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Effect of abiotic factors on population dynamics of insect pests and natural enemies in potato crop

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ABSTRACT

Insect population dynamics studies in potato crop revealed the occurrence of insect pests of different groups among which the major pests viz. Lepidopterans (*Helicoverpa* spp., *Spodoptera* spp., and *Agrotis* spp.) attained population peaks during initial stages of the crop (June- July), whereas scarabids (*Brahmina* spp., *Holotrichia* spp.,) were confined to active growing stage of the crop (July-August) which coincided with monsoon showers. A positive correlation was observed between the insect pest trap catch and abiotic factors viz. maximum temperature ('r'=0.63 and 0.50) and minimum temperature ('r'=0.60 and 0.52), relative humidity ('r'=0.62 and 0.20) and rainfall ('r'=0.22 and 0.19) during the year 2011 and 2012, respectively. The corresponding periodical sampling for natural enemies revealed the occurrence of coccinellids, syrphids, *Chrysoperla carnea* and parasitoids like *Aphelinus abdominalis* and *Aphidius* sp. The association between predators and or parasitoids with the abiotic factors revealed a positive correlation with their population fluctuation but in case of parasitoids, a negative but non-significant correlation was observed with minimum temperature ('r'= -0.15) and relative humidity during 2011 ('r'=-0.23) and with rainfall during 2011 ('r'=0.20) and 2012 ('r'=0.15) respectively.

Key Words : Abiotic factors, population fluctuations, correlation, natural enemies

The fluctuations of insect populations and the levels which they attain are of primary interest to society in general, for they often determine the value of our crops, the welfare of our domesticated animals and the health of our commodities. The environmental factors which influence these population levels and their fluctuations, and the mechanisms through which they act upon the populations are of primary importance to the entomologists.

Insects are a dominant component of agricultural ecosystems, and affects crop production in many ways. Several species are key pests of arable and horticultural crops, reducing yields by direct damage or through the transmission of plant virus diseases. Others are significant enemies of pest species, and can be exploited as natural regulatory agents for managing pest organisms. In addition, insects are considered as reliable and sensitive indicators of biodiversity in general, providing a means of determining the effects of agricultural practices on whole communities, or on the abundance and dynamics of individual species of conservation interest. The insects are ectothermic and sensitive to precipitation (Bale *et al.* 2002). They have a tendency to fluctuate as a result of their inherent characteristics, influenced by the environmental factors directly on their physiology and behaviour (Bale *et al.* 2002, Cannon 1998, Parmesan 2007). The degree of influence of various environmental factors, determines the magnitude of an increase or a decrease in the number of a pest-population. Knowledge of insect population dynamics is therefore essential for developing sustainable crop protection strategies, and for safeguarding the health of agricultural environments. It is also required for interpreting and forecasting the response of different taxonomic groups to weather patterns varying on a daily basis, seasonally, or as a long-term consequence of global climate change.

Potato (*Solanum tuberosum* L.) is the most promising non-cereal food crop of the world that can ensure food and nutritional security in the developing countries. Because of its high productivity and nutritional value, it emerged as the third most important food crop in the world after rice and wheat. India produces 7.72% of the world's potatoes from 7.57% of the total global potato-growing area, with productivity levels higher than the world's average (Rana 2011). There are various production constraints among which insect pests are the most important. Information on seasonal activity of potato insect pests and their natural enemies can help to take up effective integrated management strategies on time. Keeping this in view the present population dynamic studies were undertaken.

MATERIALS AND METHODS

Field studies were conducted on potato var. Kufri Jyoti sown during April as Kharif and during October-November as Rabi crop, with three replications in Randomized Complete Block Design, at the experimental farm of Central Potato Research Institute, Shimla, situated at 37° North latitude, 77° East longitude and at about 2200m above mean sea level (amsl) during 2011-12, to ascertain the population dynamics of insect pests as well as their natural enemies. As most the natural enemies are highly mobile and frequent fliers so the studies were also extended to the surrounding agro-ecosystem near to potato fields (upto about 100 metres) which comprised wildly grown herbs like stinging nettle, *Urtica dioca*; marijuana, *Canabis sativus* and wild spinach, *Spinacia* sp., grassy weeds like *Aster* sp., *Tagetes minuta; Chenopodium* sp., and sowthistle, *Sonchus arvens*. The studies were also carried out on garden flowers like pot marigold, *Calendula officinalis*; marigold, *Tegetes* spp.; rose, *Rosa* sp. and guldaudi, *Chrysanthemum* sp. grown in small flower beds near potato fields as the preliminary studies revealed great occurrence of natural enemies on these flowers.

The experimental site was kept free from pesticide application. No chemical treatment was given in the selected potato fields. Two light-traps were installed in the experimental sites (one in Eastern side of the site and another in opposite side about 300 metre apart) to trap various insect visitors in the area. The abundance and population fluctuation of the parasitoids and predators of the selected location was assessed by random visual sampling per 5m^2 area/10 minutes, replicated thrice. There were a total of three data sets. The observations were taken daily and later on converted to weekly basis for about one and a half year (three cropping seasons) from March 2011-September 2012.

Temperature, rainfall and relative humidity (RH) were obtained from the meteorological observatory of CPRI, Shimla during different months and was subjected to correlation with the population fluctuation of insect pests and natural enemies.

RESULTS AND DISCUSSION

Light traps were found effective in attracting the insects at night throughout the study period. Different species of beetles viz. *Brahmina coriacea* (Hope), *B. flavoserica* Brenske, *Melolontha indica* Blanch., *Holotrichia longipennis* Blanch., *Anomola dimidiata* Hope, *A. rugosa* Arrow; lepidopterans such as *Helicoverpa armigera* Hubner, *Trichoplusia* spp., *Agrotis* spp., *Spodoptera* spp., and other insects (viz. other lepidopterans, red cotton bug, stink bug, blister beetle, dung beetle, *Pysllodes* sp. etc.) were found trapped in the light traps. Among these, *B. coriacea*, *B. flavoserica* and *H. armigera* were observed as major pests in potato crop in Shimla. All these insect pests have been observed earlier and have been described as major and minor pests of potato by Chandel *et al.* (2012). Light traps were used successfully earlier by Kishimoto *et al.* (2009) and Ramamurthy *et al.* (2010) to study the insect population dynamics in different crops or trees.

During 2011, when the population monitoring studies were started an average of 14.52 insects were observed/trap during second week of March (10th standard week) which was found to increase gradually with rise in temperature and crop sowing and growing stages. The peak populations were attained during the month of June (25th SW) with an average of 84.76 insects/trap (Fig.1). The peak activity coincided with the full growth of the crop and becoming more pronounced during the tuber formation and maturation stages. The crop was harvested during last week of August to first week of September which directly affected the insect pest and hence natural enemy population. The insects were active up to September and thereafter the trap catches started declining and became very low during the month of October (an average of 4 to 9 insects/trap/week) and November (an average of 0.25 insects/trap/week) in the absence or very small stage (seedling) of the crop and later became almost zero. Severe cold conditions and snowfall resulted in leaf fall in the surrounding ecosystem also which further affected the survival and growth of insect pest and natural enemy activity up to the month of February.

During 2012, insects appeared during third week of February (with an average of 0.28 insects/trap) as is evident from the trap catches. The insects were active thereafter and their population increased gradually reaching up to peak level in third week of July (28th SW) with an average of 56.57 insects/ trap (Fig.1) coinciding with the tuber formation initiation stage and thereafter with a slow decline reached an average of 0 to 5 insects/trap/week during the month of September with the crop maturity and harvest. The trap catches were less during 2012 as compared to that during

Table 1: Correlation of trap catch and weather parameters and natural enemy populations in potato crop.

Weather parameter	Correlation of trap catch (r)	
	2011	2012
Maximum temperature (°C)	0.63**	0.50**
Minimum temperature (°C)	0.60**	0.52*
Relative humidity (%)	0.62**	0.20
Rainfall (mm)	0.22	0.19
Natural enemies	0.45**	0.53**

Ghosh *et al.* 1985); *Cheilomenes* (*Menochilus*) *sexmaculata* (Fabricius) and parasitoids like *Aphelinus* sp. (Verma *et al.*, 1976) and *Aphidius colemani* Viereck (Trivedi 1988; Trivedi and Saxena 1988) have been found associated with potato crop in various studies.

The natural enemy population followed the same trend as that of other insects and pests of the area. They started appearing during the months of March and remained active upto September (Fig. 2). The natural enemy population comprising syrphids and coccinellids were most active during the months of April- August at an average temperature range of 15.2-29.96°C and relative humidity of 44-92%.

Table 2: Correlation ('r') of population fluctuation of natural enemies with abiotic factors.

Natural enemy groups	Minimum Temperature		Maximum Temperature		Relative Humidity		Rainfall	
	2011	2012	2011	2012	2011	2012	2011	2012
Coccinellids	0.67**	0.87**	0.82**	0.45**	0.36*	0.38*	0.22	0.31
Syrphids	0.88**	0.85**	0.72**	0.69	0.43**	0.66**	0.58**	0.56**
Chrysoperla carnea	0.68**	0.71**	0.66**	0.30	0.12	0.46**	0.49**	0.31
Parasitoids	-0.15	0.33*	0.38*	0.45**	-0.23	031	-0.40	-0.15

*Significant at 5% ** Significant at 1%

the year 2011. This may be due to the severe and prolonged winters from November 2011 up to March 2012 which was followed by a short dry spell after April 2012, which resulted in difficulties in insect emergence as well as deformities in their development and morphology. Light trap catches have been observed to vary with temperature, wind, precipitation, cloud cover, and moon phase by various workers (Butler *et al.* 1999; Yela and Holyoak 1997). Kishimoto *et al.* (2009) carried out population monitoring studies of chrysomelid beetles via light traps and concluded that crop phenology and environmental conditions affects the population of beetles significantly.

The random visual observation of natural enemies of potato insect pests revealed the presence of syrphids (*Episyrphus balteatus*, *Eupeodes* sp., *Scaeva pyrastri*), coccinellids (*Coccinella septempunctata*, *Menochilus sexmaculata*, *Adalia quadrispinolata*, *Adalia decempunctata*), green lacewing bug (*Chrysoperla carnea*), and parasitoids (*Aphelinus abdominalis* and *Aphidius* sp.) in the potato fields and surrounding agro-ecosystem. *Episyrphus balteatus* (De Geer) (Raychaudhari *et al.* 1979; Parasitoids were found abundantly on aphid infested *Urtica dioca* (stinging nettle grown wildly around potato fields) plants and almost 100 per cent aphid parasitisation was observed on these plants during the months of September-November and April-May. *Chrysoperla carnea* was the least abundantly found natural enemy and was present throughout the potato cropping period (Fig. 2 and 3).

The correlations studies revealed a positive correlation between the trap catches and abiotic factors viz. temperature, relative humidity and rainfall (Table 1). Temperature is probably the most important environmental factor influencing the behaviour, distribution, development, survival and reproduction of insects (Chu and Chao 2000; Karuppaiah and Sujayanad 2012). In the present studies also temperature (minimum and maximum) showed significant effect on population fluctuation of insect pests during both the years. Matilda *et. al.* (2012) concluded that abiotic factors, especially temperature, regulate the ecology of insect communities. The trap catch also correlated positively with the natural enemy population with 'r'= 0.45 and 0.53 during 2011 and 2012, respectively.

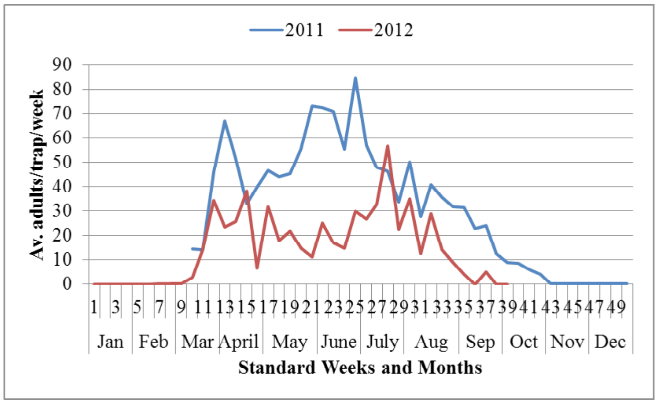

Fig. 1 : Population fluctuation of insects in trap catches during the year 2011-12 at CPRI farm Shimla.

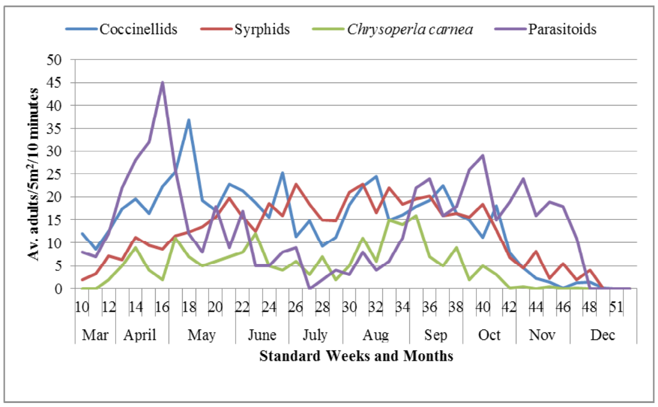

Fig. 2 : Population fluctuation of natural enemies during the year 2011.

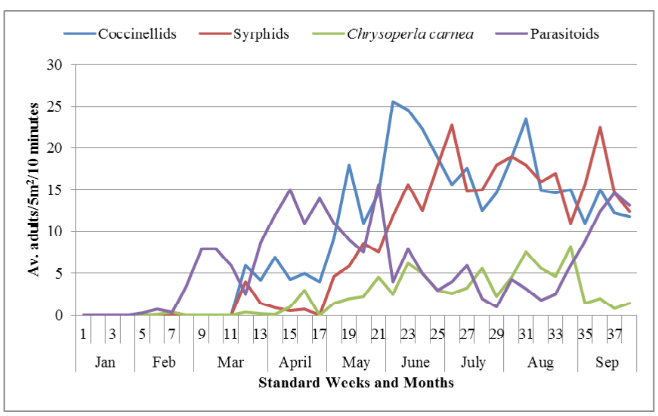

Fig. 3 : Population fluctuation of natural enemies during the year 2012.

Similarly in case of natural enemy population fluctuations, temperature played a significant positive role on the activity of syrphids, coccinellids and *C. Carnea* during both the years. However, in case of parasitoids a negative but non-significant effect was observed during 2012 ('r'=-0.15) (Table 2). Parasitoid population was also affected negatively by relative humidity during 2011 ('r'=-0.23) and rainfall during both the years with 'r'=-0.40 and -0.15, respectively.

CONCLUSIONS

The peak population levels of insects were observed during June-July. The statistically significant values indicated that occurrence of insect pests and natural enemies population was due to the prevailing ecological conditions. The management of potato pest complex should therefore be promoted and tailored from April onwards using an integrated approach. Among the abiotic factors temperature is an important force to drive the population. Temperature causes the direct effects like survival, growth, development and dispersal. Rainfall and relative humidity play vital role in soil insects and parasitoid abundance.

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