km away from each other in Kargil districts, were selected for sampling by applying sweep net method during 2005-06, 06-07, 07-08 and 08-09. The sampling started just after the appearance of grubs on twigs of alfalfa crop. There were no insecticidal treatments during the crop growth period. Under the sweep net sampling method, a standard 38 cm diameter canvas sweep net was used for sweeping. The sweeping was done in a 180 arc with placing the approximately half its opening (diameter) into the foliage. One pass was counted as one sweep. Total 10 sweeps were made randomly at different locations of each field for counting one sample. Total tan samples were collected from each location. For analysis, the counts were adjusted to per sweep basis for each date of samples. The retrieved data were analyzed through index of dispersion to estimate the spatial distribution pattern of this pest. The index of dispersion like Lloyd's mean crowding, Morisita's index, David & Moore index (David and Moore, 1954) and two regression models (Taylor's Power Law and Iwao's Patchiness Regression) were computed as suggested by Southwood and Henderson (2000). Under Taylor's power law, the logarithms of the variances (s^2) were plotted against the logarithms of the means (µ) to get a linear equation of the form $Log_{10} s^2 = b \log_{10} \mu + \log_{10} a$, Where, 'b' is the slope of the regression line or aggregation parameter and 'a' is the antilog of the intercept or sampling factor. The slope is a measure of dispersion with b< 1 uniform (regular); b> 1 aggregated (clumped) and b= 1 random distribution.

Results and Discussion

The various indices of dispersions were calculated to find out the distribution pattern of alfalfa weevil. Data presented in tables 1 to 4 indicate that 0.54 to 19.3, 1.06 to 12.8, 0.98 to 11.04 and 1.06 to 10.5 grubs per sweep were recorded during the study year 2005-06, 06-07, 07-08 and 08-09, respectively. First appearance of alfalfa weevil (grub) was observed in month of April and its population reached peak during the second fortnight of May. Thereafter, the population started to decline after first cutting. In month of July and onward no grub population was recorded.

The VMR ratio: Variance mean ratio (VMR) is an effective parameter to indicate the nature of distribution of any insect in given space and time. Calculation of variance to mean ratio is relatively easy and is the most fundamental for the entire aggregation index (Taylor, 1984; Ludwig and Reynolds, 1988; Southood and Henderson, 2000). Higher value of variance over mean of each date of observation indicated that there was aggregated or contagion nature of distribution of grub of *H. postica* on alfalfa. During the study, the VMR values were found to be more than one for each date of observation which again justify that distribution of weevil approached negative binomial distribution.

Exponent k and common k (1/kc): The exponent k is a valid parameter for justification of aggregate pattern of distribution of any organisms. If the value of exponent k is equal to zero, it indicates that aggregation is extreme to infinite that means purely random distribution of counts. Larger value of k indicates an approach toward randomness and it also indicates the relative degree of aggregation for the condition involved. In present study, the value of exponent k was found to be less than 8 which indicate that the *H. postica* (grub) followed the contagious nature or negative binomial distribution pattern on alfalfa.

Plotting of 1/kc against mean for each group of sample of year 2005-06, 06-07, 07-08 and 08-09 indicates that there was neither trend nor clustering of common 1/k value (Fig 1). Therefore, it was noticed that calculation of common 1/k is justified because there was no clustering or trend of clustering.

Devid & Moor index (IDM): The index of clumping of David & Moore gives a value of zero (= 0) for random distribution, negative value (-1) for regular and positive value (+1) for contagious pattern of distribution. David & Moor's index value for each date of observation was found to be greater than zero which indicates that the alfalfa weevil population approached negative bionomical distribution instead of random or regular distribution.

Lloyed's index: Lloyed's index expresses the mean crowding of population in space and time. During the study, Lloyd's mean crowding was calculated for *H. postica* grub stages which ranged from 1.219 to 26.935, 2.425 to 16.744, 2.333 to 12.535 and 2.463 to 17.614 during the year 2005-06, 06-07, 07-08 and 08-09, respectively (tables 1 to 4). The values of mean crowding were found to be greater than mean value of each date of observation as shown in tables 1 to 4. It indicates that the weevil population followed negative binomial distribution.

Patchiness index: The value of patchiness index indicates distribution pattern of an insect in given conditions. In present study, values of patchiness index were less than one (<1) during the all the study years which indicates that the distribution of weevil population followed dispersed in nature.

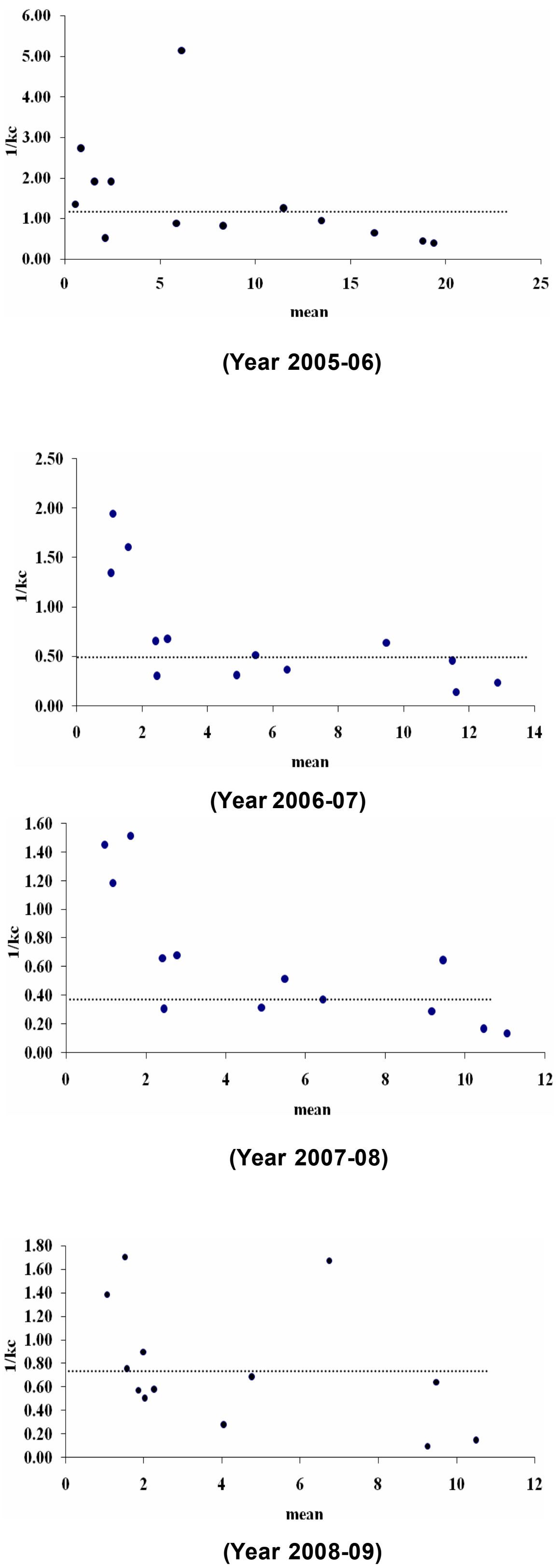

Fig 1. Relation of 1/k to the mean for alfalfa grub population

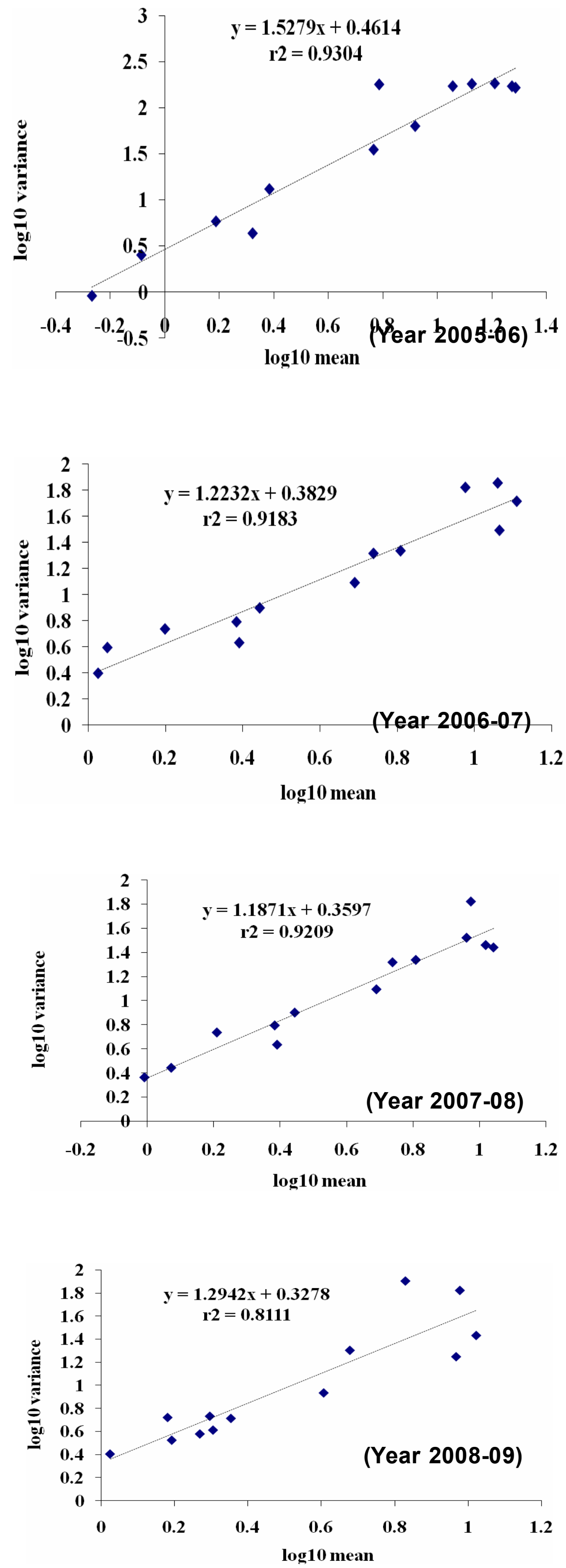

Fig 2. Taylorś Power plot for alfalfa weevil (grub)

Table 1. Different parameters of spatial distribution of alfalfa weevil on alfalfa in year 2005 - 06

Date of observation	Mean (grub/10 sweep)	Variance	VMR	k-value	Lloyed's index (X*)	Patch index	Mean crowding size (C*)	CV	I_{DM}
08.04.2005	0.820	2.518	3.071	0.396	2.891	1.148	3.891	3.071	2.071
15.04.2005	2.100	4.337	2.065	1.972	3.165	0.730	4.165	2.065	1.065
22.04.2005	6.120	179.904	29.396	0.216	34.516	0.192	35.516	29.396	28.396
30.04.2005	11.480	172.214	15.001	0.820	25.481	0.148	26.481	15.001	14.001
07.05.2005	16.260	184.564	11.351	1.571	26.611	0.144	27.611	11.351	10.351
14.05.2005	19.380	165.791	8.555	2.565	26.935	0.162	27.935	8.555	7.555
21.05.2005	18.800	171.878	9.142	2.309	26.942	0.157	27.942	9.142	8.142
26.05.2005	13.480	182.173	13.514	1.077	25.994	0.143	26.994	13.514	12.514
03.06.2005	8.300	63.439	7.643	1.249	14.943	0.236	15.943	7.643	6.643
10.06.2005	5.840	35.198	6.027	1.162	10.867	0.309	11.867	6.027	5.027
17.06.2005	2.420	13.106	5.416	0.548	6.836	0.522	7.836	5.416	4.416
24.06.2005	1.540	5.845	3.796	0.551	4.336	0.742	5.336	3.796	2.796
01.07.2005	0.540	0.907	1.679	0.796	1.219	1.344	2.219	1.679	0.679
								1/kc	0.747772

Table 2. Different parameters of spatial distribution of alfalfa weevil on alfalfa in year 2006 - 07

Date of observation	Mean (grub/10 sweep)	Variance	VMR	k-value	Lloyed's index (X*)	Patch index	Mean crowding size (C*)	CV	I_{DM}
08.04.2006	1.060	2.507	2.365	0.777	2.425	0.967	3.425	2.365	1.365
15.04.2006	2.460	4.294	1.746	3.299	3.206	0.746	4.206	1.746	0.746
22.04.2006	2.420	6.208	2.565	1.546	3.985	0.642	4.985	2.565	1.565
30.04.2006	5.480	20.744	3.785	1.967	8.265	0.398	9.265	3.785	2.785
07.05.2006	11.500	71.806	6.244	2.193	16.744	0.233	17.744	6.244	5.244
14.05.2006	12.880	52.026	4.039	4.238	15.919	0.306	16.919	4.039	3.039
21.05.2006	11.620	31.179	2.683	6.903	13.303	0.427	14.303	2.683	1.683
26.05.2006	9.480	66.418	7.006	1.578	15.486	0.233	16.486	7.006	6.006
03.06.2006	6.440	21.721	3.373	2.714	8.813	0.406	9.813	3.373	2.373
10.06.2006	4.900	12.378	2.526	3.211	6.426	0.519	7.426	2.526	1.526
17.06.2006	2.780	7.930	2.853	1.501	4.633	0.584	5.633	2.853	1.853
24.06.2006	1.580	5.473	3.464	0.641	4.044	0.739	5.044	3.464	2.464
01.07.2006	1.120	3.944	3.522	0.444	3.642	0.923	4.642	3.522	2.522
								1/kc	0.365673

Taylor's power law: In order to have further confirmation about the aggregation pattern of alfalfa weevil's grub distribution, Taylor's power law was applied with 13 samples pertaining to all four cropping seasons. Under the Taylor's power law, the logarithms of variance (s^2) were plotted against the logarithms of the means (μ) to get a linear equation. The regression coefficient is an index of aggregation describing an intrinsic property of the organism concerned (Taylor, 1961). The law state that $\mathrm{Log10}\ s^2 = b\ \mathrm{Log}_{10}\ \mu + \mathrm{Log}_{10}\ a$; where s^2 and μ are sample variance and sample mean, respectively. The 'a' is scaling factor that is dependent on sampling method and habitat, while exponent 'b' is a measure of aggregation. If b is equal to one, then the population has a random distribution and if the b is greater than one (>1) or smaller than one (<1), the population follow the contagious (aggregated) or regular distribution, respectively. Taylor's power law described the variance mean relation well (Fig. 2). Based on regression analyses of log s^2 and log μ, the value of 'a' and 'b' were worked out. The respective equations are as follows:

$y = 1.5279x + 0.4614$ (year 2005 - 06)

$y = 1.2232x + 0.3829$ (year 2006 - 07)

$y = 1.1869x + 0.3597$ (year 2007 - 08)

$y = 1.2941x + 0.3278$ (year 2008 - 09)

Based on regression analysis of log s^2 and log µ, the value ôbô were 1.5279, 1.2232, 1.2941 and 1.1869 during the year 2005-06, 06-07, 07-08 and 08-09, respectively, and were highly significant with high values of coefficient of determination (R^2) 0.9303, 0.9182, 0.9209 and 0.8110 respectively, for four years study. The ôbô values being greater than one in each case again showed dispersed and clumped or aggregated nature of distribution of alfalfa weevil. The difference in ôbô value of four years study of weevil population probably reflect density related changes in behavior of species. The coefficient of determination (R^2) was 0.9303, 0.9182, 0.9209 and 0.8110 respectively. The value of R^2 shows that 81 to 93 % variation in the distribution may be explained by the fitted regression equation. In terms of the index of basic contagion, the insect has definite tendency of aggregation during study years. On the basis of Taylorôs model, Vajargah *et al.* (2011) has also been reported that all life stages of alfalfa weevil followed an aggregated nature of distribution. Zahiri *et al.* (2006) analyzed the spatial distribution of alfalfa weevil and some of itsô natural enemies by Taylorôs power law and reported clumped dispersion patterns for life stage of *H. postica* and random dispersion for its natural enemies.

Iwao's m*-m relationship: The result of analysis of four years study (Fig. 3) revealed that similar to Taylorôs power law, Iwaoôs patchiness regression produced comparable results for the distribution of alfalfa weevil. Iwaoôs patchiness regression adequately described the relationship between mean crowding (x*) and mean density (m) for grub stages of *H. postica* (P<0.01, Table 4). All regression coefficient diverged significantly from unity (p <0.01). The value of â is greater than one *i.e.* 1.3817, 1.1991, 1.1523 and 1.3092 during the years 2005-06, 06-07, 07-08 and 08-09, respectively (Fig 3) which indicates that the weevil population followed aggregate or contiguous or clumped or over dispersed nature of distribution. On the basis of Iwaoôs patchiness, similar finding has also been reported by Vajargah *et al.* (2011). In Iwaoôs m*-m relationship, the intercept á, called the index of basic contagion, has a positive value *i.e.* 5.8296, 2.4226, 2.3361 and 2.246 during the years 2005-06, 06-07, 07-08 and 08-09, respectively. It again indicates that alfalfa weevil population followed aggregate nature of distribution. Although, the spatial pattern of alfalfa weevil in all sampling date was aggregated pattern but changes in distribution pattern during season could be caused by changes in population density or movement of larva from the clumped egg locations (Pedigo and Buntin, 1994).

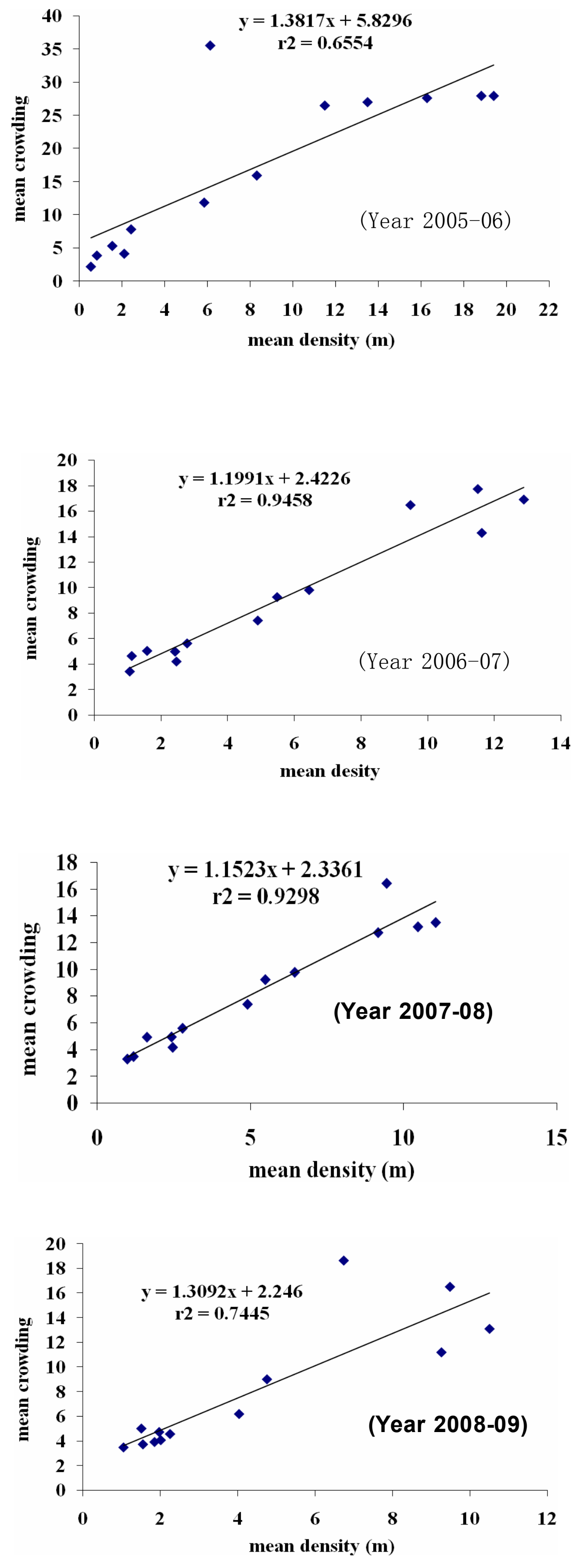

Fig 3. Relationship of mean density and mean crowding for year

Table 3. Different parameters of spatial distribution of alfalfa weevil on alfalfa in year 2007-08

Date of observation	Mean (grub/10 sweep)	Variance	VMR	k-value	Lloyed's index (X*)	Patch index	Mean crowding size (C*)	CV	I_{DM}
08.04.2007	1.180	2.763	2.341	0.880	2.521	0.913	3.521	2.341	1.341
15.04.2007	2.460	4.294	1.746	3.299	3.206	0.746	4.206	1.746	0.746
22.04.2007	2.420	6.208	2.565	1.546	3.985	0.642	4.985	2.565	1.565
30.04.2007	5.480	20.744	3.785	1.967	8.265	0.398	9.265	3.785	2.785
07.05.2007	9.160	33.158	3.620	3.496	11.780	0.355	12.780	3.620	2.620
14.05.2007	10.460	28.825	2.756	5.958	12.216	0.424	13.216	2.756	1.756
21.05.2007	11.040	27.549	2.495	7.383	12.535	0.455	13.535	2.495	1.495
26.05.2007	9.440	66.292	7.022	1.567	15.462	0.233	16.462	7.022	6.022
03.06.2007	6.440	21.721	3.373	2.714	8.813	0.406	9.813	3.373	2.373
10.06.2007	4.900	12.378	2.526	3.211	6.426	0.519	7.426	2.526	1.526
17.06.2007	2.780	7.930	2.853	1.501	4.633	0.584	5.633	2.853	1.853
24.06.2007	1.620	5.424	3.348	0.690	3.968	0.732	4.968	3.348	2.348
01.07.2007	0.980	2.306	2.353	0.724	2.333	1.012	3.333	2.353	1.353
								1/kc	0.329515

Table 4. Different parameters of spatial distribution of alfalfa weevil on alfalfa in year 2008 - 09

Date of observation	Mean (grub/10 sweep)	Variance	VMR	k-value	Lloyed's index (X*)	Patch index	Mean crowding size (C*)	CV	I_{DM}
08.04.2008	1.520	5.275	3.470	0.615	3.990	0.756	4.990	3.470	2.470
15.04.2008	1.060	2.547	2.403	0.755	2.463	0.967	3.463	2.403	1.403
22.04.2008	2.260	5.176	2.290	1.752	3.550	0.686	4.550	2.290	1.290
30.04.2008	4.760	20.104	4.224	1.477	7.984	0.397	8.984	4.224	3.224
07.05.2008	9.260	17.707	1.912	10.152	10.172	0.574	11.172	1.912	0.912
14.05.2008	10.500	27.031	2.574	6.669	12.074	0.447	13.074	2.574	1.574
21.05.2008	9.480	66.418	7.006	1.578	15.486	0.233	16.486	7.006	6.006
26.05.2008	6.740	80.033	11.874	0.620	17.614	0.220	18.614	11.874	10.874
03.06.2008	4.040	8.611	2.131	3.571	5.171	0.601	6.171	2.131	1.131
10.06.2008	2.020	4.102	2.031	1.960	3.051	0.744	4.051	2.031	1.031
17.06.2008	1.980	5.408	2.731	1.144	3.711	0.686	4.711	2.731	1.731
24.06.2008	1.860	3.796	2.041	1.787	2.901	0.764	3.901	2.041	1.041
01.07.2008	1.560	3.353	2.150	1.357	2.710	0.808	3.710	2.150	1.150
								1/kc	0.496547

Based on different statistical parameters it was found that alfalfa weevil exhibits aggregated or clumped nature of distribution in alfalfa crop grown in cold arid region, Ladakh, of Jammu & Kashmir. In a study to estimate the distribution pattern of alfalfa weevil Vajargah *et al.* (2011) reported an aggregated nature of distribution of all life stages of alfalfa weevil on alfalfa crop on the basis of index of dispersion, Lloyd◆s mean crowding, Morisita◆s index and two regression models *i.e.* Taylor◆s Power Law and Iwao◆s Patchiness Regression. However, Zalucki *et al.* (1986) reported that the spatial distribution could be affected by a number of factors including host plants, presence or absence of predator, nutritional effects, host plant, the height of the host plant, and the health and vigour of the plant. The response of individual females to various cues such as plant quality and morphology may also vary. The pattern of spatial distribution of a population may not be a constant from one time, area or life cycle to another. It happens that different distribution functions are found to be necessary to fit samples from same species population at different density (Taylor, 1971). However, sampling method chosen by the experimenter may affect the apparent distribution (Water and Henson, 1959). Characteristics of insect population distributions are not necessarily intrinsic properties of species but may be altered by microhabitat variations or imposed by varying spatial distribution of host plants. Spatial distribution of the alfalfa life stages using different analytical methods all indicated an aggregated pattern and such type of distribution has also been described in many other insects and mites (Darbemamieh *et al.,* 2011; Sedaratian *et al.,* 2010). The behavioral patterns and environment could be determinant of the spatial distribution of population individuals in an ecosystem. Different plant varieties can also affect the spatial distribution of an insect (Sedaratian *et al.,* 2010), therefore, further work is needed to verify the spatial distribution of this pest in commercial alfalfa fields and on different varieties of alfalfa.

Conclusion

Thus, on the basis of four consecutive years, it was concluded that the alfalfa weevil exhibits aggregate or contagious pattern of distribution in the field. The finding will be helpful in adaptation of management practices in the alfalfa field for the management of aphid.

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