Pest complex of potato (*Solanum tuberosum* L.) with special reference to management of white grub in northern districts of Kashmir Valley

Mohmmad Munib
(2010-296-D)

Division of Entomology

Faculty of Postgraduate Studies

Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir

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Thesis

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DEDICATION

I would like to dedicate this thesis to my late Advisor

Professor M.I. Shah Waliullah who passed away suddenly on the date of my viva voce

Professor M.I. Shah Waliullah

(16th April 1954 to 20th June 2014)

Words and tears could not express how shocked I am at his tragic death. "It was that morning on 20th June 2014 the scheduled date of my Viva Voce when I was attending you in the hospital at about 6:00 am, because it was more appropriate to be around that time when you needed me the most. I consider myself to be lucky to be at your side when you bid farewell to this world. It was my great honour to pursue a Ph.D. degree under your supervision. Starting from a fresh graduate, you guided me with your whole heart. I still remember clearly the first time we met in your office ten years ago. You kindly spent over an hour introducing and inspiring me to be a good researcher. Throughout the past years, I strongly felt your passion to work and your dedication to students. The longer I interact with you, the more I discover to learn from you. You were always there to share experience and give support. Even when you were sick, you continued to offer selfless help to my career development. I deeply appreciate all what you have done for me."

Proud to be one of your students,

No words can represent my respect, May your soul rests in peace

Sher-e-Kashmir
University of Agricultural Sciences & Technology of Kashmir
Division of Entomology, Shalimar Campus, Srinagar 190 025

Certificate – I

This is to certify that the thesis entitled **"Pest complex of potato (*Solanum tuberosum* L.) with special reference to management of white grub in northern districts of Kashmir Valley"** submitted in partial fulfilment of the requirements for the award of the degree of **Doctor of Philosophy in Agriculture (Entomolgy)**, to the **Faculty of Postgraduate Studies, Sher-e-Kahsmir University of Agricultural Sciences and Technology of Kashmir** is a record of bonafide research work carried out by **Mr. Mohmmad Munib (Regd. No. 2010-296-D)** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that information received during the course of investigation has duly been acknowledged.

(Prof. M.I.Shah Waliullah)
Chairman
Advisory Committee

Endorsed

Prof. & Head,
Division of Entomology

Sher-e-Kashmir
University of Agricultural Sciences & Technology of Kashmir
Division of Entomology, Shalimar Campus, Srinagar 190 025

Certificate – II

We, the members of the Advisory committee of **Mr. Mohmmad Munib (Regd. No. 2010-296-D)**, a candidate for the degree of **Doctor of Philosophy in Agriculture (Entomology)**, have gone through the manuscript of the thesis entitle **"Pest complex of potato (*Solanum tuberosum* L.) with special reference to management of white grub in northern districts of Kashmir Valley"** and recommend that it may be submitted by the student in partial fulfilment of the requirements for the award of degree.

Advisory Committee

Chairman	**Prof. M.I.Shah Waliullah** Professor/Chief Scheintist (Ex-Head) Division of Entomology, SKUAST-Kashmir
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Dean PG Nominee	**Prof. Shafiq-ur-Rehman** Professor & Head, Division of Environmental Science, SKUAST-Kashmir

Sher-e-Kashmir
University of Agricultural Sciences & Technology of Kashmir
Shalimar Campus, Srinagar 190 025

Certificate – III

This is to certify that the thesis entitled, **"Pest complex of potato (*Solanum tuberosum* L.) with special reference to management of white grub in northern districts of Kashmir Valley"** submitted by **Mr. Mohmmad Munib (Regd. No. 2010-296-D)** to the **Faculty of Postgraduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir** in partial fulfilment of the requirements for the award of the degree of **Doctor of Philosophy in Agriculture (Entomology)** was examined and approved by the Advisory Committee and external examiner on ……..

Chairman
Advisory Committee

External Examiner

Prpf. & Head,
Division of Entomology

Director Education
SKUAST-Kashmir, Shalimar, Srinagar

Sher-e-Kashmir
University of Agricultural Sciences & Technology of Kashmir
Division of Entomology, Shalimar – 190 025

Name of the student	:	**Mohmmad Munib**
Registration No.	:	2010-296-D
Major subject	:	Entomology
Minor subjects	:	Vegetable Science
Major advisor	:	**Prof. M.I.Shah Waliullah** Professor/Chief Scheintist (Ex-Head) Division of Entomology, SKUAST-Kashmir
Title of the Thesis	:	**"Pest complex of potato (*Solanum tuberosum* L.) with special reference to management of white grub in northern districts of Kashmir Valley"**

ABSTRACT

The investigations entitled "Pest complex of potato (*Solanum tuberosum* L.) with special reference to management of white grub in northern districts of Kashmir Valley" were undertaken at Baramulla, Kupwara and Bandipora districts for two cropping seasons 2011 and 2012. A total of 12 pests were recorded on the crop right from sowing upto harvest which were Flea beetle (*Chaetocnema* spp.), Semilooper (*Thysanoplusia orichalcea*), Aphid (*Macrosiphum euphorbiae*), Cutworm (*Agrotis ipsilon*), White grub (*Brahmina coriacea* and *B. poonensis*), Wireworm (*Melanotus horticornis*), Earwig (*Euborellia annulipes*), Stunt nematode (*Tylenchorlynctus kashmiriensis* Mahajan), Lens nematode (*Basirolaimus indicus* Shamsi), Spiral nematode (*Helicotylenchus dihystera* Sher. and *H. indicus* Siddiqi), Root lesion nematode (*Pratylenchus* spp.) and Dagger nematode (*Xiphinema basiri* Siddiqi).

Incidence of insect pests revealed that above ground pests appeared in 1st to 2nd week of May and attains peak in June in plains and midhills. Whereas, at high hills the pests appeared by the end of May to 1st week of June with a peak

incidence by end of June to 1st week of July. The overall incidence percentage of above ground insect pests of 57.77 per cent was recorded at Yarikha (Baramulla) and Budnambal (Kupwara) for flea beetle followed by 23.33 per cent at Gurez (Bandipora). However, the lowest incidence of 7.77 per cent was recorded at Sumbal (Bandipora) for semilooper and 4.99 per cent for cutworm at Gurez (Bandipora) with complete absence of semilooper at Budnambal (Kupwara) and Gurez (Bandipora). While as, rest locations shared intermediate incidence percentage against each insect pest. For foliage feeders pooled mean severity of 20.56 per cent was observed for flea beetle as highest (Scale-2) and 5.06 per cent as lowest (Scale-1) at Yarikha (Baramulla). Whereas, 24.81 per cent for flea beetle as highest (Scale-2) at Budnambal (Kupwara) and 11.03 per cent for semilooper as lowest (Scale-1) at Handwara (Kupwara) and 18.12 per cent for flea beetle as highest (Scale-1) at Gurez (Bandipora) while as, 5.12 per cent for semilooper as lowest (Scale-1) at Ajas location of Bandipora district. Severity of foliage sucking insect pests range from 0.82 per cent at Kunzer to 1.14 per cent at Yonus of Baramulla and Kupwara districts, respectively (Scale-1 scattered appearance of few aphids) and a range of 3.50 per cent at Budnambal (Kupwara) to 5.62 per cent at Sumbal (Bandipora) for collar feeding insect pests.

Incidence of below ground insect pests revealed that pests appeared in last week of May to 2nd week of June with peak in July to August in plains and midhills. Whereas, they first appeared in last week of June to 2nd week of July and attains peak towards the harvest of crop at higher hills of northern Kashmir.The overall incidence percentage for 2011and 2012 for below ground insect pests revealed that 19.99 per cent incidence was observed at Budnambal (Kupwara) for wireworm followed by 18.88, 14.44 and 14.44 per cent for white grub at Budnambal (Kupwara), Kunzer (Baramulla) and Ajas (Bandipora), respectively with low incidence of 5.55 per cent for earwig in plains and midhills of Kupwara and Bandipora district and wireworm at Ajas (Bandipora). However, earwig and wireworms were completely absent at Kunzer and Yarikha locations of Baramulla district. Whereas, earwigs were also absent at Budnambal (Kupwara) and Gurez (Bandipora).

Infestation percentage of below ground insect pests at Baramulla districts revealed that white grub exhibits highest 19.00 and 17.77 per cent on number and weight basis, respectively at Kunzer whereas, 9.00 and 8.59 per cent for wireworm and 8.00 and 8.54 per cent infested tubers for earwig on number and weight basis, respectively at Pattan on white peeled tubers. For Kupwara district 19.00 and 18.00 per cent; 20.00 and 21.17 per cent infested tubers were recorded due to white grub and wireworm at Budnambal on number and weight basis, respectively. Whereas, for earwigs the highest per cent infested tubers were 9.0 and 8.62 per cent at Yonus on both number and weight basis on white peeled tubers. High tuber infestation percentage of 17.00 and 18.49 per cent was recorded at Ajas by white grub on both number and weight basis followed by earwig with 11.00 and 9.65 per cent at Sumbal on number and weight basis in Bandipora

district. Further red peeled tubers were significantly resistant to tuber feeders than white peeled tubers.

Severity of tuber feeding insect pests range from 2.94 per cent at Sumbal to 4.94 per cent at Ajas (Bandipora) for white grub; 1.08 per cent at Gurez (Bandipora) to 4.02 per cent at Budnambal (Kupwara) for wireworm and 3.48 per cent at Handwara (Kupwara) to 5.28 per cent at Sumbal (Bandipora) for earwig at all locations of northern Kashmir (Scale-1 tuber damage from 1-20 %).

In vivo observation revealed that Imidacloprid (70WS) as seed treatment registered 97.33, 96.66 and 96.66 per cent good tubers at Kunzer, Budnambal and Ajas, respectively followed by *Bacillus thuringiensis*, *Metarrhizium anisopliae* and *Beauveria bassiana*. Whereas, Mustard cake as soil amendment recorded lowest good tubers of 76.00, 76.66 and 76.66 per cent at Kunzer, Budnambal and Ajas against 74.66, 75.33 and 74.66 per cent in control, respectively. The overall performances in descending order of different pesticides / cultural practices on the basis of per cent good tuber were *Imidacloprid* (96.88%) > *Bacillus thuringiensis* (93.55%) > *Metarrhizium anisopliae* (91.10%) > *Beauveria bassiana* (89.33%) > Cultural practices (81.33%) > *Azadirachta indica* (80.66%) > Phalada-111 C1(77.10%) > *Brassica species* (76.44%) against control (74.88%).

Key words: Pest complex, Insect pests, Incidence, Severity, Management, White grub

Signature of Student

Signature of Major Advisor

Dated : _____

Dated: _____

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IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST BENEFICIENT AND THE MOST MERCIFUL

"In the name of Almighty "Allah", the most beneficent and merciful, I would like to praise and thank "Allah" the Almighty Who bestowed me with health and courage to accomplish this goal".

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Mohmmad Munib

Place : Shalimar, Srinagar

Dated :

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Chapter – 1

INTRODUCTION

Potato, *Solanum tuberosum* L. the king of vegetables is a native of South America; in Indian sub-continent people called it *alu* though also known as white or Irish potato and no doubt it is an indispensable part of Indian cuisine. As per literature it is the most important vegetable crop ranking fourth after rice, wheat and maize being a major staple food crop. As for as production is concerned, it is the fifth largest agricultural produced crop as well the largest tuber crop of the entire world (Anonymous, 2011a). Screening of literature revealed that different varieties of potatoes are grown in more than 150 countries of the world and more than a billion people eat it worldwide. The top ten producers in the world are China, Russia, India, USA, Ukraine, Germany, Poland, Belgium, Netherlands and France which together contribute about 70 per cent of the total production (Anonymous, 2011a). India ranks 4^{th} in terms of area and 3^{rd} in terms of production of potato across the globe, producing around 42.34 million tons from an area of 1.86 million hectares (Anonymous, 2011a). Important potato producing states of India are Uttar Pradesh, Uttaranchal Pradesh, West Bengal, Bihar, Punjab, Madhya Pradesh, Gujarat and Assam where Uttar Pradesh is the largest producer of potato with 13.57 million tons production in 2010-2011 (Anonymous, 2011a).

In Kashmir province, potato is grown over an area of 1.7 thousand hectares with a production of about 34.00 thousand tons (Anonymous, 2011b). It is cultivated in large tracts and in home gardens as well.

The potato tubers are highly nutritive, rich in carbohydrates, proteins, phosphorus and minerals such as calcium, potassium and also vitamin A and C. It also contains significant levels of phenolic compounds and vitamin C as potent antioxidants (Brown, 2005) which inactivate reactive oxygen, reducing oxidative damage, lead to improved immune functions and reduce risk of cardiovascular

disease, cancer, cataract, diabetes and aging (Kaur *et al*., 2004). Being a short duration crop, it produces more quantity of dry matter, gives energy and edible protein in short duration of time compared to cereals like rice and wheat. Hence, potato may prove to be a useful tool to achieve the nutritional security of the nation. Around 80 per cent of potato production is achieved as a Rabi crop. The rest of the production mainly comes from Karnataka state of India and other hilly areas during long summer days. The Rabi crop is sown in October and harvested in March. But it is grown as a kharif crop in Maharashtra, Himachal Pradesh, Jammu & Kashmir and Uttarakhand where it is sown in April-July and becomes available in the market by August-October. The share of kharif potato in total production of potato in our country is about 12 per cent. The major potato producing states are Uttar Pradesh, West Bengal, Bihar, Punjab, Gujarat and Assam where it is grown as a Rabi crop with normal crop duration of 5-6 months. Although potato is a seasonal crop it is grown in most of the states based on climatic conditions and harvested at different times, thus making it available throughout the year.

Potato is a temperate or cool season crop which needs a low temperature, low humidity, less windy and bright sunny days. It does perform well under well-distributed rains or moist weather situations to high temperatures. Moreover, humidity and rains are not conducive to potato crop as often suffered with insects, nematodes and disease attacks.

Infact, insects, nematodes, rats and other pests are detrimental in reducing the agricultural production of potato in tropical countries (Waliullah, 2007; Ghosh and Khan, 2010). Apart from the direct attack on plant some of the insects and nematodes are the vectors of virus particularly those of sap feeders viz., aphids, *Xiphinema, Longidorus* species etc. They suck sap of leaves, shoots, stem and roots and causing diseases to plants and indirectly affect photosynthesis also. But nevertheless inspite of all efforts the control of insects and nematodes is challenging since vectors are usually mobile and small in size and more so it is

very difficult to prevent colonization of some pests in fields (Chenulu, 1984; Banjo, 2010).

It is well documented that this important vegetable crop in fields is always subjected to qualitative and quantitative losses due to biotic and abiotic stresses. Screening of literature revealed that potato crop is attacked by more than 100 arthropods and 156 species of plant-parasitic nematodes that belonged to 52 genera all over the world. Out of these, 80 arthropods and 93 species of nematodes fall under 40 genera have been reported from India alone (Pandey, 2007). Important insect pests which feed on both above and underground parts of potato include, cutworm, flea beetles, tobacco caterpillar, aphids, potato leafhopper, lygus bugs, potato tuberworm, whitefly, wireworm, earwigs and white grub etc. Nematode species, *Globodera* and *Meloidogyne* are among those nematodes that have been reported as endoparasitic on potato crop (Waliullah, 1992). Among the insect pests, white grubs of *Holotrichia* species belonging to soil pests have been reported as serious threat to this crop particularly in the high hills. Further, it has been also deemed that actual damage to potato tubers is done by 2^{nd} and 3^{rd} instars grubs by making large, shallow and circular holes thus rendering tubers to low market value. It is reported that this pest may cause 15.5 to 80.0 per cent losses of tuber yield in endemic areas located at the higher hills of Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir and also in North-eastern hills of India (Mishra, 1995; Misra, 2003).

Keeping in view the importance of above mentioned pests, attention has been paid to manage that cause heavy loss to the potato crop. It is worth to mention here that informations from Jammu and Kashmir state particularly from the valley of Kashmir on the pest complex of potato is negligible. Since, it is mandatory for a researcher to have basic data on the pest complex along with their incidence, extent of damage and to develop an eco-friendly management strategies against the white grub infesting potato crop. The present research work, therefore, was planned with a view to monitor the pests associated with the potato crop with

special attention on the management of the predominant species of white grub with the following objectives :

- To survey pest complex of potato in various potato growing belts of northern Kashmir,
- To study the incidence and severity of potato insect pests and
- To manage white grub by using integrated pest management strategies.

Chapter – 2

REVIEW OF LITERATURE

Screening of research literature revealed that a lot of work on pest complex and management of white grub infesting potato (*Solanum tuberosum* L.) have been carried out worldwide which is reviewed here as under:

2.1 Pest complex of potato (*Solanum tuberosum* L.)

Britton (1918) while working on insects attacking potato crop in Connecticut (USA) reported an number of chewing insects where the most important were Colorado potato beetle and potato flea beetle. He reported that three lined potato beetle, tortoise beetle, blister beetle, stalk borer, cutworm, wireworm, white grub and European corn borer caused occasional damage and according to him the principal sucking insect damaging potato were potato aphid species.

Eden and Garrett (1955) reported that wireworms, primarily the Gulf wireworm and the imported fire ant were serious pests of the Irish potato crop in the Gulf Coast Area of Alabama.

Sharma and Bhalla (1964) conducted a survey on insect pests of economic importance in Himachal Pradesh and reported 13 insect pests belonging to different orders from potato crop grown fields in hills.

Getzendaner (1966) reported that European earwig feeds on other insects, plants, ripe fruit, and garbage. Plants that it feeds on include clover, dahlias, zinnias, butterfly bush, hollyhock, lettuce, strawberry, celery, potatoes, roses, seedling beans, beets, tender grass shoots and roots. It also damages sweet corn by feeding on the silks.

Squire (1972) reported that the most important insect pests in root crop potato in Bolivia were *Liriomyza* spp., as the larvae of which feed in the stems. The material collected by him included *L. quadrata* (Mall.), *L. brasiliensis* (Frost)

and several undescribed species. The leaves were attacked by *Acordulecera* sp. (a Tenthredinid that feeds on the parenchyma), *Empoasca fabialis* DeLong, *E. fabae* (Harris) and *Macrosiphum euphorbiae* (Solanifolii (Ashm.)); this last transmits the viruses causing potato mosaic and leaf-curl. Several species of *Epicauta* were noticed to feed on the leaves, and *E. adspersa* (Klug) and *E. vittata* (F.) occasionally destroy both leaves and young shoots. The major species attacking the tubers were *Premnotrypes latithorax* (Pierce) *Phthorimaea* (Gnorimoschema) *operculella* (Zell.). The tubers, particularly those growing in humus or peaty soil were also attacked by larvae of *Cyclocephala melanocephala* (F.), *Bothynus* (Ligyrus) *burmeisteri* (Steinheil) and *Ontherus sulcator* (F.). However, *Leptinotarsa decemlineata* (Say) was not recorded from Bolivia.

Sexana (1974) described some soil insect pests, defoliators, sap feeders and storage pests of potato in India and gave informations on their control.

Adashkevich (1975) pointed out in a review paper that there were more than 600 species of insect, mite and other invertebrate pests of vegetable crops in the Soviet Union and in the European part alone more than 500 species of insect enemies of such pests. The crops most studied include, among field crops, cabbage, tomato, potato and cucurbits; 75 per cent of the enemies observed were polyphagous and less than 5 per cent monophagous. It was reckoned that they destroyed about half the pest population in general. The situation was less favourable in the case of *L. decemlineata* (Say), because the effect of its 50 species of enemies was small.

Dorozhkin *et al.* (1975) while working on combined protection of potatoes in Byelorussia, reported that potato were attacked by numerous diseases and insect pests where the most important being *L. decemlineata* (Say) and wireworms.

In an another study at least 38 species of insect pests were reported to attack potato at Cusco (Peru) which was partly based on literature and partly on

surveys carried out during 1972-73. These pests were placed in 7 orders and 18 families including 12 new species that were recorded for the first time from potato fields in Cusco (Escalante, 1975).

Menschoy (1975) made detailed studies on the insect pests of potato and their control. He found that the major pests attacking the young plants were noctuid larvae. The larvae of *Phthorimaea operculella* feed on the young shoots and other foliage parts of crop and those of the last generation make tunnels in the tubers. The larvae of *Manduca (Phlegethontius) sexta* subsp. *paphus* feed extensively on the foliage and *Epicauta* spp., *Diabrotica speciosa* (Germ.) and *Epitrix parvula* (F.) also damage the foliage. He also reported that the important aphids like *Myzus persicae* (Sulz.), *M.euphorbia* (Thos.), *Solanifolii* (Ashm), *Aulacorthum solani* (Kalt) and *Aphis euonymi* F. which infested the potato crop at Brazil.

Butani and Verma (1976) studied on pests of vegetables and their control in India. They reported that *Phthorimaea operculella*, *Agrotis ipsilon* and other *Agrotis* species were attacking both above and underground parts of potato. *M. persicae* and 12 other species of aphids were associated with leaves whereas, *Gryllotalpa africana* and *Eremotermes* sp., *Microtermes obesi* and *Odontotermes obesus* were the major insect pests which infested the other parts of potato crop.

Koppen *et al*. (1976) conducted an experiment for monitoring insect pests of potato in East Germany especially *L. decemlineata*; *A. segetum* and suggested that sampling with the aid of a check plot method should be based on certain characters and independent of pest distribution. Monitoring of *L. decemlineata* should also be done regularly that covers the stages which are important for short-term prognosis and that cause active damage during growing season. The supervision of *A. segetum* covers young larvae and should be carried out 30 days after adult flight where the period could be detected with the aid of light traps.

Bacon *et al*. (1978) reviewed the damage caused by the most important pests of potato *Phthorimaea operculella* (Zell.) and *M. persicae* (Sulz.) in California by monitoring the populations of *P. operculella* in 1976 by means of water-pan traps baited with synthetic sex pheromone and found that in fields imperfectly irrigated, where the soil was cracked potato damage was heavier because adults and larvae were able to gain access to the tubers through the soil cracks. However, more damage was caused by *M. persicae* to potato through the transmission of leaf-roll virus. The population monitoring by means of water-pan traps during 1970-1972 showed an annual decline in numbers probably owing to insecticide applications and improved weed control; however, even short-lived aphids feeding briefly on infected plants, if present, were able to transmit the virus before being killed by the sprays.

Jensen *et al*. (1979) listed 67 species belonging from 24 genera to nematodes associated with potatoes. Among them the most damaging were the potato cyst nematode, *Globodera rostochiensis* and *G. pallida* causing tremendous losses in several countries. The other nematode species distributed worldwide causing significant losses including stubby root (*Trichodorus* and *Paratrichodorus* spp.), root lesion (*Pratylenchus* spp.), potato rot (*Ditylenchus* spp.) and *Basirolaminus indicus* (Waliullah, 1992).

Nagaich *et al*. (1979) made a collection of leaf hopper fauna from potato and other adjoining crops from different agroclimatic regions of India and collected 74 leaf hopper species.

Tsendsuren (1979) listed soil-inhabiting pests in Mongolia particularly those which were much damaging to crops, pastureland and soil-consolidating plants by wireworms, tenebrionids, cockchafers, lepidopterous larvae and other soil-inhabiting insects. Among 80 known species of wireworms, the most injurious to field crops were *Selatosomus latus* (F.), *S. spretus* (Mannh.), *S. aeneus* (L.), *Agriotes obscures* (L.), *A. sputator* (L.), *A. lineatus* (L.), *A. meticulosus* Cand. and *A. dahuricus* Cand. The larvae of those species damage

cereal crops especially maize in May-June and also damage potatoes, cabbage, beet and onion. Further, over 100 species of scarabaeids were recorded and the most injurious include *Amphimallon solstitiale* (L.), which damages maize in irrigated soil in the south of the Mongol Altai region and likewise potatoes, sugar-beet and cereals, Other injurious beetles include species of *Eodorcadion*. Leaf-feeding Lepidoptera in river valleys and other suitable sites include *Euxoa islandica* Stgr., *E. tritici* (L.) and *A. exclamationis* (L.), which damage especially vegetables, potato and other crops.

Kashyap and Verma (1982) conducted a survey on aphids infesting seed crop of potato in Haryana (India) and reported on a total of seven aphid species infesting potato crop namely *A. craccivora* Koch, *A. gossypii*, *A. fabae*, *M. persicae* Sulz., *Rhopalosiphum nymphaeae* Linn., *R. rufiabdominalis* and *Tetraneura nigriabdominalis* Sasaki.

Radcliffe *et al.* (1982) have reviewed the insect pests of potato that were belonged to 5 main headings: aphids (including aphid-transmitted potato viruses; aphid life-cycles and biology; aphids and virus transmission; population monitoring and modelling; insecticide resistance and biological control), leafhoppers, *Leptinotarsa decemlineata* (Say), *Phthorimaea operculella* (Zell)., and pests of tubers and roots. A short section on varietal resistance to insect pests is also included.

Hooker *et al.* (1983) while studying the potato insect pests in Brazil, their status and future trends. They reported that the main pests of potato were *M. persicae* (Sulz.), as the main species limiting to seed production (on account of the viruses it transmits); *Diabrotica speciosa* (Germ.) and *Epitrix* spp., the larvae of which feed on the tubers of both seed and table crops and the adults of which feed on the foliage and *Liriomyza huidobrensis* (Blanch.) which is highly important as in some areas reduced yields by 30 per cent in 1981, while as *P. operculella* (Zell.), elaterids, *A. ipsilon* (Hufnagel.), *M. euphorbiae* (Thos.), *Nezara viridula* (L.) and *Epicauta* spp. recorded as minor pests.

Velupillai and French (1986) conducted a survey on previously reported diseases and pests of potato on the main Island of Sri Lanka. They confirmed that most pathogens and pests recorded had been reported previously except some fungi viz., *Choanephora cucrditarum, Fusarium oxysporum,* the aphid, *Rhopalosiphoninus latysiphon* Davidson and the mite *Polyphagotarsenemus latus* Banks.

Anwar *et al*. (1987) while recording the insect pests associated with potato cultivar Multan in Pakistan that included *Gryllus bimaculatus* and *Acrotylus humbertianus*. They further recorded peak population of aleyrodid *Bemisia tabaci* (2.25 individual plant^{-1}) in the first week of February and the cicadellid *Amrasca devastans* (1.22 plant^{-1}) in second week of January, while *M. persicae* (1.68 aphid plant^{-1}) in the first week of December to (9.01 plant^{-1}) in the fourth week of January and maximum attack of larvae of *Phthorimaea operculella* was also noted in February with 13.5 per cent of tuber infestation.

Hill *et al.* (1987) studied biology of *Thysanoplusia orichalcea* (Lepidoptera: Noctuidae) in New Zealand and reported that plusiine noctuid moth, *T. orichalcea* was a polyphagous pest with a host plant range differing from *Chrysodeixzs eriosorna* and more abundant than *C. eriosoma* on 7 species of plant could become a significant defoliating pest in legumes and brassicas.

Raodeo and Deshpande (1987) reported that white grubs (Scarabaeidae) in Marathwada region of Maharashtra (India) were attacking the roots of various crops including wheat, ground nut, potato, tomato and sugarcane.

Sharma *et al*. (1987) while investigating the occurrence of insect pests on stored potato tubers in an ordinary room temperature 20-25 ^{o}C and in cold storage at 2-3 ^{o}C, reported that potatoes in cold storage were not infested, while the tenebrionids *Alphitobius laevigatus*, *Tribolium castaneum*, the trogossitid *Tenebroides mauritanicus* and the dermestid *Trogoderma granarium* were found with greatest infestation on tubers stored in ordinary room.

Tyagi and Misra (1987) while surveying for the extent of damage done by white grub species (*Lachnosterna coriacea* and *L. longipennis*) in and around Shimla during 1984 and 1985 on potato crop reported that both attained the status of key pests of potato crop in certain pockets of Himachal Pradesh particularly at Shilaroo and its adjacent areas.

Das (1988) conducted trial on insect pests of potato crop and their control in Tripura (India) which revealed that 23 species of insect pests were infesting potato of which only *Odontotermes obesus, Agrotis segetum, A. ipsilon, Aphis gossypii, A. fabae* and *M. persicae* were of economic importance.

Das and Ram (1988) conducted a field study in Bihar (India) during 1983-84 and 1984-8 to determine the damage, incidence and carry-over of the noctuid *A. ipsilon* on potato revealed that during 1983-84, damage to tubers averaged 12.76 and 4.26 per cent during 1984-85. Further the plant damage was first observed during the 3rd week of December and increased thereafter until the 2nd week of January and the tuber damaged was first observed during late December that increased thereafter till harvest. No larvae were observed in 1st week after harvest and from the 4th week of February until April. However, larvae and pupae were found only on the following alternative host plants: *Chenopodium album, Solanum nigrum, Portulaca oleracea, Amaranthus viridis, Evolvulus alsinoides* and 2 unidentified weed species.

Misra and Agrawal (1988) while investigating on the potato pests in India and their control, reported that potatoes were attacked by more than 80 insects and several nematode pests in the fields. The pests were classified into soil pests, sucking sap feeders, defoliators and storage pests. They further reported two major nematode pests viz., root-knot and cyst forming ones infesting the crop.

Rai *et al*. (1988) conducted a survey to record the insect pests of potato at the experimental fields of R.A.R. Station Chhindwara, Madhya Pradesh and reported three new insect pest species for the first time on potato which were niger

capsule fly, *Dioxyna sororcula* Wiedmann (Diptera: Tephritidae), niger green bug, *Creontiades* sp. (Hemiptera: Miridae) and mirid bug *Taylorilygus pallidulus* Walk (Hemiptera: Miridae).

Rajagopal and Trivedi (1989) reported that among the major insect pests that attack potato, the coccinellid *Epilachna vigintioctopunctata* is very important in Asia which is widely distributed in South and East Asia, Australia, America and the East Indies where some of the species are *E. dodecastigma* and *E. vigintioctopunctata*, *E. ocellata* and *Henosepilachna sparsa* [*E. sparsa*] commonly attack *Solanaceous* plants. They further reported that the peak period of infestation varied with region, but the peak was generally in July-August. The pest also feeds on aubergine, tomato, tobacco, pumpkin and bitter gourd [*Momordica charantia*].

Sontakke *et al*. (1989) while studying the effect of climatic factors on the phenology of foliage pests of potato in Orissa (India) during the kharif and rabi seasons of 1983-84 and 1984-85, reported that potato crop was attacked by the aphids *A. gossypii* and *M. persicae*, the chrysomelid *Chalaenosoma metallicum*, the cicadellid *Amrasca biguttula*, the coccinellid *Henosepilachna viginctioctopunctata* [*Epilachna vigintioctopunctata*], the thrips *Thrips flavus*, the tarsonemid *Polyphagotarsonemus latus* and the noctuid *A. ipsilon* in both seasons. However, the phenology of the pests and the intensity of their attack varied considerably in the different seasons and regions. The correlation analysis between various meteorological variables and the incidence of the different pest species during the kharif season revealed that temperature was having positive significant correlation with the incidence of most of the insect pests, except *A. ipsilon*. The population development of *A. ipsilon* has shown significant influence by day temperature during the rabi season.

An interdisciplinary research project on the management of potato pests in the highlands and coastal regions conducted at Peru contains chapters on the intensification of potato production and pesticide use there, pest management

practices in the highlands, the endemic potato pest *Premnotrypes* spp., the storage pests *Phthorimaea operculella* and *Symmetrischema plaesiosema* and a case study of *Liriomyza huidobrensis* in the Canete valley (Ewell *et al.*, 1990).

Lal (1990) reported that many insect pests causing severe damage to the potato crop and the tubers in north-eastern India which were recorded for the first time and were different in different crop stages of the region. However, cutworms (*Agrotis ipsilon* Ratt), white grubs (*Lachnosterna coriacea* Hope), leaf-eating caterpillars (*Prodenia litura* Fab.), (*Heliothis armigera* Hubn.) and *Plusia* sp. and aphids (*Myzus persicae* Sulzer) were some amongst the common pests observed throughout that region. The potato tuber moth (*Phthorimaea opercullela* Zeller) caused severe damage only in Meghalaya, where it showed more than 50 per cent plant infestations and 70 per cent tuber damage under indigenous storage conditions. An Epilachna beetle (*Henosepilachna vigintioctopunctata* Fab.) caused severe damage to potato foliage in Assam (10-55%) and in Arunachal Pradesh (30-70%). Red ants (*Dorylus orientalis* Westwood) was prevalent in Meghalaya and Arunachal Pradesh causing about 37 and 20 per cent tuber infestation, respectively. Mole cricket (*Gryllotalpa africana* Palisot de Beauvois) was found damaging young plants only in Tripura (10-30%).

Learmonth and Matthiessen (1990) studied the damage, biology and potential for the integrated control of the main soil insect pests of potato in Western Australia, *Graphognathus leucoloma* and *Heteronychus arator*. The other pests causing damage to smaller areas include *Atrichonotus taeniatulus*, *Phlyctinus callosus*, *Otiorhynchus cribricollis* and *Asynonychus cervinus* [*Pantomorus cervinus*].

Infact potatoes were attacked by several insects in fields as well as in storage with severe damage caused by aphids, jassids, cutworms, termites, white grubs, leaf eating caterpillars, epilachna and other beetles whereas, tuber moth larvae damage the crop mainly in stores inflicting sometimes considerable losses in hills of Uttar Pradesh (Singh, 1990).

Trivedi and Verma (1990) while studying the population trend of *M. persicae* Sulzer on different stages of potato crop in Karnataka (India) reported that the aphid population was significantly different on 27, 38, 50 and 63 days crop and there was no significant differences in 63 and 69 day old crop which indicate that stage of crop and its new emerging leaves have definite role on landing, settling and population build-up of aphids on potato in that region of the country.

Zaki and Masoodi (1990) listed some15 insect pests associated with the potato crop affecting both above and below ground parts of the plant. They also considered soil inhabiting insects as a major source of damage to potato crop in the Kashmir valley.

Tiwari *et al*. (1991) studied the species composition of white grubs (Scarabaeidae) in Himachal Pradesh (India) and reported total of 47 species of white grub among them 19 species including *Popillia cyanea*, *Xylotropes gideon* and *Brahmina coracea* which were collected for the first time.

There are reports that several constraints being involved which are biotic, abiotic and agronomical that leads to both hectarage and yield of the crop very low. Insect pests are one of the biotic factors. A monitoring study of potato tuber moth (PTM) and aphids was conducted at Holetta for four years and the peak months with high PTM or aphid population were identified and an attempt was made to correlate aphid population fluctuation with some abiotic factors where temperature and moisture found to affect aphid population significantly. Besides, work on aphid virus transmission was also conducted where only *M. persicae* (green peach aphid) and *Macrosiphum euphorbiae* (potato aphid) gave positive results (Anonymous, 1992).

Misra *et al*. (1992) studied the impact/effect of different population levels of cutworm, *A. segetum* (Schiffer) larvae on tuber damage and determined the economic threshold level (ETL) for two years during summer crop season (March

to September) on both the table and seed crops of potatoes at Shimla. They reported that a positive correlation was observed between the number of cutworm larvae released and damage caused by them to potatoes (tubers) on all the recorded parameters, *viz.*, plant showing tuber damage (%), tubers damaged on number basis (%), damaged yield (%), and damaged yield (q/ha). Besides, the population level of 40 larvae/plot containing 16 plants (2.5 larvae/plant) was responsible for highest damage and yield losses. The economic threshold levels (ETLs) on table and seed crops were worked out, respectively to be 2.88 and 1.20 larvae of *A. segetum* per 10 m^2 crop area. Hence, they suggested that judicious and need-based control programmes could be decided accordingly.

Waliullah (1992) collected a total of 267 soil and root samples from 14 vegetable crops in the Kashmir valley. He observed that potato crops (*S. tuberosum* L.) were infested by several ecto and endoparasitic nematodes viz., *Tylenchorhynchus* spp., *Basirolaimus indicus*, *Helicotylenchus* spp. *Pratylenchus* spp., *Tylenchorhynchus mashhoodi* and *Trichodorus* spp. though their number and occurrence varied with localities.

Mishra and Singh (1993) studied on the biology of *H. longipennis* infesting potato in Uttar Pradesh and found that adult emergence began at the end of May and noted its peak in 2^{nd} week of June. Eggs and 1^{st} instar larvae were found during June- July with 2^{nd} and 3^{rd} instar larvae damaging tubers by the end of July and during mid-August, respectively.

Rodri *et al*. (1993) conducted a survey to determine insect pests associated with potato and the extent of their damage in Costa Rica and reported that a total of 50 insect species were associated with potato crops where *Phthorimaea operculella* and *Scrobipalposis solanivora* were noted to cause high percentage of damage. They further reported that greatest damage of tubers was done by *Phthorimaea* spp., followed by *Phyllophaga* spp. and *Epicaerus* species.

Zaki *et al.* (1993) conducted two experiments to assess the extent or retrievable losses caused by plant parasitic nematodes in tomato and potato in Kashmir. The results indicated that 9.34 and 11.0 per cent retrievable losses in tomato and potato, respectively were recorded at pre-plant population of 170, 123, 48.5 and 81 per ml soil in tomato and 45, 20, 1510 and 21 per ml soil in potato of lesion, spiral and stunt nematodes and *Tylenchus* spp., respectively.

Parihar *et al*. (1994) studied the distribution and extent of damage to potato by *Agriotes* and *Lygus* species in the Lahaul and Spiti, a dry temperate region in the north-east of Himachal Pradesh (India) in July-September 1987. They have provided details of the tuber damage by *Agriotes* spp., *Agrotis ipsilon* and the number of *Lygus* spp. per 5 plants in 41 villages of Himachal Pradesh.

Mishra (1995) reported several species of insect pests that damage potatoes and found *Holotrichia coriacea* as the predominant species in north-western hills of Himachal Pradesh. He further reported that the damage to potato tubers ranged from 15.5 to 80.0 per cent on the weight basis.

Parihar *et al*. (1995) while conducting a survey on insect pests damaging potato in Himachal Pradesh reported 31 species of insect pests amongst them 9 species were found for the first time in this area.

Seyedoleslami and Naderi (1995) studied the populations of *Thrips tabaci*, *Empoasca decipiens* and *Trioza* sp. and a common arthropod predators during 1985 and 1988 in Iran. Cicadellids and psyllids had two distinct activity peak periods, the 1st being from early June to late July and the 2nd from late July to late September. The relative density of thrips was high from early June to late July and parasitism of adult cicadellids was synchronised with a peak in their activity. It was noted that predators were most abundant in June and July where *Trioza* sp. was more common on a few new potato varieties.

Chandel *et al*. (1996) conducting a survey on white grub infesting potato in Lahaul valley of Himachal Pradesh (India) reported *H. longipennis* as a major specie of insects infesting potato.

Fauziah and Siti (1996) carried out a field experiment to monitor and identify major insect pests of potato in the lowlands from mid-1993 to 1994 at Selangor (Malaysia). Visual sampling on plants (3x) in Sungai Baging showed that the population of mites was high (greater than 43,000/100 shoots per plot) followed by whitefly, aphids, and thrips. As per their findings on yellow-sticky trap, whitefly was found dominant (greater than 10,000) followed by leaf miner, leaf hopper, aphids and potato flea beetle.

Nandhihalli *et al*. (1996) conducted a survey on insect pests associated to potatoes in Hassan area of Karnataka which revealed the occurrence of 33 species of insects belonging to 8 orders and 23 families and also a species of mite.

Pernal *et al.* (1996) investigated the patterns of feeding injury to potato by potato flea beetle (Coleoptera: Chrysomelidae) in Manitoba and noted that flea beetles exhibit preferences for feeding in specific portions of potato plants. These preferences change in response to previous defoliation which were influenced by meteorological conditions and according to these researchers counting, feeding and punctures would not be a reliable method of assessing whether control measures for potato flea beetles are justified.

Peter (1996) reported about 18 insect and non insect pests including nematodes that damage both above and below ground parts of the potato crop. The insect pests include aphids, thrips, leafhoppers, potato tuberworm, cutworm, flea beetle, Andean potato weevil, white grub, wireworm, leafminer flies, whiteflies, blister beetle and leaf beetles, whereas non insect pests include *Globodera pallida, G. rostochiensis Meloidogyne* spp.*, Pratylenchus* spp. *and Nacobbus aberrans*.

Resnais (1996) published the article summarizing the main potato diseases and pests (potato top rot, the invasion of aphids-vehicles of viruses, colorado beetle, potato leaf dry spot disease, black scab, common scab, dry rot, wet rot, cockchafers, caterpillars and crackles caterpillars) in different regions of Latvia in 1995 and forecasts were given for 1996. He emphasized that in spring before the choice of potato fields one must examine the number of pests hibernating in the soil in order not to exceed the critical number.

Min *et al*. (1997) observed the occurrence pattern of major insect pests on 7 recommended cultivars of potato during growing season in Korea and reported that *Myzus persicae Macrosiphum euphorbiae* and *Spodoptera exigua* were the major insect pests damaging leaves while as, *Selatosomus puncticollis* destructive to tubers.

Maredia *et al.* (1998) presented the available data on the first occurrence and the damage severity of the potato leafhopper in the north central and north eastern United States collected during the 47 years (1951-1997) which were collected from a variety of sources including: potato leafhopper literature review; published reports; pest alerts; pest surveys; and delphi surveys. It was noted that first occurrence, severity data, arrival time of potato leafhopper and subsequent damage severity varied substantially from year to year. However, the correlation analysis between date of first occurrence and severity of damage for Michigan, Minnesota, Wisconsin, the north central region and the north-eastern region indicated no significant relationship between first arrival dates and damage severity. The lack of a relationship between the time of arrival of the migrant leafhopper and severity indicated that other factors, including frequency and magnitude of arrivals, weather conditions during the growing season and crop management contribute to the eventual severity of damage caused to crops by this migratory pest. The analysis of potato leafhopper severity data showed significant differences between years. There were no significant differences in severity

among states within the north central region, indicating that potato leafhopper severity was a regional phenomenon.

Verma *et al*. (1998) conducted field experiment during the main crop seasons from 1984-91 and 1995-97 at/around C.P.R.S. Modipuram Meerut (India) and reported that aphid *M. persicae* appeared on the unprotected potato crop from 15th November onwards every year i.e. approximately 35 days after planting the crop. They further mentioned that either *M. persicae* was not serving as an efficient vector or there was lack of the virus source for Potato Virus-Y and potato leafroll virus in and around the seed crop under the prevailing conditions.

Chandla *et al*. (2001) observed serious attack of white grub, *Lachnosterna coriacea* in and around Fagu village fields of potato in Shimla during 1997. They further recorded that soil type (sandy loam with loose texture), lower elevation and weather factors (rains) favoured pest actively with higher tuber damage.

Dharpure (2002a) conducted a survey in Madhya Pradesh (India) during 1995-98 to determine the insect pests attacking the crop and recorded a total of 28 pest species infesting potatoes from which *Thrips palmi*, *Scirtothrips dorsalis* and *Haplothrips* spp. were recorded for the first time as new pests on potato.

Dharpure (2002b) reported painted bug (*Bagrada cruciferarum* Kirkaldy) as a serious pest for the first time on potato in Madhya Pradesh India which otherwise was considered as the pest of cruciferous crops.

Konar and Mohasin (2002) while recording the incidence of Epilachna beetle at different locations of West Bengal (India) reported that maximum incidence of grub and adults was at Memari whereas, it was minimum at Boinchee of Hooghly district. They further noted that variations in incidence and damage of pest from place to place and year to year were due to the variation in the prevailing environment factors.

Sing (2002) reported that potato crop is attacked and damaged by a number of insect pests including wireworms, white grub, aphids, cutworm and

others as a result, the yield of the crop is adversely affected. Cutworms and Potato peach aphid were the two devastating insect pests in the spring crop.

Chandel and Chandla (2003) while working on the management of the tuber damaging pests of potato, reported that more than 100 insects attack potato that caused most variable and complex problems to potato farmers. These pests can damage potato plants by feeding on leaves, reducing photosynthetic area and efficiency by attacking stems, weakening plants and inhibiting nutrient transport and also by attacking potato tubers destined for consumption or use as seed. Among non-insect pests, snails, slugs and nematodes cause economic losses, the nematodes being more harmful than molluscs.

Chandel *et al*. (2003) studied the population dynamics of potato white grub by soil sampling in Shimla hills revealed high population of *Brahmina coriaceae* Hope representing all stages. Pupae were found in the soil during April followed by the adults in May and eggs in June-July. Larvae were present in the soil from July to April while as, 3rd instar grubs cause damage in September-October and overwinter in earthen cells up to April and adult emergence begins in May, maximum being in mid-June.

Chib and Malik (2003) studied the population fluctuation of leaf hopper under different treatments reported that leaf hopper was a serious pest of potato and even relatively low numbers could cause significant yield reduction.

Garg *et al*. (2003) while studying the health status of potato crop in Leh and Ladakh (J&K) reported that crop showed heavy degeneration as was apparent from sickly appearance marked with foliar symptoms of mosaics, wavy leaf margins and leafroll at majority of locations which was due to varied level (low to fairly high) of aphid population.

Mogahed (2003) conducted a field experiment during the winter season (from December to April) of 1999-2000 and 2000-01 at north Sinai Governorate (Egypt) and reported that potato cultivars had lesser infestation of cotton whitefly,

cotton thrips, potato leaf aphids and potato leaf hoppers when intercropped with garlic and onion compared to the same cultivars of potato grown as monocrop and the average yield of potato tubers in plots of potato grown alone was lower compared as to those of intercropped potatoes.

Singh *et al*. (2003) conducted a survey to record the faunal composition of white grub in four hill districts of Garhwal (Uttaranchal) India during 1996 and1997 and recorded 33 species of white grub belonging to eight sub-families on 51 host plants including potato crop.

Prasad (2003) while studying the intensity and build-up of cyst nematodes in varying ecological situations at Nilgiri (India) found that nematodes were encountered at varying levels from all potato growing localities of Nilgiri situated at 920 to 2470 meters above sea level with the intensity low below 1550 and high to very high at altitudes above 2000 meters.

Kumar (2004) surveyed the insect pests of agricultural crops in high altitude arid temperate regions of north western Himalayas and noted several species of insect pests on almost all the crops and most of these species commonly occurred in plains and low hilly areas as well. However, he found that potato crops were mainly infested by cutworms (*Agrotis* spp.) and different species of white grubs.

Singh *et al*. (2004) while studying the nature and extent of damage on 15 rainy season crops at 16 locations in Uttaranchal (India) reported that larvae of *H. longipennis* feed on live roots, thereby plants show stunted growth, yellowing, wilting and drying up. They further observed significant symptoms of damage that were not observed on the apical parts of potato, although the tubers were severally damaged. The extent of damage reported to be 5.67-65.16 and 4.96-62.92 per cent in high and mid hills, respectively but very high hills showed lower mean damage (2.28-12.62%).

Lakra (2005) while monitoring the disease and insect pests of potato crop during 2001 to 2005 in Haryana, reported high incidence of apical leaf curl, whiteflies (*Bemisia tabaci*) and Jassids (*Amrasca biguttula*) on October sown crops while as, crops exhibited moderated incidence in November sown crop. He further noted that December planted crops were seriously attacked by an aphid (*M. persicae*), early blight, leaf roll and severe mosacic causing higher yield loss which was recorded upto 30 per cent.

Pandey (2007) reported that among pests, aphids and leaf hoppers were the most important vectors responsible for transmitting and spreading of a number of viral and mycoplasmal diseases. The other important pests were to be cutworms, white grubs, potato tuber moth and cyst nematodes. He further reported that cyst nematodes were confined to the southern hills of Shimla (H.P.) only.

Among vertebrates, rats were often noticed in the potato fields in localities where potato is grown. A few rat species have also been reported to attack plants like floriculture crops including bulbs and corns in the field (Waliullah, 2007).

Kamano and Mbata (2008) while studying the incidence and abundance of insect pests of potatoes in the Fouta Djallon region of Guinea reported that insect pests such as tuber moth, *Phythorimmaea opercullele* (22.7%), the variegated grasshopper, *Zonocerus variegatus* (14.8%), the noctuid moths, *Agrotis ipsilon* (13.2%) and *Helicoverpa* spp (9.2%), and the whitefly, *Bemisia tabaci* (12.0%) were infesting the potato crop. Insect infestation was based on a method of diagonal 20-point observation in each plot. They further observed that some plants exhibited symptoms of viral attack and the proportion of sampled plants suffered with viral attack upto 7.5 per cent.

Omar *et al.* (2008) surveyed the occurrence of aphids and viral diseases on potatoes in Syria. Aphids were trapped in a yellow pan with water in a Tissue Culture Laboratory of the General Organization for Seed Multiplication (GOSM) at Al Eeramoun from June, 2006 to June, 2007. The number of winged aphids

trapped increased slightly in Autumn and attained peak in Spring. On Autumn-cultivated potato plants in the Aleppo and Hama areas, aphid densities increased from mid-October to early November just before the harvest in 2006. On Spring-cultivated potatoes aphid densities decreased from late May, although the densities were higher in Mid-April, just after sprouting, in 2007. Virus-infected plants were common in both Autumn- and Spring-cultivated potatoes in fields not contracted to GOSM, but there were a few in contracted fields in which virus-free plants grew. Aphid species belonging to 13 genera, including *M. persicae, A. gossypii, A. fabae, A. craccivora, Schzaphis borealis* and *Lipaphis erysimi* were identified among aphid samples collected from potato plants. In addition, *Rhopalosiphum rufiabdominalis* was found on rhizomes and roots of potato plants in GOSM greenhouses in 2007. The major aphids as potato pests were considered to be *M. persicae, A. gossypii* and *A. fabae* to a lesser extent.

Vallejo and Moron (2008) while studying on the description of immature stages and redescription of adults of *Ancognatha scarabaeoides* Erichson (Coleopthera: Scarabaeidae: Dynastinae) a member of soil white grub, described for the first time. A 3rd instar larva and a pupa of *Ancognatha scarabaeoides* Erichson and adults of both sexes were also redescribed in order to support the study of the soil white grub species, assemblage in Colombia, where it was found to be associated with potato crop.

Waliullah *et al.* (2008) while studying the diversity of nematodes on brinjal (*S. melongena* L.) in Jammu district of J&K state noted that frequency of both endo and ecto-parasitic nematodes varied with the age of crop and location.

Basavaraju *et al.* (2009) studied the yield loss estimation due to major insect and mite pests on potato in Madenur, Hassan, Beekanahalli and Chikmagalur (Karnataka) during 2004 and 2005 reported that aphids, *M. persicae* caused on an average 6 per cent loss in yield at Madenur and 3 per cent loss in Beekanahalli. The yield loss due to *Spodoptera litura* was 8 per cent at Madenur and 4 per cent at Beekanahalli. The yield loss due to potato tuber moth,

Phthoremaea operculella was 9 per cent at Madenur while it was 6 per cent at Beekanahalli. The yield loss due to mite, *Polyphagotarsonemus latus* was 26.80 per cent at Madenur and it was 4 per cent at Beekanahalli.

Khan *et al.* (2009) mentioned some major pests of potato in Kashmir Valley including spring tails (*Sinella curvista*), cutworm (*A. ipsilon*), white grub (*Brahmina coriacea* and *H. longipennis*), green peach aphid (*M. persicae*), root knot (*M. hapla*) and root lesion nematode (*Pratylenchus* spp.) causing heavy yield losses in potato.

Khanal *et al.* (2012) conducted a survey to study the abundance and distribution of white grubs in three districts Makawanpur, Tanahu and Chitwan representing different ecological domains of Nepal during June-July 2010 by installing two light traps for two nights in two locations each of districts and a season long light trap at Mangalpur of Chitwan district from April to September 2010 for assessing scarab beetles flight activity, revealed that the dominant species in Chitwan were *Anomala dimidiata* Hope (24%) followed by *Maladera affinis* Blanchard (23.75%), *A. varicolor* (Gyllenhal) (23%), *Heteronychus lioderus* Redtenbacher (14%) and *Holotrichia* spp. with a flight activity and species composition of scarab beetles in the three districts noted to be different.

Prasannakumar *et al.* (2012) while investigating the influence of weather parameters on pheromone trap catches of potato cutworm, *S. litura* (Fabricius) (Lepidoptera: Noctuidae) during 2007-08 (*kharif* and *rabi*) in and around 6 villages of Bengaluru rural district, Karnataka (India) to assess the percent potato cutworm damage. The trap catches (21.30±15.28 moths/trap/week) of potato cut worm were maximum (47.21 moths/trap) during 37th standard week. There was no significant difference in trap catches, but highly significant difference in moth catches during weeks and their interaction. They further revealed that there was a significant difference in moth catches across weeks and the trap catches lowered the damage caused by the insect. However, the performance of the pheromone traps, lures and the activity of the pest were influenced by several weather factors

especially maximum and minimum temperatures, evaporation as well as wind speed which exhibited positive effects on the trap catches and per cent defoliation caused by the pest.

In a recent study Chandel *et al.* (2013) reported that more than 100 species of insect pests attack that damage tubers include white grubs, cutworms, potato tuber moth, termites, red ants and mole crickets. Sap-feeding insects such as aphids, leafhoppers, thrips and white files inflict damage by directly feeding on different parts of a plant and acting as vectors of plant viruses. Aphids and whiteflies constitute a major threat to the cultivation of seed potato because they transmit viruses such as PLRV, PVY and Gemini viruses from one plant to another in an efficient manner. Leaf-feeding insects include several species belonging to the orders Lepidoptera and Coleoptera. The important leaf-feeding caterpillars are *Spodoptera* spp. *H. armigera*, *Plusia orichalcea* and *Spilosoma obliqua*. No doubt among coleopterans, the most destructive pests are hadda beetle, flea beetle, blister beetle and chaffer beetles.

2.2 Management of white grub infesting potatoes

Semyanov *et al*. (1981) conducted an experiment for the control of insect pests of potato in Lithuania (USSR). The pests belonging to 3 groups, sucking pests, leaf eating pests and soil pests. They reported that *Aphis naturtii* Kalt and *A. gossypii* Glov. accounted for more than 90 per cent of aphid population on potato. Pre-sowing soil treatments with dust containing pirimicarb (Pirimor) and menazon (Sayfos) against these pests helped in increasing yield by 18 per cent over untreated check.

Veenakumari and Veeresh (1982) conducted laboratory investigations on the methods for infecting larvae of *Holotrichia serrata* F. with *Bacillus popilliae* and reported that the percentage infection for potato disc feeding was 84, for carrot disc feeding 76, soil treatment 74, root dipping 70.6, larval dipping 56 and

topical application 8, while as intra-haemocoelic injection killed the larvae without causing disease symptoms.

Chandla *et al.* (1988) while studying on the biology and control of scarabaeid *H.coriacea* (*Brahmina coriacea*) on potatoes in Himachal Pradesh reported that adults emerged in June and feed on *Acacia* spp., peach, plum, apricot, pear and apple trees before laying eggs. They further observed that the larval populations of 5.7 and 6.4 were in phorate and carbofuran treated plots, respectively but tuber damage were observed 24.9 and 39.7 in the treated plots over 56.3 per cent in untreated ones.

Gour and Dabi (1988) investigated the effect of an entomopathogenic form of *Verticillium lecanii* on larvae of the scarabaeid *Holotrichia consanguinea* in laboratory and reported that after 10 days, the mean mortality of *H. consanguinea* was significantly superior to the control in all 3 treatments given but soil treatment was the most effective resulting in about 50 per cent mortality.

Romero and Raman (1988) conducted an experiment at farmers fields in Huanuco (Peru) during 1980-1981 with the major tuber and foliage insect pests of potatoes and their natural enemies were identified. The improved cultivars, Molinera and Revolucion harboured significantly lower populations of *Epitrix* spp., *Myzus persicae*, *Empoasca* spp., and *Frankliniella* spp., a native variety showed lowest infestation by *Liriomyza* spp. All cultivars suffered with greater than 50 per cent tuber damage by the larvae of the Andean weevil and the improved varieties Ranrahirca and Mariva showed significantly less damage over the other varieties. Renacimiento was the highest yielding cultivar, with 35 t/ha. At the same time they recommended for further studies to identify useful natural enemies, host plant resistance and other control components so that to develop an integrated control system for insect pests of potato in the higher elevations of the Andean region.

Golberg *et al.* (1989) made an effort to control the damage caused by the scarabaeid *Maladera matrida* to sweet potatoes by comparing heptachlor with other insecticides in Besor region of southern part of Israel. Taking the percentage of clean tubers at the final harvest as the criteria of insecticidal efficacy, the best results were achieved with heptachlor (97.3 per cent clean tubers) and with the synthetic pyrethroid Talstar (bifenthrin) (91.1 per cent clean tubers), while the percentage of clean tubers obtained in 2 untreated control plots was 52.5 and 65.9.

Misra and Chandla (1989) while working on management of white grub infesting potatoes, suggested that both beetles and grubs could be controlled by using integrated approach including mechanical, physical, cultural and chemical methods.

Kokate *et al*. (1991) reported that quinalphos and phorate were effective in controlling the scarabaeid *L. coriacea* (*Brahmina coriacea*) as that resulted in cost: benefit ratio of 1:6.8 and 1:5.6, respectively.

Pawinska and Turska (1995) investigated new insecticide imidacloprid for the control of potato insect pests viz., aphids (vectors of virus diseases) and colorado beetles (*Leptinotarsa decemlineata*) in the field condition. In the experiment two formulations of imidacloprid were used: Gaucho 70 WS and Gaucho 350 FS. Imidacloprid showed a high effectiveness in aphids and colorado beetles (eggs, larvae and adults), controled both in the dry season 1994 and in the wet season 1993. Infection of potato tubers with potato leaf roll virus after the use of imidacloprid was significantly lower in comparison to the untreated field.

Salles (1998) conducted a field trial experiment to evaluate the performance of five commercial insecticides for the control soil insect pests of potato in Rio Grande do Sul (Brazil). Insecticides were used at recommended commercial dosage and applied in planting furrows as follows: aldicarb 150G @ 13 kg/ha, carbofuran 50G @ 40 kg/ha, disulfoton GR100 @ 15 kg/ha, fipronil 20G @ 5 kg/ha, and phorate 50G @ 60 kg/ha. Carbofuran 50G and phorate 50G

showed the best field performances. Disulfoton GR100 and fipronil 20G were of equal performance but lower than carbofuran 50G and phorate 50G. Aldicarb 150G showed the lowest performance as a potato tuber protector against insect pest damage (mainly from *Diabrotica speciosa* and *Heteroderes* sp. larvae). As per their findings the soil insecticides increased potato yield and external tuber quality.

Sharma *et al*. (1998) while studying the effect of temperatures on growth, sporulation and biodiversity of entomofungi against white grub (*H. consanguinea*) reported that 28^{o}C was found most favourable for growth as well as sporulation of *Metarrhizium anisopliae* and the highest conidial production was found in Ma-4. *Beauveria bassiana* grow at temperature range of 20^{o}C-28^{o}C, but 25^{o}C was the best for conidial production in all isolates, whereas 28^{o}C and 20^{o}C were most favourable for growth and sporulation, respectively in *B. brongniartii*. However at 35^{o}C and 40^{o}C, there was some growth but sporulation was completely absent in almost all the isolates of the test fungi.

Mishra (2001) conducted a field experiment in Uttaranchal to determine the effectiveness of some insecticides against white grub (*H. longipennis*) on potato cv. Kufri jyoti and revealed that chlorpyrifos was the most effective followed by quinalphos and phorate.

Anil *et al*. (2002) while conducting on-farm participatory research in Shimla (H.P.) to address three problems of potato growers viz., use of degenerated seeds, high incidence of late blight and high infestation of white grubs (*Lachnosterna coriaceae*) recommended that the application of phorate 10G @ 20 kg ha^{-1} helped in reducing of white grub infestation from 5 to 1 per cent.

Lacey (2002) enumerated insect pests of potato in the western Hemisphere (from southern Argentina to several provinces of Canada) and presented the entomopathogens (bacteriae and fungi) and parasites (entomophilic nematodes and parasitoids) that were proposed for the control of these potato pests.

Misra (2002) studied the impact of planting and harvesting dates on the incidence of white grubs, *Holotrichia* spp., and reported that potato crop planted on 1st April and harvested on 1st September showed the least tuber damage by white grub, but the incidence progressively increased with the delay in harvesting i.e., 15, 30 September and 15 October. He further reported that two sprays on ridges with chlorpyrifos 20 EC @ 0.5 kg a.i. ha^{-1} also failed in registering desired protection to potatoes from the attack of white grub *Holotrichia* spp., if harvested late.

Misra (2003) conducted a field experiment for 2 years in Shimla (Himachal Pradesh) to estimate the avoidable yield losses in potato through management of white grub, *Holotrichia* spp. and reported that their damage on potatoes was maximum during 1995 and 1996 than that during 1997 and 1998. This was merely because he used chlorphyrifos 20EC @ 2.5 litres/ha. for suppressing the white grub population in the second year experiment 1997 and 1998.

Chandla and Chandel (2005) evaluated eco-friendly IPM schedule during 2002 and 2003 seasons using seven treatments for the control of white grubs, *B. coriacea* and cutworm, *A. segetum* which are the major constraint in potato production in higher hills of Himachal Pradesh and revealed that all the treatments proved to be superior over control in minimizing plant and tuber damage by soil pests. Phorate 10G alone and with garlic as intercrop was found the best for the management of cutworm, while chlorpyrifos 20EC was found superior against cutworms and white grubs both. *Bacillus thuringiensis* (Bt) and *Beauveria bassiana* proved to be effective when applied in combination with garlic and Phorate 10G and that also resulted in maximum marketable tuber yield and benefit/ha. They further suggested that IPM schedule consisting of bio-pesticides + garlic or bio-pesticide + synthetic pesticide + garlic could be equally good as alternate to synthetic pesticide for the management of soil pests in higher hills and getting maximum net benefit/ha.

Chandel *et al.* (2005) conducted an experiment to determine the efficacy of entomogenous fungi and nematode in controlling *B. coriacaea* (Hope) grubs in pot experiments and under field conditions, reported that *B. coriacea* grubs noted to have medium to low susceptibility to fungi, *M. anisopliae* and *B. bassiana* in laboratory. Under field condition, both these fungi didn't provide satisfactory control of potato white grubs but *B. coriacea* grubs were highly susceptible to nematode *Heterorhabditis indica*. In laboratory assays, *H. indica* caused 100 and 80.46 per cent mortality of 2^{nd} and 3^{rd} instar grubs, respectively. The application of *H. indica* reduced the damage done by grubs to potato tubers however, lesser number of grubs were observed in nematode treated plots and white grub infestation was 8.13 per cent as compared to 11.28 per cent in untreated plots.

Lucero *et al*. (2006) while putting efforts on the integrated management of white grubs on small farms in the Nario Department Colombia, reported that entomopathogenic micro-organisms viz., *Beauveria bassiana* and *Metarrhizium anisopliae* caused to 28.75 and 14.67 per cent of pest mortality at Ospina and Yacuanquer localities, respectively as compared to 28.89 and 18.82 per cent against applying chemical insecticides, while *Steinernema* spp. caused 17.26 and 12.74 per cent of white grub mortality.

Yaginuma *et al.* (2006) while studying the friction associated conidial detachment of the entomopathogenic fungus *Beauveria amorpha* from the cuticle of a scarab grub, *Anomala cuprea* in the soil by treating the larvae with imidacloprid to suppress the mobility and then treated with fluorescein isothiocyanate labelled conidia of the entomopathogenic fungus, *B. amorpha*. In the case of non-paralyzed larvae without imidacloprid treatment, conidia on the vertex, dorsum and abdomen became detached by 12 h after application. In contrast, the number of conidia on paralyzed larvae with imidacloprid treatment remained stable throughout the test period. In parallel with conidial detachment from non-paralyzed larvae, the number of conidia detected in the rearing soil increased. They found that the fungal conidia adhering to the surface of scarab

grubs were detached by friction with soil in association with the larval movement, suggesting that insect movement might be an important factor that affected the infection with pathogens.

Zaki *et al*. (2006) conducted an experiment to evaluate the efficacy of some insecticides and bio-pesticides against white grub infesting potato in three different patterns viz., soil treatment, seed treatment and foliar sprays. They reported that seed treatments with imidacloprid 200 SL and soil treatments with chlorpyrifos 1.5 per cent dust and carbofuran 3G proved to be best against white grub under rainfed conditions of the Kashmir valley.

Chandla and Chandel (2007) conducted an experiment to evaluate the efficacy of two biological pesticides and two synthetic pesticides, singly or in combination with garlic as intercrop against cutworm (*A. segetum*) and white grub (*B. coriacea*) on potato in Himachal Pradesh (India) and reported that phorate 10G applied in furrows during planting at 1.5 kg a.i./ha was the most effective against cutworms and white grubs with and without garlic followed by chlorpyrifos 20EC at 0.5 kg a.i./ha. While as, biological pesticides *B. thuringiensis* and *B. bassiana* were more effective when applied in combination with garlic and synthetic pesticides in terms of the reduction of pest damage and these treatments also gave the highest marketable potato yield and net benefit/ha.

Keller and Schweizer (2007) experimented on white grub control by applying *Metarhizium anisopliae* alone or in combination with *Beauveria brongniartii* using a commercial drill machine, exceptionally with a rotary machine reported that the fungi established in the soil and reduced the white grub populations so that no more damages were visible.

Pozenel and Rot (2007) while working on population of common Cockchafer (*Melolontha melolontha* L.) in Idrija region in Slovenia reported that different methods (mechanical, biological and chemical treatments) were used to reduce the population of the pest, but they were only partly successful. In June

2005, by them 92 ha of grasslands were treated with *Beauveria brongniartii*. The efficiency of *Beauveria* sp., was 38.7 per cent. The total decrease in the number of grubs in the treated area was recorded to be 88 per cent.

In another experiment Zaki *et al*. (2007) studied the efficacy of some insecticides as post sown foliar spray against white grubs (*Holotrichia, Melolontha, Brahmina, Adoretus* and *Anomala* species.) and cutworms (*A. ipsilon* and *A. segetum*) infesting and revealed that the grub population in all the insecticidal treatments were significantly low. They also computed the highest benefit : cost ratio (29.95:1) by the use of imidacloprid treatment followed by chlorphyrifos (15.54:1).

Ranger *et al*. (2009) evaluated the toxicity of eight botanical based bio-pesticides against 3rd instar of scarab larvae (Coleoptera : Scarabaeidae) *Popillia japonica, Rhizotrogus majalis, Anomala orientalis* and *Cyclocephala borealis* using soil dip bioassays to obtain concentration mortality data 7 days after treatment of larvae and reported that Armorex product was one of the most active formulations against *P. japonica, R. majalis, A. orientalis* and *C. borealis*. Aromex the composed extract from diverse botanical sources include sesame oil, garlic oil, clove oil, rosemary oil and white pepper extracts.

Rani *et al*. (2009) conducted field experiment against white grub to test the efficacy of botanical extracts of *Azadirachta indica, Sapindus mukorossi, Jatropha curcas, Chrysanthemum cinerarifolium, Nerium oleander, Urtica diocia* and *Vitex negundo* in bin cattle urine during 2007 and 2008. They reported that all the concentrations of extract were effective in reducing the grub population as well as per cent tuber damage.

Sharma *et al*. (2009) while studying the efficacy of the entomopathogenic nematodes (EPN) *S. carpocapsae* and *H. indica* against different developmental stages of *B. coriacea* Hope (Coleoptera: Scarabidae) under laboratory and field conditions, reported that in laboratory studies significant mortality by *S.*

carpocapsae (68-93%) and *H. indica* (39-71%) after 7 days of treatment was observed at three dosages viz.; 500, 1000 and 2000 infective juveniles(ij)/100g soil while as, in fields at Fagu and Shimla all the three dosages of *S. carpocapsae* and *H. indica* (1, 3 and 6×10^5 ij/ m^2) were effective in reducing the grub population, percent plant damage as well as percent tuber damage. Percent reduction in grub population was 66-80 per cent due to *H. indica* and more then 83 per cent due to *S. carpocapsae* at Fagu. There was more than 60 and 50 per cent reduction in grub population due to *S. carpocapsae* and *H. indica* treatment in 2007 and more than 80 per cent in 2008 at Shimla in plots treated with both the EPN species at normal harvesting time. The least number of grubs and damaged tuber were recorded in case of treatment with *S. carpocapsae* @ 6×10^5 ij/ m^2 during both the years both at Fagu and Shimla as well.

Wani (2009) studied on the biology and bio-intensive management of white grub in Kashmir valley. He reported 22 species of white grub beetles from different orchards and vegetable fields. As per his findings *B. bassiana* (local strain) at 1 x 10^{12} spore ml^{-1} was the most promising treatment followed by *M. anisopliae* (local strain) at 1 x 10^{12} spore ml^{-1} and also chlorphyrifos 20 EC, 4 litre/hectare.

Chelvi *et al.* (2011) made an attempt to control the white grub *H. serrata* using entomopathogenic fungi *M.anisopliae* at field level for the first time in India in sugarcane crop using different formulations i.e., Talc, Lignite and Liquid formulations at Vellore Co-operative Sugar mill near the root zone of the cane at 5-10 cm depth and irrigated immediately after application. They noted that the liquid formulation of the biopesticide *M. anisopliae* was efficient in the control of sugarcane white grub *H. serrata*.

Chapter – 3

MATERIALS AND METHODS

In order to carry out the survey for pest complex, incidence and severity of insect pests and management of white grub infesting potatoes in northern districts of Kashmir valley the materials and methods adopted are given here under:

3.1 Survey on pest complex of potato

For this purpose, survey was carried out in northern districts of Kashmir Valley namely Baramulla, Kupwara, and Bandipora, where three locations in each district were selected at three different levels of elevations (plains, mid and high hills). The crop was observed throughout the season 2011 and 2012 to record the pest complex associated with potato. The localities are:

District	Location	Altitude
Baramulla	Yarikhah	High hills - 2481 metres
	Kunzer	Mid hills - 1761 metres
	Pattan	Plains - 1556 metres
Kupwara	Budnambal	High hills - 3120 metres
	Handwara	Mid hills - 1592 metres
	Yonus	Plains - 1551 metres
Bandipora	Gurez	High hills - 2468 metres
	Ajas	Mid hills - 1593 metres
	Sumbal	Plains - 1578.2 metres

3.1.1 Collection and preservation of pests

The pests of potato were collected from different localities by using sweep nets, light traps and also by hand picking. The collected samples were pinned or preserved in 70 per cent ethyl alcohol and got identified at IARI and SKUAST Kashmir by the taxonomists.

3.1.2 Sampling of nematodes

The soil samples at the mentioned localities were collected from around the roots of the potato crop by digging upto 25 cm depth with the help of Khurpi throughout the cropping season. The soil samples were processed by using Baermann's funnel technique for isolating the nematodes. Samples were preserved in FA 4:1 formalin (10ml), acetic acid (1ml) glycerol (3ml) and water (100ml) as hot fixative (Cobb, 1918; Christie and Perry, 1951). Roots of potato crop was examined under binocular at 40X in the economic laborarory/ Nematology laboratory of Division of Entomology, SKUAST-K, Shalimar campus.

3.2 Study on the incidence and severity of infestation of potato insect pests

3.2.1 Foliage feeding insect pests

Incidence and severity of infestation of foliage feeding insect pests were ascertained at all the locations of 3 districts as mentioned above and from each location 10 plants were selected randomly from different rows. The whole plant was examined to work out the incidence of foliage feeding insect pests.

The incidence of damage was worked out by adopting the formula:

$$\frac{\text{Number of plants infested}}{\text{Total number of plants assessed}} \times 100$$

Each plant represents one replication and from each replication 3 leaves were marked randomly for recording severity of leaf infestation by foliage feeding insect pests at fortnight interval during the active period of crop. The severity of foliage feeding insect pests was determined by using scale 0-5.

0 - No leaf infestation.

1 - Leaf infestation from 1-20 per cent.

2 - Leaf infestation from 21-40 per cent.

3 - Leaf infestation from 41-60 per cent.

4 - Leaf infestation from 60-80 per cent.

5 - Leaf infestation above 81 per cent.

The mean per cent severity of leaf infestation was computed by using formula:

$$\frac{\Sigma (n \times v)}{N \times G} \times 100$$

Where,

n = Number of leaves infested

v = Infested leaves falling in grade/scale

N = Total number of leaves examined

G = Total number of grades/scale

3.2.2 Foliage sucking insect pests

For this purpose survey was carried out for recording the incidence and severity of infestation of foliage sucking insect pests in all the mentioned localities of Kupwara, Baramulla and Bandipora districts. From every locality five (5) plants were randomly selected and from each plant five (5) leaves were examined for ascertaining the sucking insect pest infestation.

Per cent of incidence was computed by using formula :

$$\frac{n}{N} \times 100$$

Where,

n = Number of leaves infested

N = Total number of leaves examined

Severity of infestation was determined by using 1-4 Scale (Nagrare *et al.*, 2009) which is as under:

Grade: 1= Scattered appearance of few aphid.

Grade: 2= Moderate infestation of aphid on any one branch of the plant.

Grade: 3= Severe infestation of aphid on more than one branch or half portion of the plant

Grade: 4= Very severe infestation of aphid in the whole plant.

Further the Severity index (SI) of sucking insect pests was calculated by selecting randomly 5 infested plants at fortnight interval and graded on the basis of appearance of sucking insect pest. The plants were considered infested even if a single pest was observed.

$$\text{Severity index (SI)} = \frac{\text{Sum of total grade points (1-4 infestation grade G-I to G-IV, respectively) of the infested plants}}{\text{Total number of infested plants observed}}$$

3.2.3 Collar/Tuber feeding insect pests

Incidence and severity of infestation of collar and tuber feeding insect pests was recorded at all the locations ranging from plains to higher belts of districts Baramulla, Kupwara, and Bandipora. The per cent severity of collar feeding insect pests was calculated by adopting the formula:

$$\text{Per cent incidence} = \frac{\text{Number of plants with cutworm larvae}}{\text{Total number of plants examined}} \times 100$$

$$\text{Per cent severity} = \frac{\text{Number of plants with partial and full cut}}{\text{Total number of plants examined}} \times 100$$

Severity of infestation of tuber feeding insect pest was worked out at final harvest from both white skined and red skined tubers based on their number (50 tubers)/ weight basis (varied) by using formula.

$$\text{Per cent incidence} = \frac{\text{Number of pits with tuber feeders}}{\text{Total number of pits digged}} \times 100$$

$$\text{Per cent infestation (number basis)} = \frac{\text{Number of tubers infested}}{\text{Total number of tubers examined}} \times 100$$

$$\text{Per cent infestation (weight basis)} = \frac{\text{Weight of infested tubers}}{\text{Total weight of tubers}} \times 100$$

Further the scale 0-5 as mentioned earlier used for foliage feeders was used to calculate the per cent severity of infestation of tuber feeders and for that purpose 5 kg of tubers were randomly taken and weighed then examined for tubers infestation done by tuber feeding insect pests. Incidence of tuber feeding insect pests was worked out on the basis of area damaged (plant stand) and for this purpose, at random five pits each having a size of 30 x 30 cm^2 were digout upto 20 cm in depth to record the incidence of tuber feeding insect pest in standing crop at fortnight intervals for each location.

3.3 Management of white grub damaging potato

Management of white grub damaging potato was carried out by selecting one location indicating high damage by white grub from district Baramulla (Kunzer), Kupwara (Budnambal) and Bandipora (Ajas) during the year 2012. For this purpose randomized block design (RBD) was used for different treatments and each treatment was replicated thrice. The different treatments were:

	Treatment	Concentration/quantity
T_1	Imidacloprid (70 % WS)	3 mg/kg seed
T_2	*Beauveria bassiana* (Daman)	5 g/litre of water
T_3	*Metarrhizium anisopliae*(Kalichakara)	5 g/litre of water
T_4	*Bacillus thuringiensis* (Doom)	3 g/litre of water
T_5	Phalada-111 C1	1 ml/litre of water
T_6	Neem cake (*A. indica*)	300 kg/ha
T_7	Mustard cake (*Brassica* spp.)	300 kg/ha
T_8	Cultural practices (Deep ploughing, vermicompost @ 200 kg/ ha, hoeing, mass collection of beetles at dusk on light traps/ host trees) were followed.	
T_9	Untreated check (control)	

3.3.1 Treatment application

The treatments were given by using different methods of application viz.,

- Imidacloprid used as seed treatment.
- *Beauveria bassiana*, *Metarrhizium anisopliae*, *Bacillus thuringiensis* and Phalada-111 C1 drenched around the roots of standing potato crop at an interval of 65 and 80 days after sowing.
- Neem and mustard cakes used as soil amendment at the time of field preparation.

The efficacy of individual treatments was worked out on the basis of percentage of good tubers at final harvest and compared with good tubers in control i.e., both percentage good tubers in treated and in untreated plots.

3.4 Statistical analysis

The statistical analysis of the data was carried out in R-software implemented by Box *et al*. (1978) and OP-Stat to determine the incidence, severity of insect pests and critical difference (CD) between various treatments used for management of white grub.

Chapter – 4

EXPERIMENTAL FINDINGS

The results obtained from the present investigation entitled, "Pest complex of potato (*Solanum tuberosum* L.) with special reference to management of white grub in northern districts of Kashmir Valley" are presented in this chapter:

4.1 Survey on pest complex of potato

A random survey was carried out in northern districts of Kashmir Valley namely Baramulla, Kupwara and Bandipora where three locations in each district were selected at three different levels of elevations (plains, mid and high hills). The crop was examined throughout the season to record the pest complex associated with potato. A total of 12 pests including 7 insect pests and 5 nematode genera were found associated with the crop right from sowing/germination upto harvest which were Flea beetle (*Chaetocnema* spp.), Semilooper (*Thysanoplusia orichalcea*), Aphid (*Macrosiphum euphorbiae*), Cutworm (*Agrotis ipsilon*), White grub (*Brahmina coriacea* and *B. poonensis*), Wireworm (*Melanotus horticornis*), Earwig (*Euborellia annulipes*), (Plates-1 to 7) Stunt nematode (*Tylenchorlynctus kashmiriensis* Mahajan), Lens nematode (*Basirolaimus indicus* Shamsi), Spiral nematode (*Helicotylenchus dihystera* Sher. and *H. indicus* Siddiqi), Root lesion nematode (*Pratylenchus* spp.) and Dagger nematode (*Xiphinema basiri* Siddiqi) (Table-1). The pests of potato were categorized based on the plant parts damaged.

Foliage feeder: Flea beetle (*Chaetocnema* spp. Stephans) and Semilooper (*Thysanoplusia orichalcea* Fabricus).

Foliage sucker: Aphid (*Macrosiphum euphorbiae* Thomas).

Collar feeder: Black Cutworm (*Agrotis ipsilon* Hufnagel).

Table-1 : Pest complex (insects and nematodes) of potato (*Solanum tuberosum* L.) at different locations of district Baramulla, Kupwara and Bandipora during 2011 and 2012

District	Location	Foliage feeder	Foliage sucker	Collar feeder	Tuber feeder	Nematode
Baramulla	**Pattan**	**Flea beetles** (*Chaetocnema* spp. Stephans) and **Semiloopers** (*Thysanoplusia orichalcea* Fabricus).	**Aphids** (*Macrosiphum euphorbiae* Thomas).	**Black Cutworm** (*Agrotis ipsilon* Hufnagel).	**White grub** (*Brahmina coriacea* Hope and *Brahmina poonensis* Frey), **Wireworms** (*Melanotus horticornis* Blyth) and **Earwigs** (*Euborellia annulipes* Lucas).	**Stunt nematode** (*Tylenchorhynchus kashmiriensis* Mahajan), **Lens nematode** (*Basirolaimus indicus* Shamsi), **Spiral** (*Helicotylenchus dihystera* Sher. and *H. indicus* Siddiqi), **Root lesion nematode** (*Pratylenchus* spp.) and **Dagger nematode** (*Xiphinema basiri* Siddiqi).
	Kunzer	**Flea beetles** (*Chaetocnema* spp. Stephans) and **Semiloopers** (*Thysanoplusia orichalcea* Fabricus).	**Aphids** (*Macrosiphum euphorbiae* Thomas).	**Black Cutworm** (*Agrotis ipsilon* Hufnagel).	**White grub** (*Brahmina coriacea* Hope and *Brahmina poonensis* Frey).	**Lens nematode** (*Basirolaimus indicus* Shamsi), **Spiral** (*Helicotylenchus dihystera* Sher. and *H. indicus* Siddiqi), **Root lesion nematode** (*Pratylenchus* spp.) and **Dagger nematode** (*Xiphinema basiri* Siddiqi).
	Yarikhah	**Flea beetles** (*Chaetocnema* spp. Stephans) and **Semiloopers** (*Thysanoplusia orichalcea* Fabricus).	**Aphids** (*Macrosiphum euphorbiae* Thomas).	**Black Cutworm** (*Agrotis ipsilon* Hufnagel).	**White grub** (*Brahmina coriacea* Hope and *Brahmina poonensis* Frey).	**Stunt nematode** (*Tylenchorhynchus kashmiriensis* Mahajan) , **Lens nematode** (*Basirolaimus indicus* Shamsi), **Spiral** (*Helicotylenchus dihystera* Sher. and *H. indicus* Siddiqi), **Root lesion nematode** (*Pratylenchus* spp.) and **Dagger nematode** (*Xiphinema basiri* Siddiqi).
Kupwara	**Yonus**	**Flea beetles** (*Chaetocnema* spp. Stephans) and **Semiloopers** (*Thysanoplusia orichalcea* Fabricus).	**Aphids** (*Macrosiphum euphorbiae* Thomas).	**Black Cutworm** (*Agrotis ipsilon* Hufnagel).	**White grub** (*Brahmina coriacea* Hope and *Brahmina poonensis* Frey), **Wireworms** (*Melanotus horticornis* Blyth) and **Earwigs** (*Euborellia annulipes* Lucas).	**Spiral** (*Helicotylenchus dihystera* Sher. and *H. indicus* Siddiqi) and **Root lesion nematode** (*Pratylenchus* spp.). .
	Handwara	**Flea beetles** (*Chaetocnema* spp. Stephans) and **Semiloopers** (*Thysanoplusia orichalcea* Fabricus).	**Aphids** (*Macrosiphum euphorbiae* Thomas).	**Black Cutworm** (*Agrotis ipsilon* Hufnagel).	**White grub** (*Brahmina coriacea* Hope and *Brahmina poonensis* Frey), **Wireworms** (*Melanotus horticornis* Blyth) and **Earwigs** (*Euborellia annulipes* Lucas).	**Stunt nematode** (*Tylenchorhynchus kashmiriensis* Mahajan), **Spiral** (*Helicotylenchus dihystera* Sher. and *H. indicus* Siddiqi) and **Dagger nematode** (*Xiphinema basiri* Siddiqi).
	Budnambal	**Flea beetles** (*Chaetocnema* spp. Stephans).	**Aphids** (*Macrosiphum euphorbiae* Thomas).	**Black Cutworm** (*Agrotis ipsilon* Hufnagel).	**White grub** (*Brahmina coriacea* Hope and *Brahmina poonensis* Frey) and **Wireworms** (*Melanotus horticornis* Blyth).	**Stunt nematode** (*Tylenchorhynchus kashmiriensis* Mahajan), **Spiral** (*Helicotylenchus dihystera* Sher. and *H. indicus* Siddiqi), **Root lesion nematode** (*Pratylenchus* spp.) and **Dagger nematode** (*Xiphinema basiri* Siddiqi).

Contd…….

Table-1 Contd…….

District	Location	Foliage feeder	Foliage sucker	Collar feeder	Tuber feeder	Nematode
Bandipora	**Sumbal**	**Flea beetles** (*Chaetocnema* spp. Stephans) and **Semiloopers** (*Thysanoplusia orichalcea* Fabricus).	**Aphids** (*Macrosiphum euphorbiae* Thomas).	**Black Cutworm** (*Agrotis ipsilon* Hufnagel).	**White grub** (*Brahmina coriacea* Hope and *Brahmina poonensis* Frey), **Wireworms** (*Melanotus horticornis* Blyth) and **Earwigs** (*Euborellia annulipes* Lucas).	**Stunt nematode** (*Tylenchorhynchus kashmiriensis* Mahajan), **Lens nematode** (*Basirolaimus indicus* Shamsi), **Spiral** (*Helicotylenchus dihystera* Sher. and *H. indicus* Siddiqi) and **Root lesion nematode** (*Pratylenchus* spp.)
	Ajas	**Flea beetles** (*Chaetocnema* spp. Stephans) and **Semiloopers** (*Thysanoplusia orichalcea* Fabricus).	**Aphids** (*Macrosiphum euphorbiae* Thomas).	**Black Cutworm** (*Agrotis ipsilon* Hufnagel).	**White grub** (*Brahmina coriacea* Hope and *Brahmina poonensis* Frey), **Wireworms** (*Melanotus horticornis* Blyth) and **Earwigs** (*Euborellia annulipes* Lucas).	**Stunt nematode** (*Tylenchorhynchus kashmiriensis* Mahajan), **Lens nematode** (*Basirolaimus indicus* Shamsi), **Spiral** (*Helicotylenchus dihystera* Sher. and *H. indicus* Siddiqi) and **Root lesion nematode** (*Pratylenchus* spp.)
	Gurez	**Flea beetles** (*Chaetocnema* spp. Stephans).	**Aphids** (*Macrosiphum euphorbiae* Thomas).	**Black Cutworm** (*Agrotis ipsilon* Hufnagel).	**White grub** (*Brahmina coriacea* Hope and *Brahmina poonensis* Frey) and **Wireworms** (*Melanotus horticornis* Blyth).	**Spiral** (*Helicotylenchus dihystera* Sher. and *H. indicus* Siddiqi) and **Root lesion nematode** (*Pratylenchus* spp.).

Flea beetle (*Chaetocnema* spp. Stephans)

Semilooper (*Thysanoplusia orichalcea* Fabricus)

Aphid (*Macrosiphum euphorbiae* Thomas)

Black Cutworm (*Agrotis ipsilon* Hufnagel)

White grub (*Brahmina coriacea* Hope)

White grub (*Brahmina poonensis* Frey)

Wireworm (*Melanotus horticornis* Blyth)

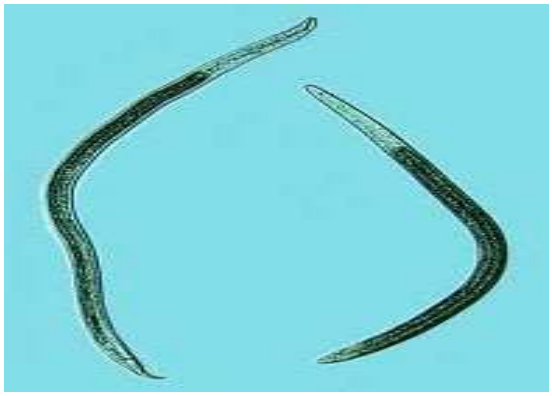
Earwig (*Euborellia annulipes* Lucas)

Plate-1 : Pest complex of potato (*Solanum tuberosum* L.) in northern Kashmir

Contd……

Plate-1 Contd…..

Spiral nematode (*Helicotylenchus* spp.)



Stunt nematode (*Tylenchorhynchus* spp.)

Root lesion nematode (*Pratylenchus* spp.)

Dagger nematode (*Xiphinema* spp.)

Lens nematode (*Basirolaimus indicus*)

Flea beetle (*Chaetocnema* spp. Stephans)

Flea beetle damage

Flea beetle on potato leaf

Flea beetle (*Chaetocnema* spp. Stephans)

Semilooper (*Thysanoplusia orichalcea* Fabricus).

Semilooper damage

Semilooper larvae on leaf

Adult moth of semilooper

Plate-2 : **Foliage feeding insect pests (Flea beetle, *Chaetocnema* spp. Stephans and Semilooper, *Thysanoplusia orichalcea* Fabricus) on potato crop**

Aphid on leaf

Scattered aphids on leaf

Aphids on apical part of plant

Nymphs and adults on leaflet

Plate-3: Foliage sucking aphid (*Macrospihum euphorbiae* Thomas) on potato crop

Larvae of cutworm

Partial cut

Full cut

Cutworm larvae

Adult cutworm

Plate-4 : Collar feeding cutworm (*Agrotis ipsilon* Hufnagel) on potato crop

White grub damage field

White grub larvae in potato

White grub (*Brahmina poonensis* Frey)

White grub (*Brahmina coriacea* Hope)

Plate-5 : Tuber feeding white grub (*Brahmina coriacea* Hope and *B. poonensis* Frey) on potatoes

Wireworm damage

Larvae of wireworm

Larvae of wireworm

Adult wireworm

Plate-6 : Tuber feeding wireworm (*Melanotus horticornis* Blyth) on potatoes

Earwig damage

Earwig damage

Nymphal stages of Earwig

Adult earwigs

Plate-7 : Tuber feeding earwig (*Euborellia annulipes* Lucas) on potatoes

Tuber feeder: White grub (*Brahmina coriacea* Hope and *B. poonensis* Frey), Wireworm (*Melanotus horticornis* Blyth) and Earwigs (*Euborellia annulipes* Lucas).

Nematodes: Stunt nematode (*Tylenchorhynchus kashmiriensis* Mahajan), Lens nematode (*Basirolaimus indicus* Shamsi), Spiral nematode (*Helicotylenchus dihystera* Sher. and *H. indicus* Siddiqi), Root lesion nematode (*Pratylenchus* spp.) and Dagger nematode (*Xiphinema basiri* Siddiqi)

Among foliage feeders, semilooper was absent at Budnambal (Kupwara) and Gurez (Bandipora) while as, earwig and wireworm as tuber feeders were completely absent at Kunzer and Yarikhah of Baramulla district. In addition earwig was also absent at Budnambal (Kupwara) and Gurez (Bandipora) as depicted in Table-1.

4.2 Incidence of potato insect pests

4.2.1 Incidence of above ground insect pests

Incidence of insect pests revealed that above ground pests appeared in 1st to 2nd week of May and attains peak in June in plains and midhills. Whereas, at high hills the pests appeared by the end of May to 1st week of June with a peak incidence by end of June to 1st week of July (Annexure 1-9). The results depicted in Table-2 during 2011 revealed that among above ground insect pests flea beetle showed highest incidence of 60.00, 54.44 and 23.33 per cent at Yarikhah (Baramulla), Budnambal (Kupwara) and Ajas (Bandipora), respectively while as, lowest incidence of 12.22 per cent was recorded at Pattan and Kunzer of Baramulla district. Semilooper incidence was recorded high 11.11 per cent at Pattan, Kunzer (Baramulla) and at Yonus of Kupwara district and was completely absent at Budnambal (Kupwara) and Gurez (Bandipora). Foliage sucker aphid showed 16.00 per cent highest incidence at Ajas (Bandipora) and 8.00 per cent lowest incidence at Gurez (Bandipora). Lowest incidence of 4.44 per cent was observed for cutworm at Yonus (Kupwara) and Gurez (Bandipora) during 2011.

Table-2 : Incidence percentage of different insect pests infesting potato (*Solanum tuberosum* L.) at different locations of district Baramulla, Kupwara and Bandipora for the year 2011

Pest	Baramulla			Kupwara			Bandipora		
	Pattan	Kunzer	Yarikhah	Yonus	Handwara	Budnambal	Sumbal	Ajas	Gurez
Flea beetle	12.22±4.33	12.22±5.95	60.00±12.8	17.77±7.95	17.77±7.95	54.44±12.81	17.77±7.77	23.33±9.12	22.22±7.59
Semilooper	11.11±5.12	11.11±5.63	7.77±3.64	11.11±6.11	10.00±5.27	x	6.66±3.72	10.0±6.00	x
Aphid	15.55±5.56	12.88±4.65	12.44±4.59	13.77±4.06	13.77±4.76	10.22±3.65	13.77±4.16	16.00±4.98	8.00±3.12
Cutworm	6.66±3.72	6.66±3.72	6.66±3.72	4.44±2.42	6.66±3.72	6.66±3.72	5.55±2.93	6.66±3.33	4.44±2.42
White grub	11.11±4.84	15.55±5.55	11.11±3.51	11.11±3.51	8.88±3.51	20.00±5.77	6.66±3.33	13.33±5.77	11.11±3.51
Wireworm	13.33±4.71	x	x	11.11±3.51	8.88±3.51	17.77±5.21	8.88±3.51	4.44±2.93	13.33±4.71
Earwigs	8.88±4.84	x	x	4.44±2.93	6.66±4.71	x	4.44±2.93	4.44±2.93	x

*Data based on 10 random plants for foliage and collar feeder insects; 5 random plants with 25 leaves for foliage suckers and 5 random 30-30 cm^2 pits upto depth of 20cm for tuber feeders

No. of observations in a year 9

Data expressed as Mean ± SE

In the year 2012, incidence of flea beetle was observed high 61.11, 55.55 and 24.44 per cent at Yarikhah (Baramulla), Budnambal (Kupwara) and Gurez (Bandipora), respectively with its lowest incidence of 11.11 per cent at Pattan (Baramulla). For other above ground pests, same trend was observed in the year 2012 (Table-3).

The overall incidence percentage for the year 2011 and 2012 (Table-4) of above ground insect pests revealed that flea beetle recorded highest incidence of 57.77 per cent at Yarikhah (Baramulla) and Budnambal (Kupwara) followed by 23.33 per cent at Gurez (Bandipora) while as, lowest incidence of 11.66 per cent at Pattan (Baramulla). Semilooper recorded highest incidence of 12.77 per cent at Kunzer (Baramulla) with lowest incidence of 7.77 per cent at Sumbal (Bandipora) and complete absence at Budnambal (Kupwara) and Gurez (Bandipora). Aphids recorded highest incidence of 15.77 per cent at Pattan (Baramulla) followed by 15.11 per cent at Ajas (Bandipora) whereas, 8.44 per cent as lowest at Gurez (Bandipora). For cutworm, the highest incidence of 7.21 per cent was recorded at Ajas (Bandipora) and lowest of 4.99 per cent at Gurez (Bandipora).

4.2.2 Incidence of below ground insect pest

Incidence of below ground insect pests revealed that pests appeared in last week of May to 2nd week of June with peak in July to August in plains and midhills. Whereas, they first appeared in last week of June to 2nd week of July and attained peak towards the harvest of crop at higher hills in northern Kashmir (Annexure 1-9). From Table-2, white grub showed highest incidence of 20.00 per cent, 15.55 and 13.33 per cent at Budnambal (Kupwara), Kunzer (Baramulla) and Ajas (Bandipora), respectively with lowest incidence of 6.66 per cent at Sumbal (Bandipora). Incidence of 17.77 per cent was recorded as highest at Budnambal (Kupwara) and 4.44 per cent as lowest at Ajas (Bandipora) with complete absence at Kunzer and Yarikhah of Baramulla district for wireworm. Earwig resulted highest incidence of 8.88 per cent at Pattan (Baramulla) followed by 4.44 per cent at Yonus (Kupwara), Sumbal and Ajas of Bandipora district with complete

Table-3 : Incidence percentage of different insect pests infesting potato (*Solanum tuberosum* L.) at different locations of district Baramulla, Kupwara and Bandipora for the year 2012

Pest	Baramulla			Kupwara			Bandipora		
	Pattan	Kunzer	Yarikhah	Yonus	Handwara	Budnambal	Sumbal	Ajas	Gurez
Flea beetle	11.11±3.51	13.33±7.81	55.55±12.37	18.88±8.73	15.55±7.28	61.11±12.85	15.55±6.47	21.11±8.73	24.44±8.99
Semilooper	12.22±4.33	14.44±6.47	8.88±4.54	8.88±4.84	8.88±4.84	x	8.88±4.84	8.88±4.84	x
Aphid	16.00±5.24	12.44±4.29	13.33±5.24	15.55±4.87	14.22±5.34	12.44±4.13	13.33±3.88	14.22±4.62	8.88±2.88
Cutworm	5.55±2.93	5.55±2.93	5.55±3.37	6.66±3.72	5.55±2.93	5.55±3.37	6.66±4.71	7.77±4.00	5.55±2.93
White grub	8.88±3.51	13.33±4.71	8.88±3.51	8.88±3.51	11.11±4.84	17.77±5.21	8.88±4.84	15.55±6.47	13.33±5.77
Wireworm	11.11±3.51	x	x	8.88±3.51	11.11±4.84	22.22±5.21	11.11±4.84	6.66±3.33	11.11±3.51
Earwigs	6.66±4.71	x	x	6.66±4.71	4.44±2.93	x	6.66±4.71	6.66±4.71	x

*Data based on 10 random plants for foliage and collar feeder insects; 5 random plants with 25 leaves for foliage suckers and 5 random 30-30 cm^2 pits upto depth of 20cm for tuber feeders

No. of observations in a year 9

Data expressed as Mean ± SE

Table-4 : Pooled incidence percentage of different insect pests infesting potato (*Solanum tuberosum* L.) at different locations of district Baramulla, Kupwara and Bandipora for 2011 and 2012

Pest	Baramulla			Kupwara			Bandipora		
	Pattan	Kunzer	Yarikhah	Yonus	Handwara	Budnambal	Sumbal	Ajas	Gurez
Flea beetle	11.66±0.55	12.77±0.55	57.77±2.22	18.32±0.55	16.66±1.10	57.77±3.34	16.66±1.10	22.22±1.10	23.33±1.10
Semilooper	11.66±0.55	12.77±1.66	8.32±0.55	9.99±1.11	9.44±0.56	x	7.77±1.10	9.44±0.56	x
Aphid	15.77±0.21	12.66±0.21	12.88±0.43	14.66±0.88	13.99±0.21	11.33±1.10	13.55±0.21	15.11±0.88	8.44±0.43
Cutworm	6.10±0.55	6.10±0.55	6.10±0.55	5.55±1.10	6.10±0.55	6.10±0.55	6.10±0.55	7.21±0.55	4.99±0.55
White grub	9.99±1.11	14.44±1.10	9.99±1.11	9.99±1.11	9.99±1.11	18.88±1.11	7.77±1.10	14.44±1.10	12.22±1.10
Wireworm	12.22±1.10	x	x	9.99±1.11	9.99±1.11	19.99±2.22	9.99±1.11	5.55±1.10	12.22±1.10
Earwigs	7.77±1.10	x	x	5.55±1.10	5.55±1.10	x	5.55±1.10	5.55±1.10	x

*Data based on 10 random plants for foliage and collar feeder insects; 5 random plants with 25 leaves for foliage suckers and 5 random 30-30 cm^2 pits upto depth of 20cm for tuber feeders

No. of observations in a year 9

Data expressed as Mean ± SE

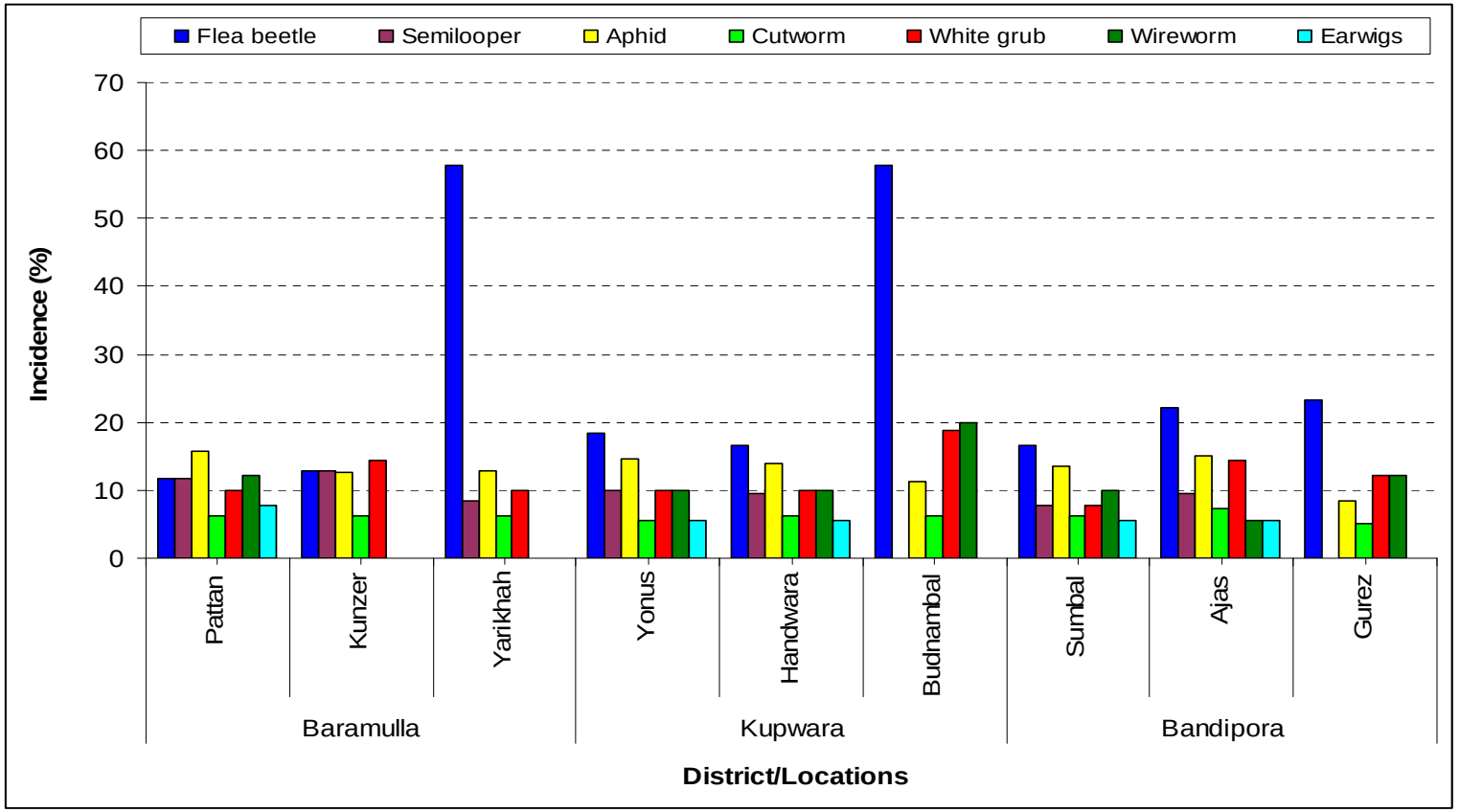


Fig. 1: Overall average incidence percentage of different insect pests infesting potato in northern districts of Kashmir during 2011 and 2012

absence at Kunzer, Yarikhah (Baramulla), Budnambal (Kupwara) and Gurez (Bandipora) locations during 2011. The results (Table-3) for the year 2012 revealed that white grub exhibited highest incidence of 17.77, 15.55, 13.33 and 13.33 per cent for Budnambal (Kupwara), Ajas (Bandipora), Kunzer (Baramulla) and Gurez (Bandipora), respectively with the lowest incidence of 8.88 per cent at Pattan and Yarikhah (Baramulla), Yonus (Kupwara) and Sumbal (Bandipora) locations. Wireworm recorded highest incidence of 22.22 per cent at Budnambal (Kupwara) and lowest 6.66 per cent at Ajas (Bandipora) with complete absence at Kunzer and Yarikhah locations of Baramulla district. However, for earwig, the highest incidence of 6.66 per cent was recorded at Pattan (Baramulla), Yonus (Kupwara), Sumbal and Ajas locations of Bandipora district with lowest incidence of 4.44 per cent at Handwara (Kupwara). The pest was completely absent at Kunzer, Yarikhah of Baramulla district, Budnambal (Kupwara) and Gurez (Bandipora).

The overall incidence percentage for 2011 and 2012 (Table-4) of below ground insect pests revealed that white grub recorded highest incidence of 18.88, 14.44 and 14.44 per cent at Budnambal (Kupwara), Kunzer (Baramulla) and Ajas (Bandipora) locations, respectively with the lowest incidence of 7.77 per cent at Sumbal location of Bandipora district. Wireworm recorded its highest incidence of 19.99 per cent at Budnambal (Kupwara) and lowest of 5.55 per cent at Ajas (Bandipora) locations but not found at Kunzer and Yarikhah locations of Baramulla district. However, highest pooled incidence of earwig for the year 2011 and 2012 of 7.77 per cent was recorded at Pattan (Baramulla) and 5.55 per cent as the lowest for rest locations except Kunzer, Yarikhah (Baramulla), Budnambal (Kupwara) and Gurez (Bandipora) were the pest was completely absent.

4.3 Severity of potato insect pests

4.3.1 Severity of foliage feeding insect pests

Among foliage feeding insect pests, flea beetle and semilooper were found to infest the crop. On the basis of leaf area damaged, 0-5 scale was used to determine the pest severity. Highest mean flea beetle severity of 21.06 per cent was recorded at Yarikhah while as, lowest 10.10 per cent at Pattan during the year 2011 (Table-5). For semilooper, highest mean severity of 15.44 per cent was exhibited at Kunzer and lowest 5.26 per cent at Yarikhah. However, during 2012 the highest mean pest severity of 20.06 per cent was recorded at Yarikhah and lowest of 10.77 per cent at Kunzer for flea beetle. Whereas, semilooper recorded highest severity of 15.08 per cent at Pattan and 4.86 per cent as lowest at Yarikhah location in Baramulla district (Table-5).

The pooled data for two consecutive years of Baramullah district showed that these pests start feeding activity from May and attain peak in June at Pattan (plain) and Kunzer (mid hill) whereas, at Yarikhah (high hill), flea beetle starts its feeding activity in May and semilooper in June with both attaining peak in July. The overall mean severity of infestation was recorded highest 20.56 per cent (Scale-2) at Yarikhah and 10.56 per cent (Scale-1) as lowest at Pattan for flea beetle. However, the highest mean severity of infestation of 15.26 per cent (Scale-1) at Pattan and lowest of 5.06 per cent (Scale-1) at Yarikhah was recorded for semilooper (Table-6).

The mean flea beetle severity at Kupwara during 2011 recorded highest 24.69 at Budnambal and 13.33 per cent as lowest at Yonus. Whereas, semilooper recorded highest severity of 14.16 per cent at Yonus followed by 11.66 per cent at Handwara with complete absence at Budnambal. However, during 2012 the mean flea beetle severity was observed 24.93 per cent as highest at Budnambal while as, 13.58 per cent as lowest at Handwara. Whereas, semilooper recorded highest

Table-5 : Pest severity of foliage feeding insect pests of potato (*Solanum tuberosum* L.) at Baramulla during 2011and 2012

Year	Month	Pattan		Kunzer		Yarikhah	
		Flea beetle	**Semilooper**	**Flea beetle**	**Semilooper**	**Flea beetle**	**Semilooper**
2011	April	0.00	0.00	0.00	0.00	-	-
	May	12.44	12.44	7.00	3.99	2.00	0.00
	June	24.33	48.67	36.67	36.10	18.00	6.33
	July	3.66	0.67	5.00	5.00	58.67	18.67
	August	-	-	-	-	21.33	1.33
	September	-	-	-	-	5.33	0.00
	Mean ±SE	**10.10 ±5.41**	**15.44 ±11.43**	**12.16 ±8.29**	**11.27 ±8.34**	**21.06 ±10.10**	**5.26 ±3.55**
2012	April	0.00	0.00	0.00	0.00	-	-
	May	9.00	10.00	15.78	7.99	1.66	0.00
	June	32.00	42.33	26.66	29.00	16.33	5.66
	July	3.10	7.99	0.66	1.66	55.33	16.00
	August	-	-	-	-	20.33	2.66
	September	-	-	-	-	6.67	0.00
	Mean ±SE	**11.02 ±7.23**	**15.08 ±9.33**	**10.77 ±6.42**	**9.66 ±6.67**	**20.06 ±9.44**	**4.86 ±2.97**

Data based on 10 replications having 3 leaves per replicate

*Leaf area damaged Scale used for Severity (0-5) Scale: 0= No damage, 1= Leaf damage from 1-20 per cent, 2 =Leaf damage from 21-40 per cent, 3= Leaf damage from 41-60 per cent, 4=Leaf damage from 61-80 per cent and 5=Leaf damage above 81 per cent.

Data expressed as Mean ± SE

Table-6 : Severity of infestation by foliage feeders on potato (*Solanum tuberosum* L.) at different locations of district Baramulla for 2011 and 2012

Month	Pooled mean number of leaves damaged					
	Pattan		Kunzer		Yarikhah	
	Flea beetle	Semilooper	Flea beetle	Semilooper	Flea beetle	Semilooper
April	0.00	0.00	0.00	0.00	-	-
May	10.72±1.73	11.22±1.21	11.39±4.39	5.99±2.00	1.83±0.17	0.00
June	28.16±3.84	45.5±3.17	31.66±5.01	32.55±3.56	17.16±0.83	5.99±0.33
July	3.38±0.27	4.33±3.66	2.83±2.17	3.33±1.67	57.00±1.67	17.33±1.33
August	-	-	-	-	20.83±0.49	1.99±0.66
September	-	-	-	-	6.00±0.66	0.00
2011	**10.10 ±5.41**	**15.44 ±11.43**	**12.16 ±8.29**	**11.27 ±8.34**	**21.06 ±10.10**	**5.26 ±3.55**
2012	**11.02 ±7.23**	**15.08 ±9.33**	**10.77 ±6.42**	**9.66 ±6.67**	**20.06 ±9.44**	**4.86 ±2.97**
Pooled Mean±SE	**10.56 ±0.46**	**15.26 ±0.17**	**11.47±0.69**	**10.46 ±0.80**	**20.56 ±0.49**	**5.06 ±0.19**

Data based on 10 replications having 3 leaves per replicate

*Mean no. of leaves damaged

Data expressed as Mean ± SE

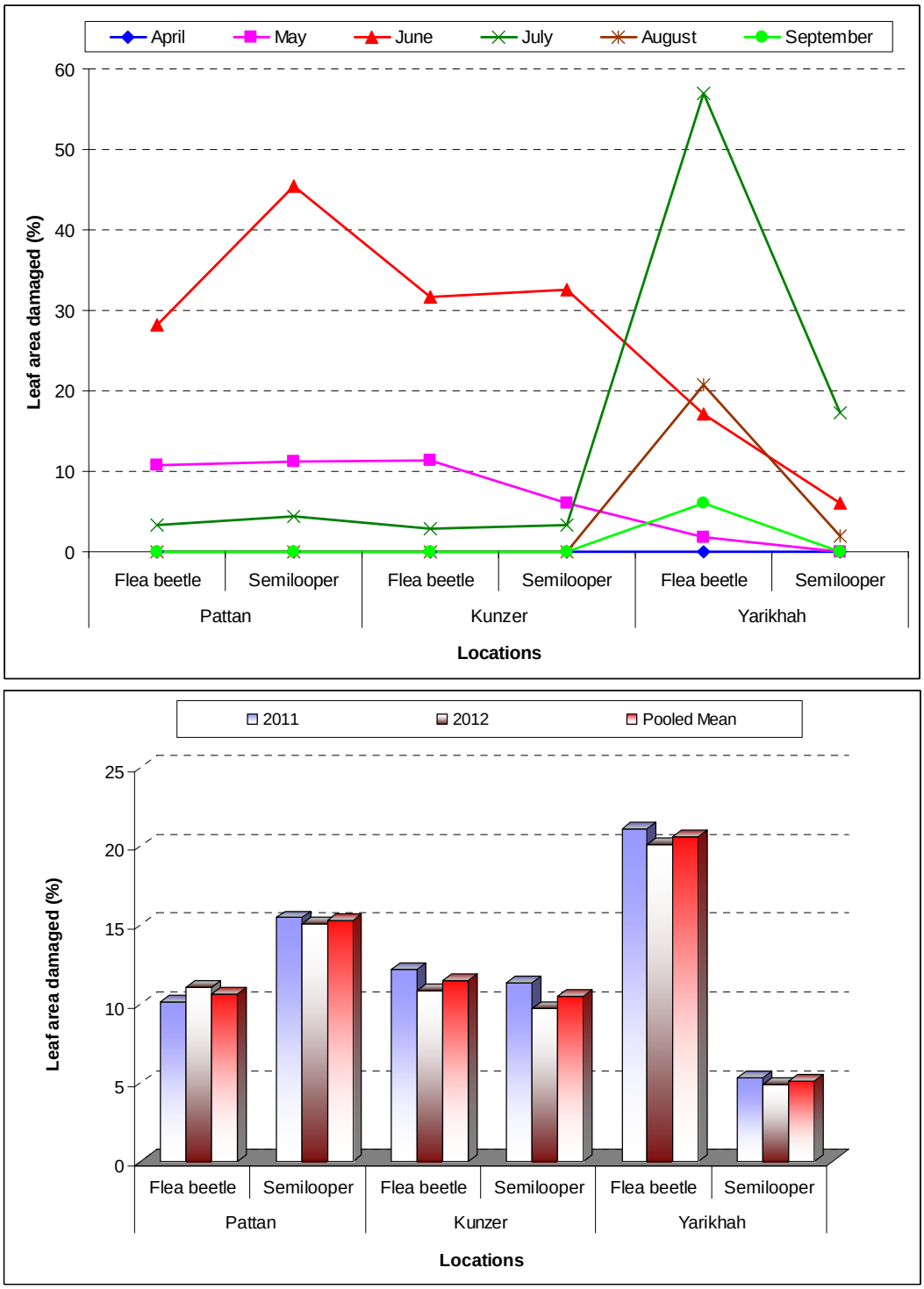


Fig. 2: Severity of infestation by foliage feeders on potato crop at different locations in Baramulla district during 2011 and 2012

severity of 14.24 per cent at Yonus followed by 10.41 per cent at Handwara and complete absence from Budnambal location of Kupwara district (Table-7).

The pooled data of two years showed that these pests start feeding activity from May and attain peak in June at Yonus (plain) and Handwara (mid hill) whereas, at Budnambal (high hill), flea beetle starts its feeding activity in May attaining peak in July with complete absence of semilooper at Budnambal location. The overall mean severity of infestation was recorded highest 24.81 per cent (Scale-2) at Budnambal and 13.83 per cent (Scale-1) as lowest at Yonus for flea beetle. However, the highest mean severity of infestation of 14.20 per cent (Scale-1) at Yonus followed by 11.03 per cent (Scale-1) at Handwara was recorded for semilooper (Table-8).

Similarly, mean flea beetle severity at Bandipora during 2011 was recorded 18.74 per cent as highest at Gurez and 8.88 per cent as lowest at Sumbal. Whereas, semilooper recorded highest severity of 5.30 per cent at Sumbal followed by 4.83 per cent at Ajas with complete absence at Gurez. However, during 2012 the mean flea beetle severity was observed 17.50 per cent as highest at Gurez and 9.91 per cent as lowest at Sumbal. Whereas, semilooper recorded highest severity of 5.41 per cent at Ajas followed by 5.25 per cent at Sumbal with its complete absence from Gurez location of Bandipora district (Table-9).

The pooled data of two years showed that these pests start feeding activity from May and attained peak in June at Sumbal (plain) and Ajas (mid hill). Whereas, at Gurez (high hill) flea beetle started its feeding activity in June attained peak in July and semilooper was completely absent at Gurez. The overall, average flea beetle infestation was recorded highest 18.12 per cent (Scale-1) at Gurez and 9.39 per cent (Scale-1) as lowest at Sumbal. However, the highest mean severity of infestation of 5.27 per cent (Scale-1) at Sumbal followed by 5.12 per cent (Scale-1) at Ajas was recorded for semilooper (Table-10).

Table-7 : Pest severity of foliage feeding insect pests of potato (*Solanum tuberosum* L.) at Kupwara during 2011and 2012

Year	Month	Yonus		Handwara		Budnambal	
		Flea beetle	**Semilooper**	**Flea beetle**	**Semilooper**	**Flea beetle**	**Semilooper**
2011	April	0.00	0.00	0.00	0.00	-	x
	May	12.33	7.33	7.66	3.33	3.33	x
	June	30.33	34.00	37.66	35.00	31.00	x
	July	10.66	15.33	11.33	8.33	55.50	x
	August	-	-	-	-	32.33	x
	September	-	-	-	-	1.33	x
	Mean ±SE	**13.33 ±6.29**	**14.16 ±7.31**	**14.16 ±8.18**	**11.66 ±7.96**	**24.69 ±10.14**	
2012	April	0.00	0.00	0.00	0.00	-	x
	May	12.00	5.33	7.33	2.33	4.67	x
	June	33.00	35.33	36.33	31.33	32.00	x
	July	12.33	16.33	10.67	8.00	54.67	x
	August	-	-	-	-	31.66	x
	September	-	-	-	-	1.66	x
	Mean ±SE	**14.33 ±6.85**	**14.24 ±7.8**	**13.58 ±7.9**	**10.41 ±7.18**	**24.93 ±9.85**	

Data based on 10 replications having 3 leaves per replicate

*Leaf area damaged Scale used for Severity (0-5) Scale: 0= No damage, 1= Leaf damage from 1-20 per cent, 2 =Leaf damage from 21-40 per cent, 3= Leaf damage from 41-60 per cent, 4=Leaf damage from 61-80 per cent and 5=Leaf damage above 81 per cent.

Data expressed as Mean ± SE

Table-8 : Severity of infestation by foliage feeders on potato (*Solanum tuberosum* L.) at different locations of district Kupwara for 2011 and 2012

Month	Pooled mean number of leaves damaged					
	Yonus		Handwara		Budnambal	
	Flea beetle	Semilooper	Flea beetle	Semilooper	Flea beetle	Semilooper
April	0.00	0.00	0.00	0.00	-	x
May	12.16±0.16	6.33±1.00	7.49±0.16	2.83±0.49	3.9±0.56	x
June	31.66±1.33	34.66±0.66	36.99±0.66	33.16±1.83	31.5±0.49	x
July	11.49±0.83	15.83±0.49	11.0±0.32	8.16±0.16	55.08±0.41	x
August	-	-	-	-	31.99±0.33	x
September	-	-	-	-	1.49±0.16	x
2011	**13.33 ±6.29**	**14.16 ±7.31**	**14.16 ±8.18**	**11.66 ±7.96**	**24.69 ±10.14**	x
2012	**14.33 ±6.85**	**14.24 ±7.80**	**13.58 ±7.9**	**10.41 ±7.18**	**24.93 ±9.85**	x
Pooled Mean±SE	**13.83 ±0.49**	**14.20 ±0.03**	**13.87 ±0.29**	**11.03 ±0.62**	**24.81 ±0.11**	

Data based on 10 replications having 3 leaves per replicate

*Mean no. of leaves damaged

Data expressed as Mean ± SE

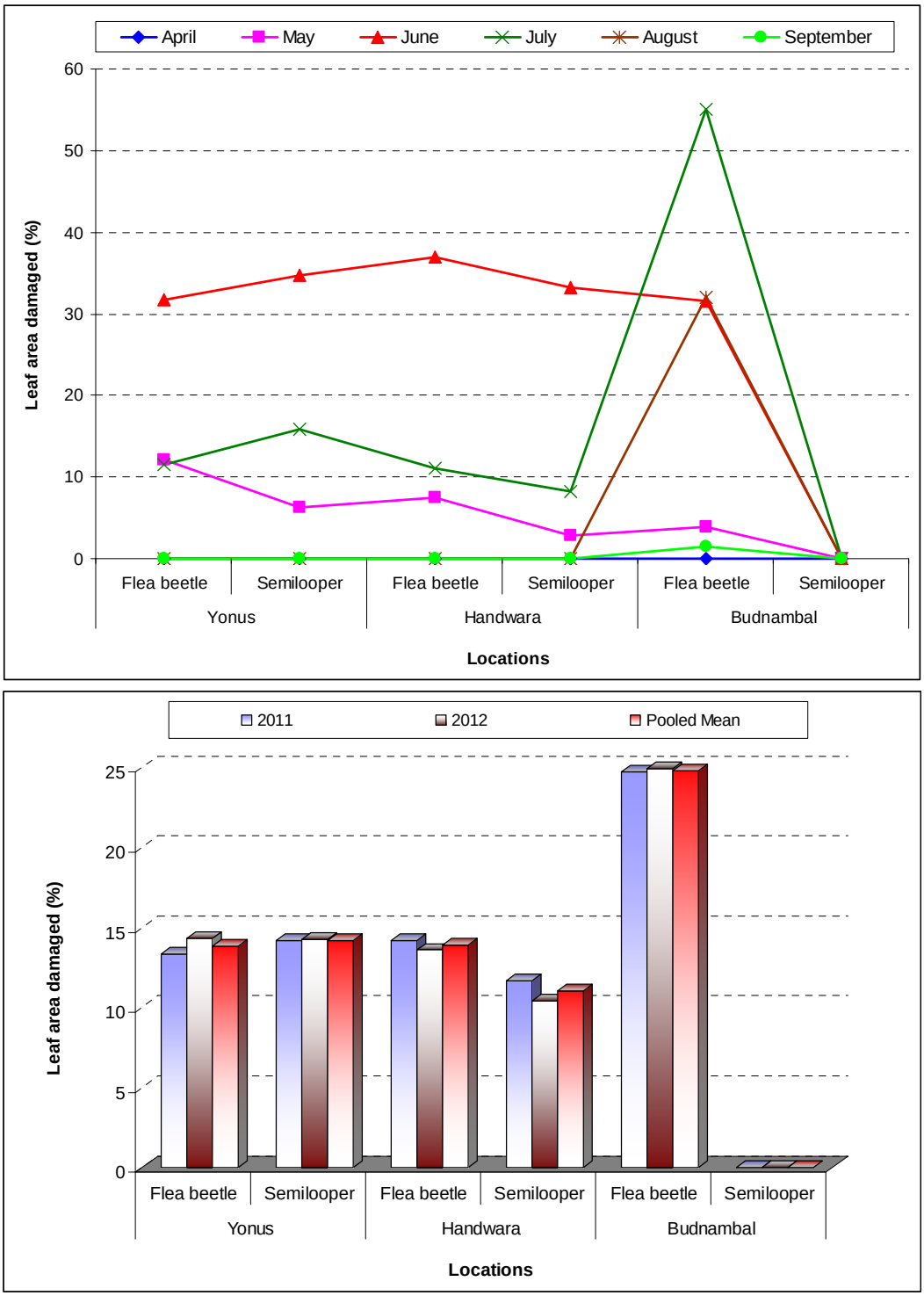


Fig. 3: **Severity of infestation by foliage feeders on potato crop at different locations in Kupwara district during 2011 and 2012**

Table-9 : Pest severity of foliage feeding insect pests of potato (*Solanum tuberosum* L.) at Bandipora during 2011and 2012

Year	Month	Sumbal		Ajas		Gurez	
		Flea beetle	Semilooper	Flea beetle	Semilooper	Flea beetle	Semilooper
2011	April	0.00	0.00	0.00	0.00	-	x
	May	6.67	0.66	7.67	0.66	-	x
	June	26.66	19.00	29.33	17.33	7.00	x
	July	2.22	1.55	5.33	1.33	38.67	x
	August	-	-	-	-	25.66	x
	September	-	-	-	-	3.66	x
	October	-	-	-	-	-	x
	Mean ±SE	**8.88 ±6.08**	**5.30 ±4.57**	**10.58 ±6.45**	**4.83 ±4.17**	**18.74 ±8.21**	
2012	April	0.00	0.00	0.00	0.00	-	x
	May	7.33	1.33	8.33	1.66	-	x
	June	28.00	18.00	32.50	18.33	6.00	x
	July	4.33	1.66	6.33	1.66	37.00	x
	August	-	-	-	-	23.66	x
	September	-	-	-	-	3.33	x
	October	-	-	-	-	-	x
	Mean ±SE	**9.91 ±6.21**	**5.25 ±4.26**	**11.79 ±7.12**	**5.41 ±4.32**	**17.50 ±7.91**	

Data based on 10 replications having 3 leaves per replicate

*Leaf area damaged Scale used for Severity (0-5) Scale: 0= No damage, 1= Leaf damage from 1-20 per cent, 2 =Leaf damage from 21-40 per cent, 3= Leaf damage from 41-60 per cent, 4=Leaf damage from 61-80 per cent and 5=Leaf damage above 81 per cent.

Data expressed as Mean ± SE

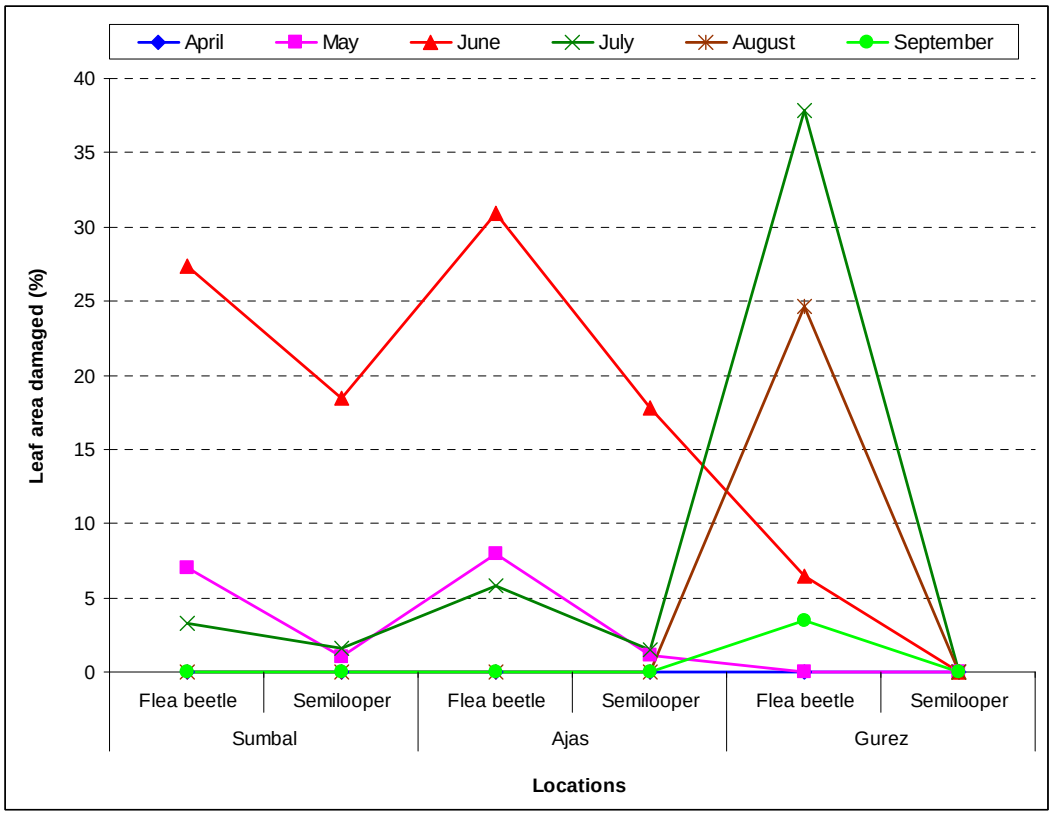
Table-10 : Severity of infestation by foliage feeders on potato (*Solanum tuberosum* L.) at different locations of district Bandipora for 2011 and 2012

Month	Pooled mean number of leaves damaged					
	Sumbal		Ajas		Gurez	
	Flea beetle	Semilooper	Flea beetle	Semilooper	Flea beetle	Semilooper
April	0.00	0.00	0.00	0.00	-	x
May	7.0±0.32	0.99±0.33	8.0±0.32	1.16±0.49	-	x
June	27.33±0.66	18.5±0.49	30.91±1.58	17.83±0.49	6.5±0.49	x
July	3.27±1.05	1.6±0.04	5.83±0.49	1.49±0.16	37.83±0.83	x
August	-	-	-	-	24.66±1.00	x
September	-	-	-	-	3.49±0.16	x
2011	**8.88 ±6.08**	**5.30 ±4.57**	**10.58 ±6.45**	**4.83 ±4.17**	**18.74 ±8.21**	x
2012	**9.91 ±6.21**	**5.25 ±4.26**	**11.79 ±7.12**	**5.41 ±4.32**	**17.50 ±7.91**	x
Pooled Mean±SE	**9.39 ±0.51**	**5.27 ±0.02**	**11.18 ±0.60**	**5.12 ±0.29**	**18.12 ±0.61**	

Data based on 10 replications having 3 leaves per replicate

*Mean no. of leaves damaged

Data expressed as Mean ± SE



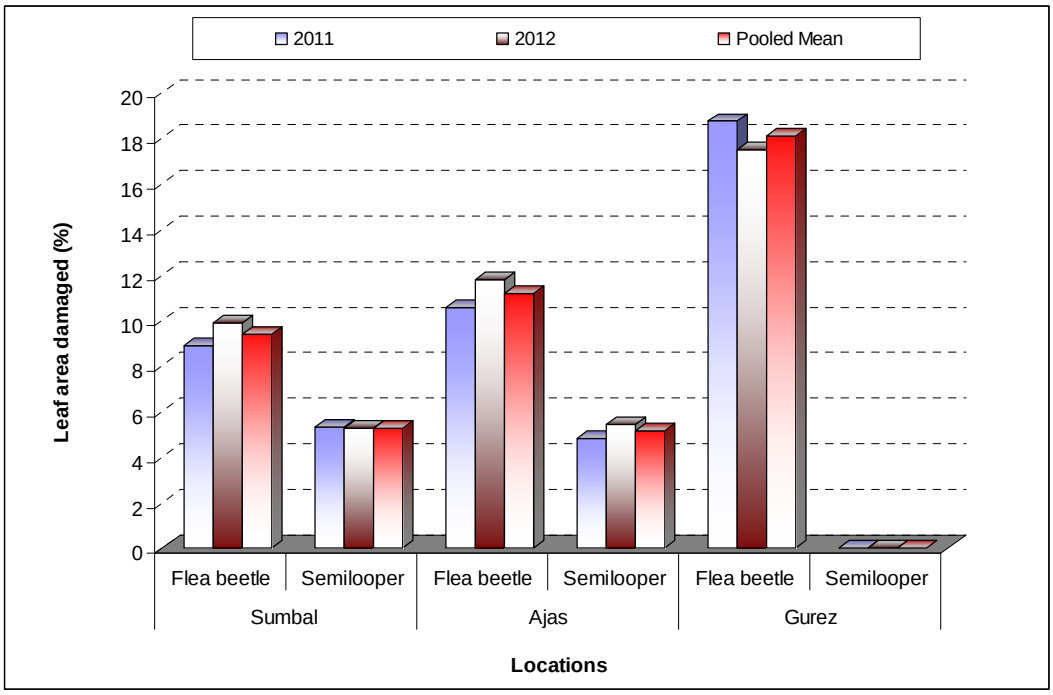


Fig. 4: Severity of infestation by foliage feeders on potato crop at different locations in Bandipora district during 2011 and 2012

4.3.2 Severity of foliage sucking insect pests

Aphid (*M. euphorbiae*) was recorded as a single foliage sucking insect pest on the potato crop. The results presented (Table-11) revealed that aphids start their feeding activity in May and attained peak towards June at Pattan (plain), Kunzer (mid hill) and Yarikhah (high hill) having mean severity of infestation 0.79, 0.85 and 0.97 per cent, respectively in Baramulla district. However, in Kupwara the pest started feeding in April at Yonus (plain) and in May at Handwara (mid hills) with peak severity in both locations in June with mean severity of infestation 1.12 and 1.00 per cent, respectively. While, at Budnambal (high hill), the pest started feeding during June and attained peak in July with 0.97 per cent mean severity of infestation. Similar trend was observed in Bandipora district as the pest started feeding from April at Sumbal (plain) and Ajas (mid hill) attaining peak towards June with mean severity of infestation 1.09 and 1.17 per cent, respectively. Whereas, at Gurez (high hill) aphid infestation started from June and attained peak towards July with mean severity of infestation 0.87 per cent during the year 2011.

During 2012, similar observations (Table-11) were recorded as the aphid started feeding activity in May and attained peak towards June at Pattan (plain), Kunzer (mid hill) and Yarikhah (high hill) having the mean severity of infestation 1.00, 0.79 and 1.07 per cent, respectively in Baramulla district. At Kupwara the pest started feeding/sucking in April at Yonus (plain) and in May at Handwara (mid hill) with peak severity in June with mean severity of infestation 1.17 and 1.07 per cent, respectively. While as, at Budnambal (high hill), the pest started feeding during June and attained peak in July with 1.05 per cent mean severity of infestation. However, in Bandipora district the aphid started feeding from April at Sumbal (plain) and Ajas (mid hill) attaining peak towards June with mean severity of infestation 1.07 and 0.90 per cent, respectively. However in Gurez (high hill), the aphid infestation started from June and attained peak towards July with 0.92 per cent mean severity infestation.

Table-11 : Monthly severity of foliage sucking insect pests of potato (*Solanum tuberosum* L.) at different locations of district Baramulla, Kupwara and Bandipora during 2011 and 2012

Year	District	Location	Severity of infestation *(Severity Index)						
			April	May	June	July	August	September	Mean ±SE
2011	Baramulla	Pattan	0.00	1.06	1.60	0.50	-	-	**0.79 ±0.34**
		Kunzer	0.00	1.00	1.40	1.00	-	-	**0.85 ±0.29**
		Yarikhah	-	1.00	1.20	1.20	0.50	-	**0.97 ±0.16**
		Yonus	0.50	1.20	1.80	1.00	-	-	**1.12 ±0.26**
	Kupwara	Handwara	0.00	1.00	2.00	1.00	-	-	**1.00 ±0.40**
		Budnambal	-	0.00	1.00	1.90	1.00	-	**0.97 ±0.38**
		Sumbal	0.50	1.10	2.10	0.66	-	-	**1.09 ±0.35**
	Bandipora	Ajas	0.50	1.30	1.90	1.00	-	-	**1.17 ±0.29**
		Gurez	-	-	0.50	1.50	1.00	0.50	**0.87 ±0.23**
2012	Baramulla	Pattan	0.00	1.40	1.80	0.80	-	-	**1.00 ±0.39**
		Kunzer	0.00	1.26	1.40	0.50	-	-	**0.79 ±0.32**
		Yarikhah	-	1.00	1.60	1.20	0.50	-	**1.07 ±0.22**
		Yonus	0.50	1.10	2.10	1.00	-	-	**1.17 ±0.33**
	Kupwara	Handwara	0.00	1.00	2.30	1.00	-	-	**1.07 ±0.47**
		Budnambal	-	0.00	1.00	2.20	1.00	-	**1.05 ±0.45**
		Sumbal	0.50	1.00	1.80	1.00	-	-	**1.07 ±0.26**
	Bandipora	Ajas	0.50	1.10	1.50	0.50	-	-	**0.90 ±0.24**
		Gurez	-	-	0.50	1.70	1.00	0.50	**0.92 ±0.28**

Data based on five infested plants

* Severity Index grade used for severity (1-4) Grade: 1= Scattered appearance of few aphids, 2= Moderate infestation of aphids on any one branch of the plant, 3= Severe infestation of aphids on more than one branch or half portion of the plant and 4=Very severe infestation of aphids in the whole plant.

Data expressed as Mean ± SE

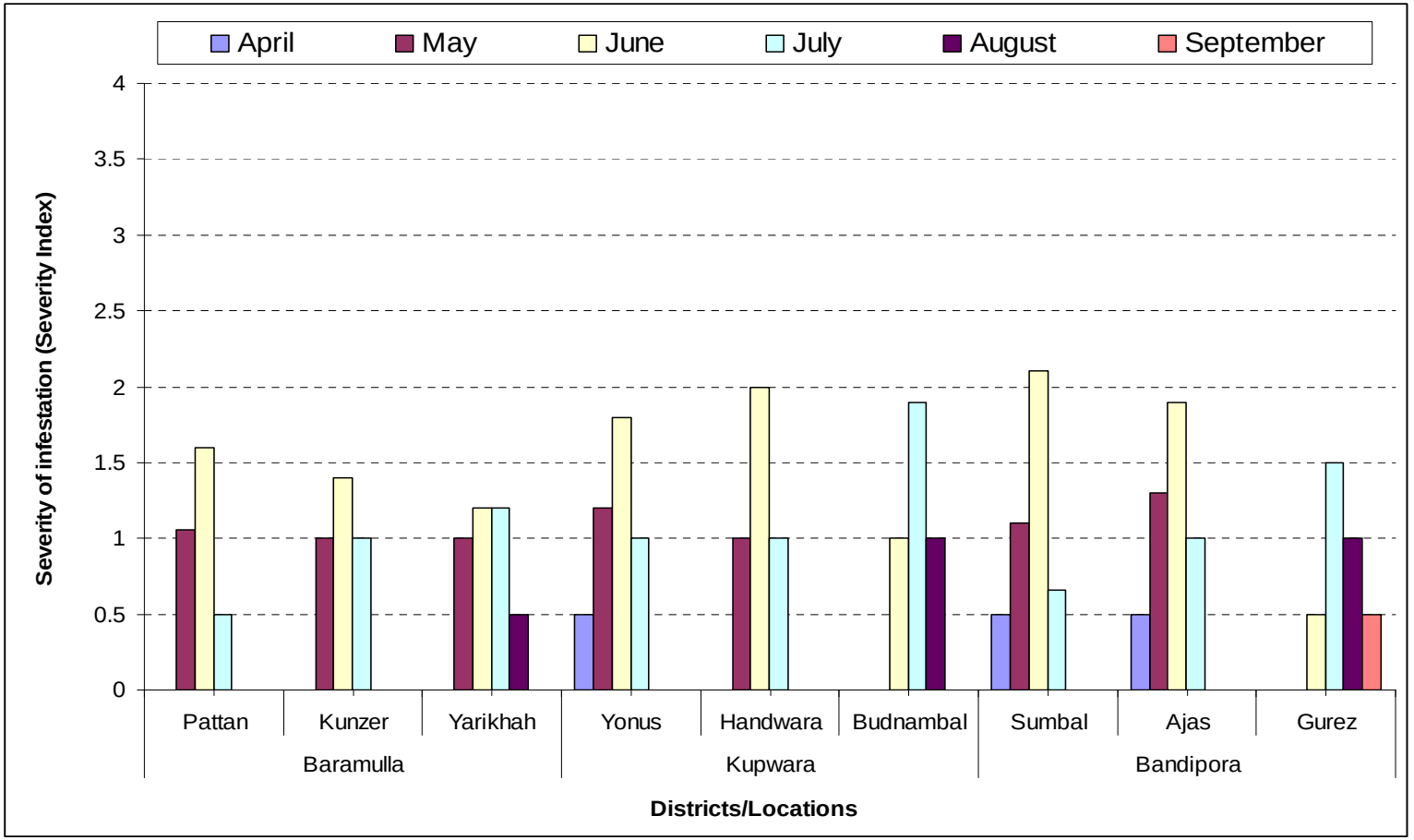


Fig. 5 : Severity index of foliage sucking aphid on potato crop in northern districts of Kashmir during 2011

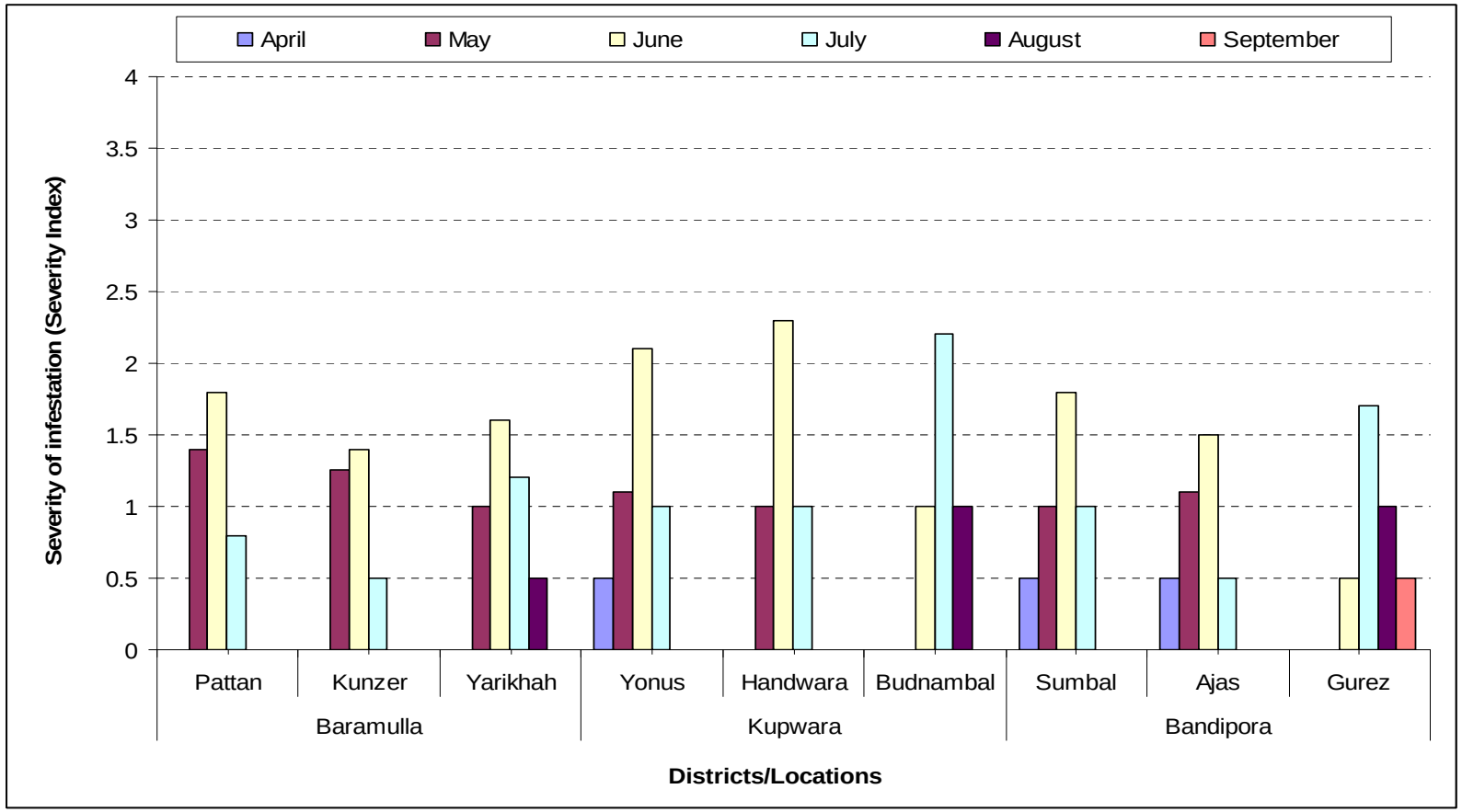


Fig. 6 : Severity index of foliage sucking aphid on potato crop in northern districts of Kashmir during 2012

From the pooled data (2011 and 2012) the highest mean severity of aphid 1.02 per cent (Scale-1) was recorded at Yarikhah and lowest 0.82 per cent (Scale-1) at Kunzer for Baramulla district. However, the highest mean severity of aphid 1.14 per cent (Scale-1) was recorded at Yonus and lowest of 1.01 per cent (Scale-1) at Budnambal in district Kupwara. At Bandipora, Sumbal location received the highest mean severity of 1.08 per cent (Scale-1) whereas, a lowest mean severity of 0.89 per cent (Scale-1) was recorded at Gurez location (Table-12).

4.3.3 Severity of collar feeding insect pests

Cutworm (*A. ipsilon*) as a collar feeder that cuts the stem near the base were found associated with the potato crop. The severity of cutworm was determined by selecting 10 random plants which were examined at fortnightly, based on partial and full cut. The data presented in Table-13 for the year 2011 revealed that the severity percentage was high at Pattan and Kunzer during May whereas, at Yarikhah it was noted high in June with mean severity of 3.75, 3.75 and 3.00 per cent, respectively in Baramulla district. The severity percentage was noted high in May at Yonus while, in June at Handwara and Budnambal locations of Kupwara district with mean severity of 3.75, 3.75 and 3.00 per cent, respectively. However, in Bandipora district, Sumbal location indicated high severity percentage during May and June whereas at Ajas and Gurez locations, per cent severity was noted to be high during June and July, respectively with mean severity of 5.00, 3.75 and 3.75 per cent, respectively.

Severity of collar feeding cutworm observed high in 2012 as compared to 2011 (Table-14) where Pattan and Kunzer locations received high severity percentage during May whereas at Yarikhah location, peak per cent severity was observed in June with overall mean severity of 6.25, 4.57 and 5.00 per cent, respectively in Baramulla district. Almost similar trend was observed in Kupwara district where Yonus location exhibit highest severity percentage in May while as, Handwara and Budnambal locations receive peak severity in June with mean

Table-12 : Pooled mean severity of foliage suckers on potato (*Solanum tuberosum* L.) at different locations of district Baramulla, Kupwara and Bandipora during 2011 and 2012

Year	*Severity Index								
	Baramulla			Kupwara			Bandipora		
	Pattan	Kunzer	Yarikhah	Yonus	Handwara	Budnambal	Sumbal	Ajas	Gurez
2011	0.79	0.85	0.97	1.12	1.00	0.97	1.09	1.17	0.87
2012	1.00	0.79	1.07	1.17	1.07	1.05	1.07	0.90	0.92
Pooled Mean±SE	**0.89 ±0.09**	**0.82 ±0.02**	**1.02 ±0.04**	**1.14 ±0.02**	**1.03 ±0.02**	**1.01 ±0.03**	**1.08 ±0.009**	**1.03 ±0.13**	**0.89 ±0.02**

Data based on five infested plants

* Severity Index grade used for severity (1-4) Grade: 1= Scattered appearance of few aphids, 2= Moderate infestation of aphids on any one branch of the plant, 3= Severe infestation of aphids on more than one branch or half portion of the plant and 4=Very severe infestation of aphids in the whole plant.

Data expressed as Mean ± SE

Table-13 : Severity percentage of collar feeding insect pests of potato (*Solanum tuberosum* L.) at different locations of district Baramulla, Kupwara and Bandipora during 2011

District	Location	Monthly severity of infestation						
		April	May	June	July	August	September	Mean ±SE
Baramulla	Pattan	0.00	10.00	5.00	0.00	-	-	**3.75 ±2.39**
	Kunzer	0.00	10.00	5.00	0.00	-	-	**3.75 ±2.39**
	Yarikhah	-	0.00	10.00	5.00	0.00	0.00	**3.00 ±2.00**
Kupwara	Yonus	0.00	10.00	5.00	0.00	-	-	**3.75 ±2.39**
	Handwara	0.00	5.00	10.00	0.00	-	-	**3.75 ±2.39**
	Budnambal	-	0.00	10.00	5.00	0.00	0.00	**3.00 ±2.00**
Bandipora	Sumbal	0.00	10.00	10.00	0.00	-	-	**5.00 ±2.88**
	Ajas	0.00	5.00	10.00	0.00	-	-	**3.75 ±2.39**
	Gurez	-	-	5.00	10.00	0.00	0.00	**3.75 ±2.39**

*Data based on 10 random plants

Data expressed as Mean ± SE

Table-14 : Severity percentage of collar feeding insect pests of potato (*Solanum tuberosum* L.) at different locations of district Baramulla, Kupwara and Bandipora during 2012

District	Location	Monthly severity of infestation						
		April	May	June	July	August	September	Mean ±SE
Baramulla	Pattan	0.00	15.00	10.00	0.00	-	-	**6.25 ±3.75**
	Kunzer	0.00	13.30	5.00	0.00	-	-	**4.57 ±3.13**
	Yarikhah	-	10.00	15.00	0.00	0.00	0.00	**5.00 ±3.17**
Kupwara	Yonus	0.00	15.00	5.00	0.00	-	-	**5.00 ±3.53**
	Handwara	0.00	5.00	15.00	0.00	-	-	**5.00 ±3.53**
	Budnambal	-	0.00	15.00	5.00	0.00	0.00	**4.00 ±2.91**
Bandipora	Sumbal	0.00	10.00	15.00	0.00	-	-	**6.25 ±3.75**
	Ajas	0.00	10.00	10.00	0.00	-	-	**5.00 ±2.88**
	Gurez	-	-	5.00	15.00	0.00	0.00	**5.00 ±3.53**

*Data based on 10 random plants

Data expressed as Mean ± SE

severity of 5.00, 5.00 and 4.00 per cent, respectively. The pest showed high severity percentage in May and June at Sumbal and Ajas locations of Bandipora district whereas at Gurez location, the crop receives high per cent severity in July with mean severity of 6.25, 5.00 and 5.00 per cent at Sumbal, Ajas and Gurez, respectively.

Pooled mean severity of cutworm during 2011 and 2012 (Table-15) showed that Pattan location exhibited highest severity of 5.00 per cent and lowest 4.00 per cent severity at Yarikhah location of Baramulla district. Whereas, equal range of severity 4.37 per cent as highest was recorded at Yonus and Handwara locations and lowest 3.50 per cent severity at Budnambal location of Kupwara district. However, in Bandipora, Sumbal location receives high severity 5.62 per cent whereas, Ajas and Gurez locations recorded equal 4.37 per cent severity.

4.3.4 Infestation of tuber feedings insect pests on white and red skinned potato tubers

Insect pests which were identified as tuber feeders include white grub, wireworm and earwig. Infestation percentage of above mentioned on white and red peeled varieties were calculated on number and weight basis for which number of tubers remained fixed (50 tubers) whereas, weight of tubers varied.

The results obtained during the year 2011 in Baramulla district as presented (Table-16) revealed that white peeled variety exhibited 16.00, 20.00 and 14.00 per cent infestation by white grub on number basis at Pattan, Kunzer and Yarikhah, respectively which was comparatively higher than recorded in red peeled variety as 4.00 per cent infestation at each location. Damage by wireworm was recorded only at Pattan location on white peeled variety with infestation 6.00 per cent on number basis. However, the pest was absent at Kunzer and Yarikhah locations. Another insect pest earwig, showed infestation of 8.00 and 2.00 per cent on number basis for white and red peeled varieties, respectively at Pattan and remained absent at Kunzer and Yarikhah locations of Baramulla district.

Table-15 : Severity percentage of infestation by collar feeders on potato (*Solanum tuberosum* L.) at different locations of district Baramulla, Kupwara and Bandipora for 2011 and 2012

Year	Pooled mean severity of collar feeders								
	Baramulla			Kupwara			Bandipora		
	Pattan	Kunzer	Yarikhah	Yonus	Handwara	Budnambal	Sumbal	Ajas	Gurez
2011	3.75	3.75	3.00	3.75	3.75	3.00	5.00	3.75	3.75
2012	6.25	4.57	5.00	5.00	5.00	4.00	6.25	5.00	5.00
Pooled Mean ±SE	**5.00 ±0.56**	**4.16 ±0.40**	**4.00 ±1.00**	**4.37 ±0.62**	**4.37 ±0.62**	**3.50 ±0.49**	**5.62 ±0.62**	**4.37 ±0.62**	**4.37 ±0.62**

*Data based on 10 random plants

Data expressed as Mean ± SE

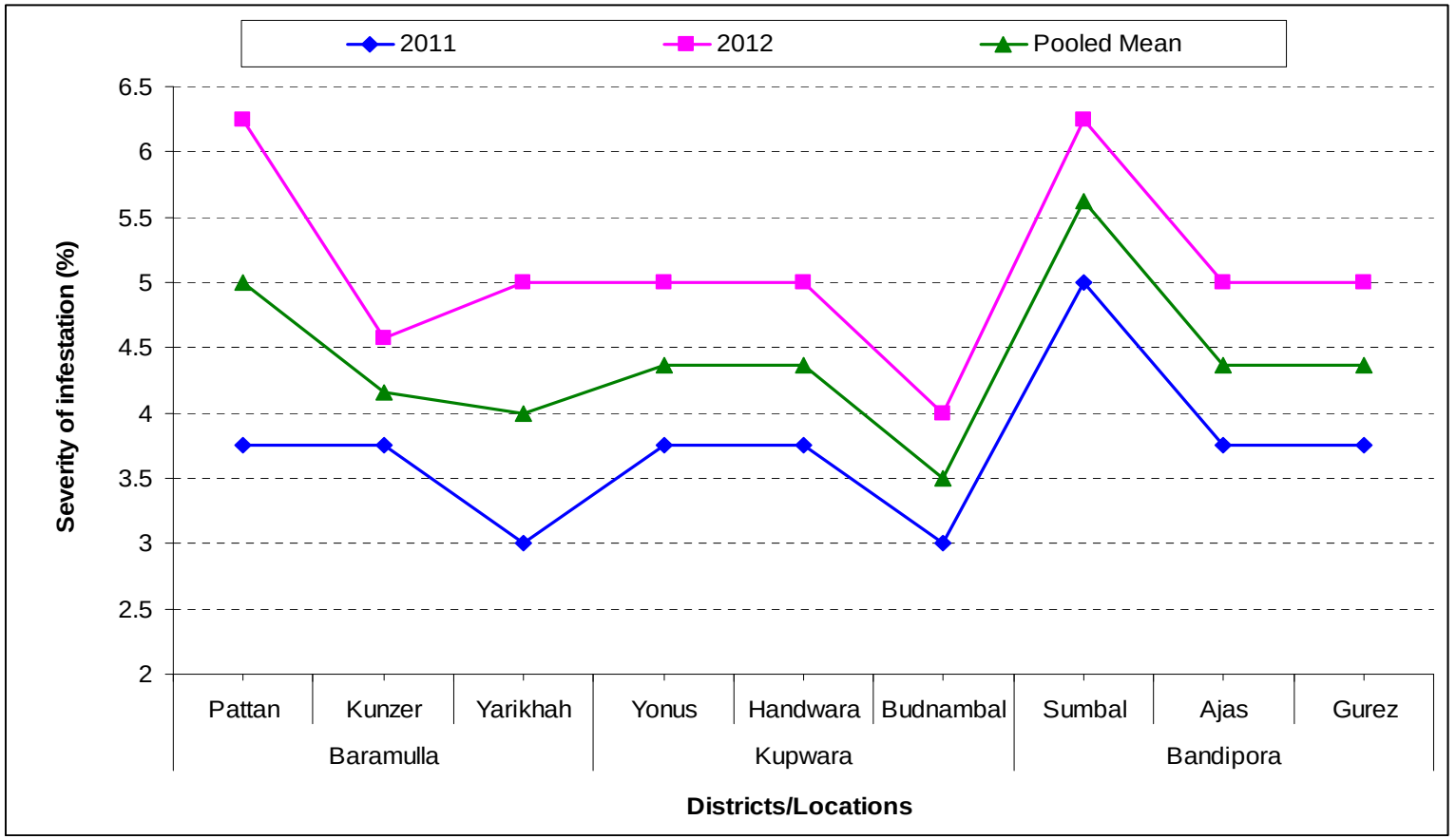


Fig. 7 : **Severity of infestation by collar feeding cutworm on potato crop in northern districts of Kashmir during 2011 and 2012**

Table-16 : Infestation percentage of tuber feeding insect pests on white and red skined potatoes at Baramulla during 2011 and 2012

Variety	*Damage	Pest	*Per cent Infestation					
			2011			2012		
			Pattan	Kunzer	Yarikhah	Pattan	Kunzer	Yarikhah
White peeled	Number bases	White grub	16.00	20.00	14.00	14.00	18.00	16.00
		Wireworm	6.00	x	x	8.00	x	x
		Earwigs	8.00	x	x	10.00	x	X
	Weight bases	White grub	15.71	18.73	14.59	12.73	16.81	15.12
		Wireworm	7.16	x	x	10.03	x	x
		Earwigs	7.70	x	x	9.39	x	X
Red peeled	Number bases	White grub	4.00	4.00	4.00	2.00	2.00	2.00
		Wireworm	0.00	x	x	2.00	x	x
		Earwigs	2.00	x	x	4.00	x	X
	Weight bases	White grub	3.96	4.22	4.38	2.04	2.28	2.30
		Wireworm	0.00	x	x	2.97	x	x
		Earwigs	1.98	x	x	3.90	x	x

*Number bases = 50 and weight varied

Data expressed in percentage

Similar infestation percentage was observed during 2011 on weight basis by white grub on white peeled variety with infestation 15.71, 18.73 and 14.59 per cent at Pattan, Kunzer and Yarikhah locations, respectively. Whereas, infestation on red peeled variety by white grub on weight basis was recorded 3.96, 4.22 and 4.38 per cent at Pattan, Kunzer and Yarikhah locations, respectively. Wireworm damage on weight basis for white peeled variety was observed only at Pattan with infestation 7.16 per cent. However, the pest was absent at Kunzer and Yarikhah locations. Further, red peeled variety was completely free from wireworm damage at all three locations of Baramulla district. Damage by earwig on weight basis was recorded only at Pattan location with infestation 7.70 per cent on white peeled variety and 1.98 per cent on red peeled variety whereas, the pest was completely absent at Kunzer and Yarikhah locations in Baramulla district.

During the year 2012 (Table-16), white peeled variety recorded 14.00, 18.00 and 16.00 per cent infestation by white grub at Pattan, Kunzer and Yarikhah locations, respectively. While as, red peeled variety exhibited 2.00 per cent infestation by white grub each at all the three locations in Baramulla district. Wireworm damage on number basis was recorded only at Pattan location with infestation 8.00 and 2.00 per cent on white and red peeled varieties, respectively. Whereas, the pest was completely absent at Kunzer and Yarikhah locations. However, earwigs infestation of 10.00 and 4.00 per cent on white and red peeled varieties, respectively on number basis was recorded at Pattan location with complete absence of pest at Kunzer and Yarikhah locations in Baramulla district.

On weight basis, the infestation 12.73, 16.81 and 15.12 per cent was observed on white peeled variety at Pattan, Kunzer and Yarikhah locations, respectively. While as, on red peeled variety, the infestation 2.04, 2.28 and 2.30 per cent was recorded at Pattan, Kunzer and Yarikhah locations, respectively. Damage due to wireworm on white and red peeled varieties was recorded only at Pattan location with infestation 10.03 and 2.97 per cent, respectively. Infestation by earwig on weight basis was recorded only at Pattan location with infestation

9.39 and 3.90 per cent on white and red peeled varieties, respectively. Whereas, Kunzer and Yarikhah locations were damage free by wireworm and earwig.

Overall infestation percentage of tuber feeders on white and red peeled varieties during the year 2011 and 2012 in Baramulla district as presented (Table-17) revealed that white peeled variety exhibit 15.00, 19.00 and 15.00 per cent infestation by white grub on number basis at Pattan, Kunzer and Yarikhah, respectively. Whereas, red peeled variety recorded 3.00 per cent infestation at each location. Damage by wireworm on white and red peeled varieties was recorded only at Pattan location with infestation 7.00 and 1.00 per cent, respectively on number basis. However, the pest was absent at Kunzer and Yarikhah locations. Another insect pest earwig, showed pooled infestation of 9.00 and 3.00 per cent on number basis for white and red peeled varieties, respectively at Pattan and remained absent at Kunzer and Yarikhah locations of Baramulla district.

On weight basis, pooled infestation percentage recorded on white peeled variety by white grub at Pattan, Kunzer and Yarikhah locations was 14.22, 17.77 and 14.85 per cent, respectively. Whereas, red peeled variety recorded infestation 3.12, 3.25 and 3.34 per cent at Pattan, Kunzer and Yarikhah locations, respectively by white grub. Wireworm damage on white and red peeled varieties was observed only at Pattan with infestation 8.59 and 1.48 per cent, respectively. Damage by earwig on weight basis was recorded only at Pattan location with infestation 8.54 and 2.94 per cent on white and red peeled varieties, respectively. While as, wireworm and earwig were completely absent at Kunzer and Yarikhah locations in Baramulla district.

The results obtained during the year 2011 in Kupwara district as presented (Table-18) revealed that white peeled variety recorded 12.00, 12.00 and 20.00 per cent infestation by white grub on number basis at Yonus, Handwara and Budnambal, respectively. Whereas, red peeled variety recorded 2.00, 2.00 and 6.00 per cent infestation at Yonus, Handwara and Budnambal, respectively.

Table-17 : Overall per cent infestation of tuber feeding insect pests on white and red skined potatoes in district Baramulla during 2011 and 2012

Variety	Pest	Damage	Pattan			Kunzer			Yarikhah		
			2011	2012	Mean±SE	2011	2012	Mean±SE	2011	2012	Mean±SE
White peeled	White grub	Number basis	16.00	14.00	15.00±1.00	20.00	18.00	19.00±1.00	14.00	16.00	15.00±1.00
		Weight basis	15.71	12.73	14.22±1.48	18.73	16.81	17.77±0.95	14.59	15.12	14.85±0.26
	Wireworm	Number basis	6.00	8.00	7.00±1.00	x	x	x	x	x	x
		Weight basis	7.16	10.03	8.59±1.43	x	x	x	x	x	x
	Earwig	Number basis	8.00	10.00	9.00±1.00	x	x	x	x	x	x
		Weight basis	7.70	9.39	8.54±0.84	x	x	x	x	x	x
Red peeled	White grub	Number basis	4.00	2.00	3.00±1.00	4.00	2.00	3.00±1.00	4.00	2.00	3.00±1.00
		Weight basis	3.96	2.28	3.12±0.83	4.22	2.28	3.25±0.97	4.38	2.30	3.34±1.04
	Wireworm	Number basis	0.00	2.00	1.00±1.00	x	x	x	x	x	x
		Weight basis	0.00	2.97	1.48±1.48	x	x	x	x	x	x
	Earwig	Number basis	2.00	4.00	3.00±1.00	x	x	x	x	x	x
		Weight basis	1.98	3.90	2.94±0.95	x	x	x	x	x	x

* Number bases=50 and weight varied

Data expressed as Mean ± SE

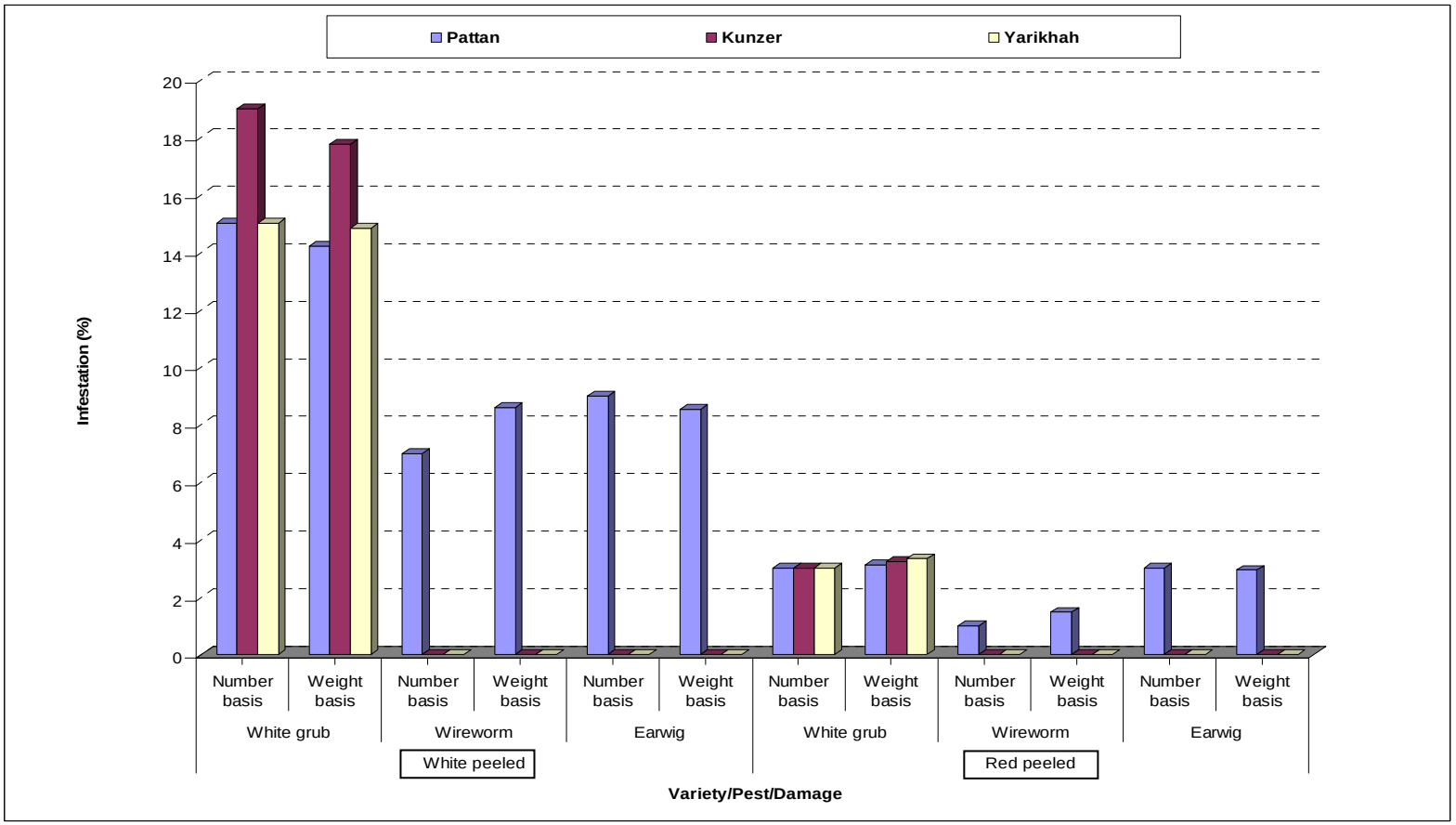


Fig. 8 : **Infestation percentage of tuber feeding insect pests on white and red peeled potatoes in Barammula district during 2011 and 2012**

Table-18 : Infestation percentage of tuber feeding insect pests on white and red skined potatoes at Kupwara during 2011 and 2012

Variety	*Damage	Pest	*Per cent Infestation					
			2011			2012		
			Yonus	Handwara	Budnambal	Yonus	Handwara	Budnambal
White peeled	Number bases	White grub	12.00	12.00	20.00	14.00	14.00	18.00
		Wireworm	6.00	4.00	22.00	4.00	6.00	18.00
		Earwigs	8.00	8.00	x	10.00	10.00	x
	Weight bases	White grub	11.21	12.15	19.24	12.77	13.12	16.77
		Wireworm	7.26	4.92	23.65	5.11	7.18	18.69
		Earwigs	8.05	7.07	x	9.20	8.43	x
Red peeled	Number bases	White grub	2.00	2.00	6.00	4.00	4.00	4.00
		Wireworm	2.00	2.00	8.00	2.00	2.00	6.00
		Earwigs	4.00	4.00	x	6.00	2.00	x
	Weight bases	White grub	2.27	2.20	6.20	4.25	3.69	4.09
		Wireworm	2.84	2.56	8.64	2.59	2.39	7.26
		Earwigs	4.55	4.22	x	5.55	1.66	x

*Number bases=50 and weight varied

Data expressed in percentage

Wireworm infestation on white peeled variety was recorded 6.00, 4.00 and 22.00 per cent on number basis at Yonus, Handwara and Budnambal, respectively. Whereas, red peeled variety recorded 2.00, 2.00 and 8.00 per cent infestation at Yonus, Handwara and Budnambal, respectively. Another insect pest earwig, showed infestation of 8.00 per cent each on number basis at Yonus and Handwara on white peeled varieties and remained absent at Budnambal location. Whereas, red peeled variety recorded 4.00 per cent infestation each at Yonus and Handwara on number basis and its complete absence at Budnambal location in Kupwara district.

On weight basis infestation 11.21, 12.15 and 19.24 per cent was recorded on white peeled variety by white grub at Yonus, Handwara and Budnambal locations, respectively. Whereas, red peeled variety recorded infestation 2.27, 2.20 and 6.20 per cent by white grub at Yonus, Handwara and Budnambal locations, respectively. Wireworm infestation on white peeled variety was recorded 7.26, 4.92 and 23.65 per cent at Yonus, Handwara and Budnambal, respectively. Whereas, red peeled variety recorded 2.84, 2.56 and 8.64 per cent infestation at Yonus, Handwara and Budnambal, respectively. Earwig showed infestation of 8.05 and 7.07 per cent at Yonus and Handwara, respectively on white peeled varieties and remained absent at Budnambal location. Whereas, red peeled variety recorded 4.55 and 4.22 per cent infestation at Yonus and Handwara, respectively on weight basis and were completely absent at Budnambal location in Kupwara district.

For the year 2012 results presented (Table-18), showed that white peeled variety possess 14.00, 14.00 and 18.00 per cent infestation on number basis by white grub at Yonus, Handwara and Budnambal locations, respectively. While as, red peeled variety exhibited 4.00 per cent infestation each at all the three locations in Kupwara district. Infestation by wireworm on white peeled variety was recorded 4.00, 6.00 and 18.00 per cent on number basis at Yonus, Handwara and Budnambal, respectively. Whereas, red peeled variety recorded 2.00, 2.00 and

6.00 per cent infestation at Yonus, Handwara and Budnambal, respectively. Earwig recorded infestation of 10.00 per cent each on number basis at Yonus and Handwara on white peeled varieties and remained absent at Budnambal location. Whereas, red peeled variety recorded 6.00 and 2.00 per cent infestation at Yonus and Handwara, respectively on number basis and was completely absent at Budnambal location in Kupwara district.

On weight basis, the infestation 12.77, 13.12 and 16.77 per cent was observed on white peeled variety at Yonus, Handwara and Budnambal locations, respectively. While as, on red peeled variety, the infestation 4.25, 3.69 and 4.09 per cent was recorded at Yonus, Handwara and Budnambal locations, respectively. Infestation by wireworm on white peeled variety was recorded 5.11, 7.18 and 18.69 per cent at Yonus, Handwara and Budnambal, respectively. Whereas, red peeled variety recorded 2.59, 2.39 and 7.26 per cent infestation at Yonus, Handwara and Budnambal, respectively. Earwig showed infestation of 9.20 and 8.43 per cent at Yonus and Handwara, respectively on white peeled varieties and remained absent at Budnambal location. Whereas, red peeled variety recorded 5.55 and 1.66 per cent infestation at Yonus and Handwara, respectively on weight basis and were completely absent at Budnambal location in Kupwara district.

Pooled infestation on percentage of tuber feeders on white and red peeled varieties during the years 2011 and 2012 in Kupwara district as presented in Table-19 revealed that white peeled variety exhibited 13.00, 13.00 and 19.00 per cent infestation by white grub on number basis at Yonus, Handwara and Budnambal, respectively. Whereas, red peeled variety recorded 3.00, 3.00 and 5.00 per cent infestation at the respective locations. Infestation by wireworm on white peeled variety was recorded 5.00, 5.00 and 20.00 on number basis at Yonus, Handwara and Budnambal, respectively. Whereas, red peeled variety recorded 2.00, 2.00 and 7.00 per cent infestation at Yonus, Handwara and Budnambal, respectively. Another insect pest earwig, showed pooled infestation of 9.00 per

Table-19 : Overall per cent infestation of tuber feeding insect pests on white and red skined potatoes in district Kupwara during 2011 and 2012

Variety	Pest	Damage	Yonus			Handwara			Budnambal		
			2011	2012	Mean±SE	2011	2012	Mean±SE	2011	2012	Mean±SE
White peeled	White grub	Number basis	12.00	14.00	13.00±1.00	12.00	14.00	13.00±1.00	20.00	18.00	19.00±1.00
		Weight basis	11.21	12.77	11.99±0.78	12.15	13.12	12.63±0.48	19.24	16.77	18.00±1.23
	Wireworm	Number basis	6.00	4.00	5.00±1.00	4.00	6.00	5.00±1.00	22.00	18.00	20.00±2.00
		Weight basis	7.26	5.11	6.18±1.07	4.92	7.18	6.05±1.12	23.65	18.69	21.17±2.48
	Earwig	Number basis	8.00	10.00	9.00±1.00	8.00	10.00	9.00±1.00	x	x	x
		Weight basis	8.05	9.20	8.62±0.57	7.07	8.43	7.75±0.68	x	x	x
Red peeled	White grub	Number basis	2.00	4.00	3.00±1.00	2.00	4.00	3.00±1.00	6.00	4.00	5.00±1.00
		Weight basis	2.27	4.25	3.26±0.99	2.20	3.69	2.94±0.74	6.20	4.09	5.14±1.05
	Wireworm	Number basis	2.00	2.00	2.00±0.00	2.00	2.00	2.00±0.00	8.00	6.00	7.00±1.00
		Weight basis	2.84	2.59	2.71±0.12	2.56	2.39	2.47±0.08	8.64	7.26	7.95±0.68
	Earwig	Number basis	4.00	6.00	5.00±1.00	4.00	2.00	3.00±1.00	x	x	x
		Weight basis	4.55	5.55	5.05±0.49	4.22	1.66	2.94±1.28	x	x	x

* Number bases=50 and weight varied

Data expressed as Mean ± SE

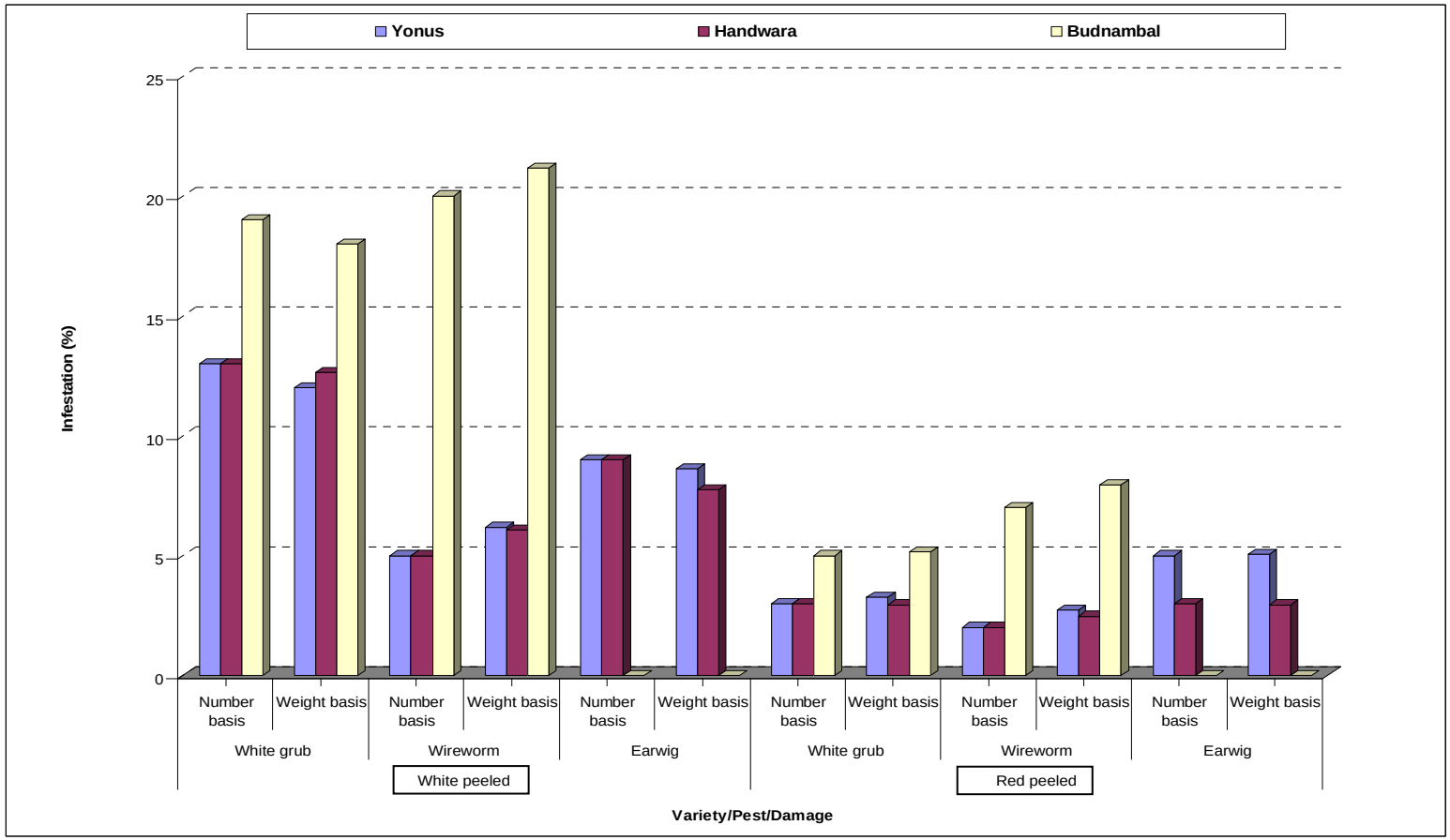


Fig. 9 : Infestation percentage of tuber feeding insect pests on white and red peeled potatoes in Kupwara district during 2011 and 2012

cent each on number basis at Yonus and Handwara on white peeled varieties and remained absent at Budnambal location. Whereas, red peeled variety recorded 5.00 and 3.00 per cent infestation at Yonus and Handwara, respectively on number basis and was completely absent at Budnambal location in Kupwara district.

On weight basis, pooled infestation percentage recorded during the year 2011 and 2012 on white peeled variety by white grub at Yonus, Handwara and Budnambal locations were 11.99, 12.63 and 18.00 per cent, respectively. Whereas, red peeled variety recorded infestation 3.26, 2.94 and 5.14 per cent at Yonus, Handwara and Budnambal locations, respectively. Infestation by wireworm on white peeled variety was recorded 6.18, 6.05 and 21.17 per cent at Yonus, Handwara and Budnambal, respectively. Whereas, red peeled variety recorded 2.71, 2.47 and 7.95 per cent infestation at Yonus, Handwara and Budnambal, respectively. Earwig showed infestation of 8.62 and 7.75 per cent at Yonus and Handwara, respectively on white peeled varieties and remained absent at Budnambal location. Whereas, red peeled variety recorded 5.05 and 2.94 per cent at Yonus and Handwara, respectively on weight basis and were completely absent in both the years at Budnambal location in Kupwara district.

In Bandipora district, the results obtained during the year 2011 as presented in Table-20 revealed that white peeled variety recorded 12.00, 18.00 and 14.00 per cent infestation by white grub on number basis at Sumbal, Ajas and Gurez, respectively. Whereas, red peeled variety recorded 4.00, 4.00 and 2.00 per cent infestation at Sumbal, Ajas and Gurez, respectively. Infestation by wireworm on white peeled variety was recorded 6.00, 8.00 and 6.00 per cent on number basis at Sumbal, Ajas and Gurez, respectively. Whereas, red peeled variety recorded 2.00 per cent infestation at Ajas. However, at Sumbal and Gurez locations tubers were free from wireworm infestation. Another insect pest earwig, showed infestation of 12.00 and 8.00 per cent on number basis at Sumbal and Ajas, respectively on white peeled varieties and remained absent at Gurez

Table-20 : Infestation percentage of tuber feeding insect pests on white and red skined potatoes at Bandipora during 2011 and 2012

Variety	*Damage	Pest	*Per cent Infestation					
			2011			2012		
			Sumbal	Ajas	Gurez	Sumbal	Ajas	Gurez
White peeled	Number bases	White grub	12.00	18.00	14.00	14.00	16.00	12.00
		Wireworm	6.00	8.00	6.00	8.00	6.00	4.00
		Earwigs	12.00	8.00	x	10.00	10.00	x
	Weight bases	White grub	11.90	19.68	14.17	12.63	17.30	12.17
		Wireworm	8.12	8.12	6.54	8.62	6.57	4.16
		Earwigs	10.07	6.87	x	9.24	9.61	x
Red peeled	Number bases	White grub	4.00	4.00	2.00	2.00	2.00	4.00
		Wireworm	0.00	2.00	0.00	2.00	4.00	2.00
		Earwigs	4.00	2.00	x	2.00	4.00	x
	Weight bases	White grub	4.08	4.62	2.27	2.00	2.35	4.22
		Wireworm	0.00	2.50	0.00	2.18	4.90	2.38
		Earwigs	3.53	1.92	x	1.81	3.92	x

*Number bases=50 and weight varied

Data expressed in percentage

location. Whereas, red peeled variety recorded 4.00 and 2.00 per cent infestation at Sumbal and Ajas, respectively on number basis and its complete absence at Gurez location in Kupwara district.

On weight basis infestation 11.90, 19.68 and 14.17 per cent was recorded on white peeled variety by white grub at Sumbal, Ajas and Gurez locations, respectively. Whereas, red peeled variety recorded infestation 4.08, 4.62 and 2.27 per cent by white grub at Sumbal, Ajas and Gurez locations, respectively. Wireworm infestation on white peeled variety was recorded 8.12, 8.12 and 6.54 per cent at Sumbal, Ajas and Gurez, respectively. Whereas, red peeled variety recorded 2.50 per cent, infestation at Ajas location, while as the tubers were damage free at Sumbal and Gurez locations. Earwig recorded infestation of 10.07 and 6.87 per cent at Sumbal and Ajas, respectively on white peeled varieties and remained absent at Gurez location. Whereas, red peeled variety recorded 3.53 and 1.92 per cent at Sumbal and Ajas, respectively on weight basis and the pest was completely absent at Gurez location in Kupwara district.

During the year 2012, the results presented (Table-20), showed that white peeled variety possess 14.00, 16.00 and 12.00 per cent infestation by white grub on number basis at Sumbal, Ajas and Gurez locations, respectively. While as, red peeled variety exhibited 2.00, 2.00 and 4.00 per cent infestation at Sumbal, Ajas and Gurez locations, respectively in Kupwara district. Infestation by wireworm on white peeled variety was recorded 8.00, 6.00 and 4.00 per cent on number basis at Sumbal, Ajas and Gurez, respectively. Whereas, red peeled variety recorded 2.00, 4.00 and 2.00 per cent infestation by wireworm at Sumbal, Ajas and Gurez, respectively. Earwig recorded infestation of 10.00 per cent each on number basis at Sumbal and Ajas on white peeled varieties and remained absent at Budnambal location. Whereas, red peeled variety recorded 2.00 and 4.00 per cent infestation at Sumbal and Ajas, respectively on number basis and was completely absent at Gurez location in Bandipora district.

On weight basis, the infestation 12.63, 17.30 and 12.17 per cent was recorded on white peeled variety at Sumbal, Ajas and Gurez locations,

respectively during 2012. Whereas, on red peeled variety, 2.00, 2.35 and 4.22 per cent infestation was recorded at Sumbal, Ajas and Gurez locations, respectively. Infestation by wireworm on white peeled variety was recorded 8.62, 6.57 and 4.16 per cent at Sumbal, Ajas and Gurez, respectively. Whereas, red peeled variety recorded 2.18, 4.90 and 2.38 per cent infestation at Sumbal, Ajas and Gurez, respectively. Earwig showed infestation of 9.24 and 9.61 per cent at Sumbal and Ajas, respectively on white peeled varieties and remained absent at Gurez location. The red peeled variety recorded 1.81 and 3.92 per cent infestation at Sumbal and Ajas, respectively on weight basis and were completely free from infestation at Gurez location in Bandipora district.

Pooled infestation percentage of tuber feeders on white and red peeled varieties during the year 2011 and 2012 in Bandipora district as presented in Table-21, revealed that white peeled variety exhibited 13.00, 17.00 and 13.00 per cent infestation by white grub on number basis at Sumbal, Ajas and Gurez, respectively. Whereas, red peeled variety recorded 3.00 per cent infestation each at respective locations. Infestation by wireworm on white peeled variety was recorded 7.00, 7.00 and 5.00 per cent on number basis at Sumbal, Ajas and Gurez, respectively. Whereas, red peeled variety recorded 1.00, 3.00 and 1.00 per cent infestation consequently at Sumbal, Ajas and Gurez. Another insect pest earwig, showed infestation of 11.00 and 9.00 per cent on number basis at Sumbal and Ajas locations, respectively on white peeled varieties and no infestation absent at Gurez location. Whereas, the red peeled variety recorded 3.00 per cent infestation each at Sumbal and Ajas locations on number basis and was free from infestation at Gurez location in Bandipora district.

On weight basis, pooled infestation percentage recorded on white peeled variety by white grub at Sumbal, Ajas and Gurez locations was 12.26, 18.49 and 13.17 per cent, respectively. Whereas, red peeled variety recorded infestation of 3.04, 3.48 and 3.24 per cent at Sumbal, Ajas and Gurez locations, respectively. Infestation by wireworm on white peeled variety was recorded 8.37, 7.34 and 5.35

Table-21 : Overall per cent infestation of tuber feeding insect pests on white and red skined potatoes in district Bandipora during 2011 and 2012

Variety	Pest	Damage	Sumbal			Ajas			Gurez		
			2011	2012	Mean±SE	2011	2012	Mean±SE	2011	2012	Mean±SE
White peeled	White grub	Number basis	12.00	14.00	13.00±1.00	18.00	16.00	17.00±1.00	14.00	12.00	13.00±1.00
		Weight basis	11.90	12.63	12.26±0.36	19.68	17.3	18.49±1.19	14.17	12.17	13.17±1.00
	Wireworm	Number basis	6.00	8.00	7.00±1.00	8.00	6.00	7.00±1.00	6.00	4.00	5.00±1.00
		Weight basis	8.12	8.62	8.37±0.24	8.12	6.57	7.34±0.77	6.54	4.16	5.35±1.19
	Earwig	Number basis	12.00	10.00	11.00±1.00	8.00	10.00	9.00±1.00	x	x	x
		Weight basis	10.07	9.24	9.65±0.41	6.87	9.61	8.24±1.36	x	x	x
Red peeled	White grub	Number basis	4.00	2.00	3.00±1.00	4.00	2.00	3.00±1.00	2.00	4.00	3.00±1.00
		Weight basis	4.08	2.00	3.04±1.04	4.62	2.35	3.48±1.13	2.27	4.22	3.24±0.97
	Wireworm	Number basis	0.00	2.00	1.00±1.00	2.00	4.00	3.00±1.00	0.00	2.00	1.00±1.00
		Weight basis	0.00	2.18	1.09±1.09	2.50	4.90	3.70±1.19	0.00	2.38	1.19±1.19
	Earwig	Number basis	4.00	2.00	3.00±1.00	2.00	4.00	3.00±1.00	x	x	x
		Weight basis	3.53	1.81	2.67±0.85	1.92	3.92	2.92±1.00	x	x	x

*Number bases=50 and weight varied

Data expressed as Mean ± SE

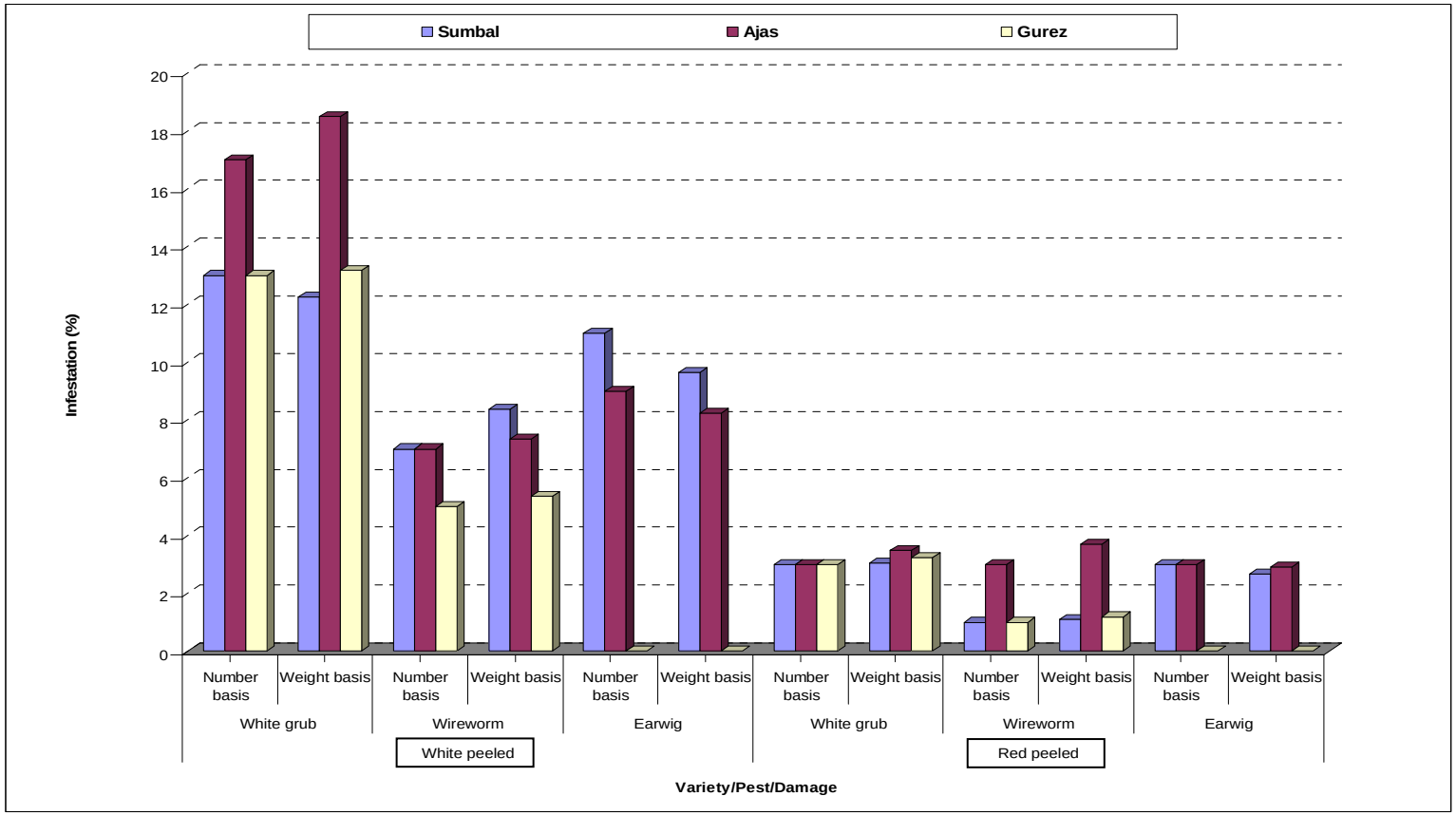


Fig. 10 : Infestation percentage of tuber feeding insect pests on white and red peeled potatoes in Bandipora district during 2011 and 2012

per cent at Sumbal, Ajas and Gurez, respectively. Whereas, red peeled variety recorded 1.09, 3.70 and 1.19 per cent infestation at Sumbal, Ajas and Gurez, respectively. Earwig showed infestation of 9.65 and 8.24 per cent at Sumbal and Ajas, respectively on white peeled varieties and remained undamaged at Gurez location. Whereas, red peeled variety recorded 2.67 and 2.92 per cent at Sumbal and Ajas, respectively on weight basis and showed no damage in both the years at Gurez location in Bandipora district.

4.3.5 Severity of tuber feedings insect pests on potato tubers

For this purpose 5 kg of tubers of white peeled variety were examined at final harvest by using scale 1-5 to obtain the severity of infestation by tuber feeders. The results presented (Table-22) revealed that Ajas (Bandipora), Budnambal (Kupwara) and Kunzer (Baramulla) locations recorded highest severity 5.28, 5.08 and 4.56 per cent, respectively by white grub during the year 2011. Whereas, wireworm as tuber feeder recorded lowest severity at all locations except Budnambal (Kupwara) were 4.64 per cent of severity was recorded. However, the pest was completely absent at Kunzer and Yarikhah locations in Baramulla district. Earwig was completely absent at high altitudes including Kunzer and Yarikhah (Baramulla), Budnambal (Kupwara) and Gurez (Bandipora) locations in northern Kashmir. However, the highest severity of 4.96 per cent was recorded at Sumbal (Bandipora) followed by Pattan (Baramulla) with severity 4.12 per cent while as, the lowest severity 3.44 per cent was recorded at Handwara location in Kupwara district during the year 2011.

Similarly, during the year 2012 (Table-22), Ajas (Bandipora), Budnambal (Kupwara) and Kunzer (Baramulla) recorded highest severity of 4.60, 4.48 and 4.20 per cent, respectively by white grub. Whereas, wireworm recorded lowest severity range of 0.88 to 1.76 per cent at all locations except Budnambal (Kupwara) were 3.40 per cent of severity was recorded as highest. However, the pest was completely absent at Kunzer and Yarikhah locations in Baramulla district. Earwigs were completely absent at high altitudes including Kunzer and

Table-22 : Severity of infestation by tuber feeders on white peeled potato at different locations of district Baramulla, Kupwara and Bandipora on final harvest for 2011 and 2012

Year	Pest	Severity of infestation (%age)								
		Baramulla			Kupwara			Bandipora		
		Pattan	Kunzer	Yarikhah	Yonus	Handwara	Budnambal	Sumbal	Ajas	Gurez
2011	White grub	3.84	4.56	3.12	2.84	3.36	5.08	2.80	5.28	3.68
	Wireworm	1.40	x	x	1.40	0.88	4.64	1.28	1.60	1.28
	Earwigs	4.12	x	x	3.92	3.44	x	4.96	3.52	x
2012	White grub	3.20	4.20	3.52	3.44	3.60	4.48	3.08	4.60	3.36
	Wireworm	1.76	x	x	1.04	1.36	3.40	1.68	1.28	0.88
	Earwigs	5.28	x	x	4.36	3.52	x	5.60	4.80	x

Data based on 5 kg tubers and expressed in percentage.

*Tuber area damaged, Scale used for Severity (0-5) Scale: 0= No damage, 1= Tuber damage from 1-20 per cent, 2 =Tuber damage from 21-40 per cent, 3= Tuber damage from 41-60 per cent, 4= Tuber damage from 61-80 per cent and 5= Tuber damage above 81 per cent.

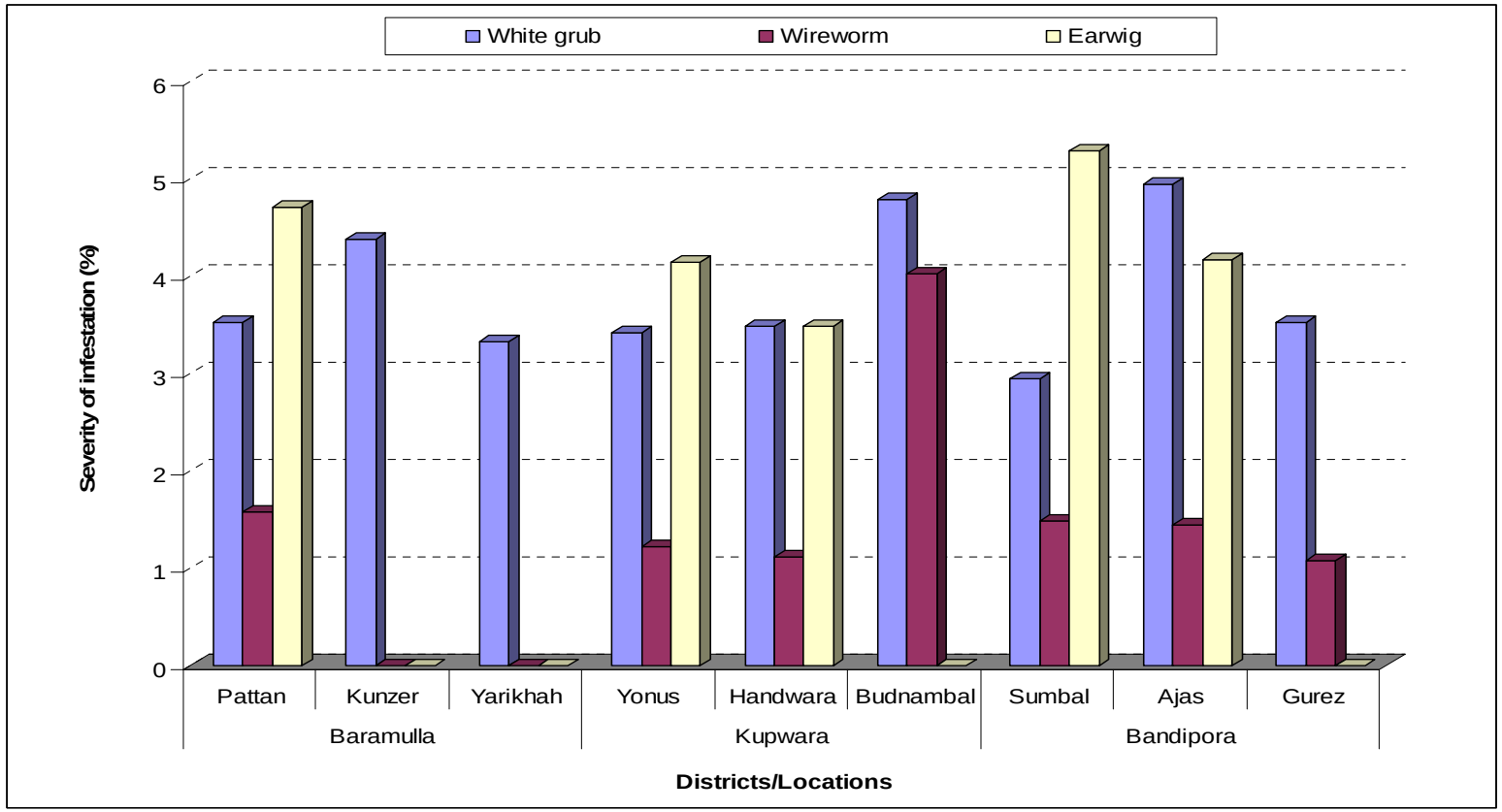


Fig. 11 : Pooled severity of infestation by tuber feeding insect pests on potato at different locations in Baramulla, Kupwara and Bandipora districts during 2011 and 2012

Yarikhah (Baramulla), Budnambal (Kupwara) and Gurez (Bandipora) locations in northern Kashmir. However, the highest severity of 5.60 per cent was recorded at Sumbal (Bandipora) followed by Pattan (Baramulla) with severity 5.28 per cent. The lowest severity (3.52%) was recorded at Handwara location in Kupwara district during 2012.

Pooled mean severity of infestation by tuber feeders on potato during the year 2011 and 2012 seasons at different locations of district Baramulla, Kupwara and Bandipora on final harvest as presented in Table-23, revealed that severity of 4.94, 4.78 and 4.38 per cent was recorded as highest at Ajas (Bandipora), Budnambal (Kupwara) and Kunzer (Baramulla) respectively. Whereas, lowest severity 2.94, 3.32 and 3.41 per cent was recorded at Sumbal (Bandipora), Yarikhah (Baramulla) and Yonus (Kupwara), respectively by white grub. Wireworm recorded severity of 4.02 per cent as highest at Budnambal (Kupwara) and 1.08 per cent as lowest at Gurez (Bandipora). However, the pest was completely absent at Kunzer and Yarikhah locations in Baramulla district. Severity of infestation by earwig was recorded highest 5.28 per cent at Sumbal (Bandipora) whereas, lowest 3.48 per cent was recorded at Handwara (Kupwara). However, the pest was completely absent at Kunzer and Yarikhah (Baramulla), Budnambal (Kupwara) and Gurez (Bandipora) locations.

4.4 Management of white grub

The field experiment was conducted at Kunzer (Baramulla), Budnambal (Kupwara) and Ajas (Bandipora) during 2012 to work out per cent good tubers at final harvest using nine treatments viz., Imidacloprid 70 WS (3 mg/kg seed), *Beauveria bassiana* (5 g/litre of water), *Metarrhizium anisopliae* (5 g/litre of water), *Bacillus thuringiensis* (3 g/litre of water), Phalada-111 C1(1 ml/litre of water), Neem cake (300 kg/ha), Mustard cake (300 kg/ha), Cultural practices and untreated check (control). The per cent good tubers in treatments were compared with per cent good tubers in control to work out the most effective treatments for the management of white grub.

Table-23 : Severity of infestation by tuber feeders on potato (*Solanum tuberosum* L.) at different locations of district Baramulla, Kupwara and Bandipora on final harvest for 2011 and 2012

Pest	Pooled mean severity of infestation (%age)								
	Baramulla			Kupwara			Bandipora		
	Pattan	Kunzer	Yarikhah	Yonus	Handwara	Budnambal	Sumbal	Ajas	Gurez
White grub	3.52±0.31	4.38±0.17	3.32±0.19	3.41±0.29	3.48±0.11	4.78±0.29	2.94±0.13	4.94±0.34	3.52±0.15
Wireworm	1.58±0.17	x	x	1.22±0.17	1.12±0.23	4.02±0.61	1.48±0.19	1.44±0.15	1.08±0.19
Earwig	4.70±0.58	x	x	4.14±0.21	3.48±0.03	x	5.28±0.31	4.16±0.63	x

Data based on 5 kg tubers.

*Tuber area damaged, Scale used for Severity (0-5) Scale: 0= No damage, 1= Tuber damage from 1-20 per cent, 2 =Tuber damage from 21-40 per cent, 3=Tuber damage from 41-60 per cent, 4= Tuber damage from 61-80 per cent and 5= Tuber damage above 81 per cent.

Data expressed as Mean ± SE

Observations on per cent good tubers recorded at Kunzer (Baramulla) (Table-24) revealed that Imidacloprid (seed treatment) provide the most effective control of white grub by exhibiting 97.33 per cent good tubers that differ significantly with the *B. thuringiensis* which resulted 94.00 per cent good tubers. However, *M. anisopliae and B. bassiana* were statistically on par yielding 90.66 and 89.33 per cent good tubers, respectively. Cultural practices and Neem cake were statistically on par yielding 80.66 and 80.00 per cent good tubers, respectively. Treatments like Phalada-111 C1 and Mustard cake resulted 76.66 and 76.00 per cent good tubers, respectively against Control (untreated) recording 74.66 per cent good tubers.

Similar observations were recorded at Budnambal location of district Kupwara during the year 2012 (Table-25) which suggested that Imidacloprid (seed treatment) is effective control measure recording 96.66 per cent good tubers which differ significantly with the *B. thuringiensis* which resulted 93.33 per cent good tubers. Bioagents like *M. anisopliae* and *B. bassiana* were statistically on par resulting 91.33 and 90.00 per cent good tubers, respectively. Cultural practices and Neem cake were statistically on par yielding 84.00 and 83.33 per cent good tubers, respectively. However, treatments like Phalada-111 C1 and Mustard cake exhibited 77.33 and 76.66 per cent good tubers, respectively against Control (untreated) which yielded 75.33 per cent good tubers, which were statistically on par.

At Ajas location of Bandipora district, similar performances were recorded (Table-26) in which Imidacloprid (seed treatment) was the most effective yielding 96.66 per cent good tubers differing significantly with *B. thuringiensis* which yielded 93.33 per cent good tubers. Treatment like *M. anisopliae* and *B. bassiana* resulted in 91.33 and 88.66 per cent good tubers which statistically differ from each other. Cultural practices and Neem cake exhibited 79.33 and 78.66 per cent good tubers and were statistically on par. However, Phalada-111 C1 and Mustard cake yielded 77.33 and 76.66 per cent good tubers,

Table-24 : Management of white grub by using different pesticides/cultural practices at Kunzer (Baramulla) on potato crop during 2012

Treatment	Pesticide\Cultural	Trade name	Concentration/quantity	*Per cent good tubers
T_1	Imidacloprid	Gaucho 70%WS	3 mg/kg seed	97.33 (80.59)e
T_2	*Beauveria bassiana*	Daman	5 g/litre of water	89.33 (70.93)c
T_3	*Metarrhizium anisopliae*	Kalichakara	5 g/litre of water	90.66 (72.20)c
T_4	*Bacillus thuringiensis*	Doom	3 g/litre of water	94.00 (75.82)d
T_5	Phalada-111 C1	Phalada-111 C1	1 ml/litre of water	76.66 (61.11)a
T_6	*Azadirachta indica*	Neem cake (Indigenous)	300 kg/ha	80.00 (63.43)b
T_7	*Brassica species*	Mustard cake (Local)	300 kg/ha	76.00 (60.66)a
T_8	Cultural practices	Deep ploughing, vermi-compost @ 200kg/ha, hoeing, mass collection of beetles at dusk on light traps/ host trees		80.66 (63.91)b
T_9	Control (untreated)	-	-	74.66 (59.77)a
		CD ($p \leq 0.05$)		**3.06**

*Data based on mean of three replications each

No. of tubers examined 50

Values in parenthesis are Arcsine transformed values

Table-25 : Management of white grub by using different pesticides/cultural practices at Budnambal (Kupwara) on potato crop during 2012

Treatment	Pesticide\Cultural	Trade name	Concentration/quantity	*Per cent good tubers
T_1	Imidacloprid	Gaucho 70%WS	3 mg/kg seed	96.66 (79.47)e
T_2	*Beauveria bassiana*	Daman	5 g/litre of water	90.00 (71.56)c
T_3	*Metarrhizium anisopliae*	Kalichakara	5 g/litre of water	91.33 (72.87)c
T_4	*Bacillus thuringiensis*	Doom	3 g/litre of water	93.33 (75.03)d
T_5	Phalada-111 C1	Phalada-111 C1	1 ml/litre of water	77.33 (61.56)a
T_6	*Azadirachta indica*	Neem cake (Indigenous)	300 kg/ha	83.33 (65.90)b
T_7	*Brassica species*	Mustard cake (Local)	300 kg/ha	76.66 (61.11)a
T_8	Cultural practices	Deep ploughing, vermi-compost @ 200kg/ha, hoeing, mass collection of beetles at dusk on light traps/ host trees		84.00 (66.42)b
T_9	Control (untreated)	-	-	75.33 (60.21)a
		CD ($p \leq 0.05$)		**2.05**

*Data based on mean of three replications each

No. of tubers examined 50

Values in parenthesis are Arcsine transformed values

Table-26 : Management of white grub by using different pesticides /cultural practices at Ajas (Bandipora) on potato crop during 2012

Treatment	Pesticide\Cultural	Trade name	Concentration/quantity	*Per cent good tubers
T_1	Imidacloprid	Gaucho 70%WS	3 mg/kg seed	96.66 (79.47)g
T_2	*Beauveria bassiana*	Daman	5 g/litre of water	88.66 (70.32)d
T_3	*Metarrhizium anisopliae*	Kalichakara	5 g/litre of water	91.33 (72.87)e
T_4	*Bacillus thuringiensis*	Doom	3 g/litre of water	93.33 (75.03)f
T_5	Phalada-111 C1	Phalada-111 C1	1 ml/litre of water	77.33 (61.56)b
T_6	*Azadirachta indica*	Neem cake (Indigenous)	300 kg/ha	78.66 (62.48)c
T_7	*Brassica species*	Mustard cake (Local)	300 kg/ha	76.66 (61.11)b
T_8	Cultural practices	Deep ploughing, vermi-compost @ 200kg/ha, hoeing, mass collection of beetles at dusk on light traps/ host trees		79.33 (62.95)c
T_9	Control (untreated)	-	-	74.66 (59.77)a
		CD ($p \leq 0.05$)		**1.99**

*Data based on mean of three replications each

No. of tubers examined 50

Values in parenthesis are Arcsine transformed values

respectively and were on par against Control (untreated) which yielded 74.66 per cent good tubers and differed significnatly with all treatments.

The overall performance as presented (Table-27) revealed that Imidacloprid as seed treatment proved to be most effective in yielding 96.88 per cent good tubers which was statistically different with *B. thuringiensis* resulting 93.55 per cent good tubers. However, *M. anisopliae* and *B. bassiana* yielding 91.10 and 89.33 per cent good tubers differ statistically with each other. Cultural practices and Neem cake yield 81.33 and 80.66 per cent good tubers, respectively and were statistically on par. Treatments like Phalada-111 C1 and Mustard cake resulted 77.10 and 76.44 per cent, respectively and were statistically on par with each other. Descending order for different pesticides/cultural practices on the basis of per cent good tuber were:

Imidacloprid (96.88%) > *B. thuringiensis* (93.55%) > *M. anisopliae* (91.10%) > *B. bassiana* (89.33%) > Cultural practices (81.33%) > *Azadirachta indica* (80.66%) > Phalada-111 C1 (77.10%) > *Brassica species* (76.44%) against control (74.88%).

Table-27 : Overall performances of different pesticides/cultural practices against white grub damaging potatoes in northern Kashmir during 2012

Treatment	Pesticide\Cultural	Trade name	Concentration/ quantity	*Per cent good tubers			Cumulative mean
				Kunzer	Budnambal	Ajas	
T_1	Imidacloprid	Gaucho 70%WS	3 mg/kg seed	97.33 (80.59)e	96.66 (79.47)e	96.66 (79.47)g	96.88 (79.84)g
T_2	*Beauveria bassiana*	Daman	5 g/litre of water	89.33 (70.93)c	90.00 (71.56)c	88.66 (70.32)d	89.33 (70.93)d
T_3	*Metarrhizium anisopliae*	Kalichakara	5 g/litre of water	90.66 (72.20)c	91.33 (72.87)c	91.33 (72.87)e	91.10 (72.64)e
T_4	*Bacillus thuringiensis*	Doom	3 g/litre of water	94.00 (75.82)d	93.33 (75.03)d	93.33 (75.03)f	93.55 (75.29)f
T_5	Phalada-111 C1	Phalada-111 C1	1 ml/litre of water	76.66 (61.11)a	77.33 (61.56)a	77.33 (61.56)b	77.10 (61.41)b
T_6	*Azadirachta indica*	Neem cake (Indigenous)	300 kg/ha	80.00 (63.43)b	83.33 65.90)b	78.66 (62.48)c	80.66 (63.91)c
T_7	*Brassica species*	Mustard cake (Local)	300 kg/ha	76.00 (60.66)a	76.66 (61.11)a	76.66 (61.11)b	76.44 (60.96)b
T_8	Cultural practices	Deep ploughing, vermi-compost @ 200kg/ha, hoeing, mass collection of beetles at dusk on light traps/host trees		80.66 (63.91)b	84.00 (66.42)b	79.33 (62.95)c	81.33 (64.42)c
T_9	Control (untreated)	-	-	74.66 (59.77)a	75.33 (60.21)a	74.66 (59.77)a	74.88 (59.91)a
CD ($p \leq 0.05$)				**3.06**	**2.05**	**1.99**	**1.45**

No. of tubers examined 50
Values in parenthesis are Arcsine transformed values.

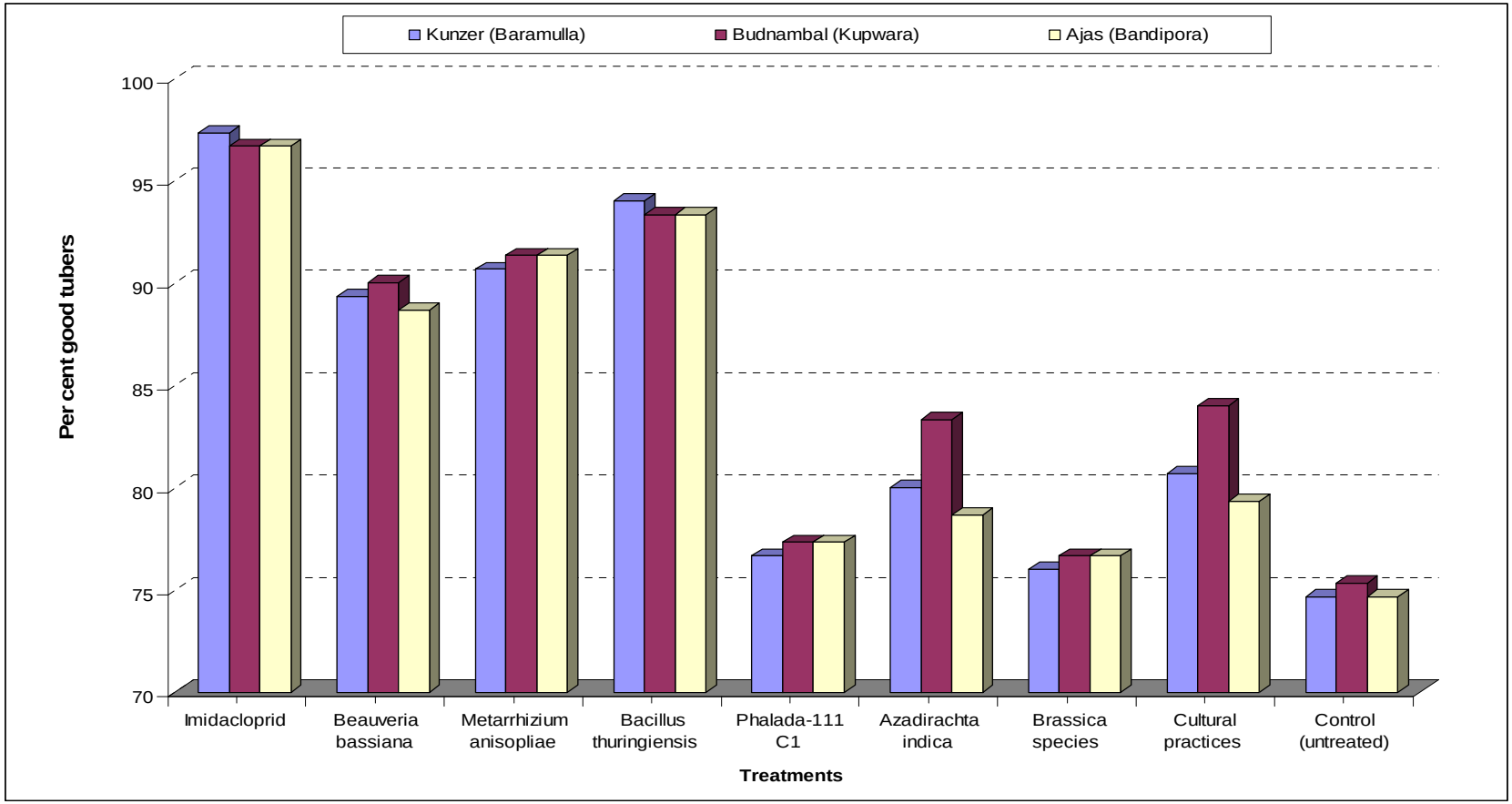


Fig. 12 : Performance of different pesticides/cultural practices against white grub in northern districts of Kashmir during 2012

Chapter – 5

DISCUSSION

The results of the present investigations "Pest complex of potato (*Solanum tuberosum* L.) with special reference to management of white grub in northern districts of Kashmir Valley" are discussed here in this Chapter.

5.1 Survey on pest complex of potato

Survey on pest complex of potato crop was carried out in two cropping seasons 2011 and 2012 at locations Pattan, Kunzer, Yarikhah (Baramulla district); Yonus, Handwara, Budnambal (Kupwara district) and Sumbal, Ajas, Gurez (Bandipora district). From survey a total of 12 pests were recorded infesting both above and below ground parts of potato plant right from sowing/germination upto harvest, including 7 insect pests which were identified as Flea beetle (*Chaetocnema* spp.), Semilooper (*Thysanoplusia orichalcea*), Aphid (*Macrosiphum euphorbiae*), Cutworm (*Agrotis ipsilon*), White grub (*Brahmina coriacea* and *B. poonensis*), Wireworm (*Melanotus horticornis*), Earwig (*Euborellia annulipes*) and 5 nematode genera were also found associated with the crop which were identified as Stunt nematode (*Tylenchorlynctus kashmiriensis* Mahajan), Lens nematode (*Basirolaimus indicus* Shamsi), Spiral nematode (*Helicotylenchus dihystera* Sher. and *H. indicus* Siddiqi), Root lesion nematode (*Pratylenchus* spp.) and Dagger nematode (*Xiphinema basiri* Siddiqi). Pests of potato were categorized into five groups based on the plant parts they damage.

Foliage feeder: Flea beetle (*Chaetocnema* spp. Stephans) and Semilooper (*Thysanoplusia orichalcea* Fabricus).

Foliage sucker: Aphid (*Macrosiphum euphorbiae* Thomas).

Collar feeder: Black Cutworm (*Agrotis ipsilon* Hufnagel).

Tuber feeder: White grub (*Brahmina coriacea* Hope and *B. poonensis* Frey), Wireworm (*Melanotus horticornis* Blyth) and Earwigs (*Euborellia annulipes* Lucas).

Nematodes: Stunt nematode (*Tylenchorlynctus kashmiriensis* Mahajan), Lens nematode (*Basirolaimus indicus* Shamsi), Spiral nematode (*Helicotylenchus dihystera* Sher. and *H. indicus* Siddiqi), Root lesion nematode (*Pratylenchus* spp.) and Dagger nematode (*Xiphinema basiri* Siddiqi).

The above findings are supported by Zaki and Masoodi (1990) who in there preliminary studies reported that potato crop is infested by 15 insect pests and 6 nematode genera. They further reported that cutworm, white grub, wireworm and spring tails are the important pests of the crop in central region of Kashmir. Khan *et al.* (2009) mentioned some major pests of potato in Kashmir Valley including spring tails (*Sinella curvista*), cutworm (*A. ipsilon*), white grub (*Brahmina coriacea* and *H. longipennis*), green peach aphid (*Myzus persicae*), root knot (*Meloidogyne hapla*) and root lesion nematode (*Pratylenchus* spp.) causing heavy yield losses in potato. These findings are also supported by Birtton (1918), Eden and Garrett (1955), Sharma and Bhalla (1964), Dorozhkin *et al.* (1975), Escalante (1975), Menschoy (1975), Butani and Verma (1976), Das (1988), Misra and Agrawal (1988), Singh (1990), Parihar *et al.* (1995), Nandhihalli *et al.* (1996), Peter (1996), Dharpure (2002a), Sing (2002), Chandel and Chandla (2003), Pandey (2007) and Chandel *et al.* (2013) who reported that the crop is infested by number of insect pests and nematodes while working on pest complex of potato in India and across the world which include flea beetle, colorado potato beetle, blister beetle, potato tuber moth, cutworm, wireworm, white grub, leaf eating caterpillar, termites, earwig, aphids, thrips, jassids, whiteflies, root knot nematode, spiral nematode, stunt nematode, root lesion nematode and cyst nematode. They further concluded that these pests damage potato plant by feeding on leaves, reducing photosynthetic area and efficiency by attacking stems, weakening plants and inhibiting nutrient transport which

ultimately affect the yield of crop and were classified into soil pests, sucking sap feeders, defoliators and storage pests.

5.2 Incidence of potato insect pests

5.2.1 Incidence of above ground insect pests

The present studies carried out during 2011 and 2012 revealed that above ground pests appeared in 1st to 2nd week of May and attains peak in June in plains and midhills. Whereas, at high hills the pests appeared by the end of May to 1st week of June with a peak incidence by end of June to 1st week of July. It is also evident from the data that overall incidence percentage of above ground insect pests, flea beetle recorded highest 57.77±2.22 at Yarikhah (Baramulla) and Budnambal (Kupwara) followed by 23.33±1.10 per cent incidence at Gurez (Bandipora). Whereas, lowest incidence percentage 11.66±0.55 was recorded at Pattan (Baramulla) which suggest that its incidence was high at high hills and low in plains and mid hills which is in close proximity with Vig and Markó (2004, 2005) who reported that incidence of flea beetle was high at high altitudes as attributed due to availability of secondary hosts as the particular genera (*Chaetocnema* spp.) was reported to be found on wide variety of habitats in forests and as well on field crops.

Semilooper recorded highest incidence percentage 12.77±1.66 at Kunzer (Baramulla) and lowest incidence percentage 7.77±1.10 at Sumbal (Bandipora). However the pest was completely absent at Budnambal (Kupwara) and Gurez (Bandipora) which may be attributed due to high elevation and difference in climate. These findings suggest that damage done by semilooper was evident at most locations which is similar to the findings that *Thysanoplusia orichalcea* (Fab) damages the soybean crop from August to September during kharif and March to May during *rabi* season and the infestation can result upto 30 per cent undeveloped pods and about 50 per cent yield loss. While as, in case of heavy

infestation caterpillars are also found to feed on flowers and pods (Anonymous, 2007).

Incidence percentage for cutworm was observed highest 7.21±0.55 at Ajas (Bandipora) and lowest 4.99±0.55 at Gurez (Bandipora) which suggest that the pest remains consistent at all locations in northern region of Kashmir valley. These findings are in close conformity with Das and Ram (1988) who reported that plant damage was first observed during the 3rd week of December and increased thereafter until the 2nd week of January and the tuber damaged was first observed during late December that increased thereafter till harvest. No larvae were observed in 1st week after harvest and from the 4th week of February until April; and larvae and pupae were found only on the following alternative host plants: *Chenopodium album, Solanum nigrum, Portulaca oleracea, Amaranthus viridis, Evolvulus alsinoides* and 2 unidentified weed species and Singh (1990) reported that use of undecomposed manure provide suitable hiding places to cutworm.

While as, aphids registered highest incidence percentage 15.77±0.21 at Pattan (Baramulla) and lowest 8.44±0.43 at Gurez (Bandipora). However, rest locations shared intermediate incidence percentage against each insect pest. These results suggest that although aphids occur but their incidence remains low which is supported by Verma *et al.* (1998) who reported that aphids appear approximately 35 days after planting on the potato crop and there low multiplication rates were due to low temperature. These findings are also is close proximity with Misra *et al.* (2003) who reported that in north western higher hills i.e., from Kashmir to Kumaon and in north eastern hills, the critical level aphids generally reaches by the end of July.

5.2.2 Incidence of below ground insect pest

Incidence of below ground insect pests revealed that these insect pests started their activity in last week of May to 2nd week of June with peak in July to

August in plains and midhills. Whereas, they first appeared in last week of June to 2nd week of July and attains peak towards the harvest of crop at higher hills in northern Kashmir. From the data it was evident that white grub registered highest incidence percentage 18.88±1.11, 14.44±1.10 and 14.44±1.10 at Budnambal (Kupwara), Kunzer (Baramulla) and Ajas (Bandipora), respectively, Whereas, Sumbal (Bandipora) registered lowest 7.77±1.10 per cent incidence. These findings suggest that white grub incidence varied location-wise which is in close conformity with the results obtained by Chandel *et al.* (1996) and Singh *et al.* (2003) who reported varied population of white grub in all surveyed locations of Garhwal hills and variation in grub population is likely to occur from one place to another that depends on temperature and rainfall. Mishra and Singh (1993) found that emergence of adult white grub began at the end of May and noted its peak in 2nd week of June. Eggs and 1st instar larvae were found during June- July with 2nd and 3rd instar larvae damaging tubers by the end of July and during mid-August, respectively. Chandla *et al.* (2001, 2003) reported that larvae of *B. coriacea* were present in the soil from July to April whereas, 3rd instar grub cause damage to potato tubers in September-October. They also reported that soil type (sandy loam with loose texture), lower elevation and weather factors (rains) favoured white grub activity.

Wireworm recorded highest 19.99±1.11 per cent incidence at Budnambal (Kupwara) and 5.55±1.10 as lowest incidence percentage at Ajas (Bandipora). However, the pest was not seen at Kunzer and Yarikhah locations in Baramulla district. Kamano and Mbata (2008) reported that incidence and severity of potato pests depends upon weather of region that sustains the development of these agents for crop losses.

Another below ground insect pest earwig registered 7.77±1.10 per cent incidence as highest at Pattan (Baramulla) and lowest 5.55±1.10 at other locations, except Kunzer and Yarikhah (Baramulla), Budnambal (Kupwara) and Gurez (Bandipora) were the crop was free from earwig damage. These findings

suggest that earwigs prefer plains were moisture in soils is adequate as they are moisture loving which is in agreement with Weems and Skelley (1998) who noted that earwig were eventually widespread in New England and middle Atlantic including western states, especially where there is abundant rainfall or irrigation that provides food and water.

5.3 Severity of potato insect pests

5.3.1 Severity of foliage feeding insect pests

Severity of foliage feeders indicated that these pests start their feeding activity from May and attain peak in June at Pattan (plain) and Kunzer (mid hill). Whereas at Yarikhah (high hill), flea beetle starts its feeding activity in May and semilooper in June with both attaining peak in July with mean per cent severity as highest (Scale-2) at Yarikhah and lowest (Scale-1) at Pattan for flea beetle While as, semilooper recorded highest (Scale-1) at Pattan and lowest (Scale-1) in Yarikhah of Baramulla district.

The results from Kupwara suggest that these pests start feeding activity from May and attain peak in June at Yonus (plain) and Handwara (mid hill). Whereas, at Budnambal (high hill), flea beetle starts its feeding activity in May attaining peak in July. Whereas, semilooper was absent at Budnambal. Per cent severity was highest (Scale-2) at Budnambal and lowest (Scale-1) at Yonus for flea beetle. However, semilooper registered the highest mean severity of infestation (Scale-1) at Yonus followed by Handwara (Scale-1) in Kupwara district.

Similarly, from district Bandipora these pests start feeding activity from May and attain peak in June at Sumbal and Ajas. Whereas, flea beetle starts its feeding activity in June attaining peak in July at Gurez and another pest semilooper was found absent at Gurez. The results recorded in Bandipora suggest that highest mean severity of infestation was recorded (Scale-1) at Gurez and (Scale-1) as lowest at Sumbal for flea beetle. However, semilooper recorded the

highest mean severity of infestation of (Scale-1) at Sumbal and lowest (Scale-1) at Ajas in Bandipora district.

The above findings are in close conformity with Jourdeuil (1963) who reported that *Chaetocnema concinna* overwinters as adults which emerge at the end of March and the beginning of April when the temperature is above 8–9°C in Europe. They search for appropriate host plants and the feeding of adult *C. concinna* is characterized by numerous small holes bordered by a narrow line of dead brown leaf parenchyma. Pernal, *et al.* (1996) reported that rainfall and temperature interfere with patterns of flea beetle injury; injury was concentrated on lower leaflets during weeks of greater rainfall and upper leaflets were injured most during weeks with higher average temperatures**.** They further concluded that flea beetles exhibit preferences for feeding in specific portions of potato plants and that these preferences change in response to previous defoliation and are influenced by meteorological conditions. Harish (2008) reported that green Semilooper, *Thysanoplusia orichalcea* neonate larvae feed on leaves by scratching the green matter, grownup larvae consumed entire leaves and the pest was noticed defoliating at vegetative stage of the crop. Maximum number of larvae recorded were 6.50, 6.20 and 8.60 larvae/m were noticed during 08-06-06, 27-06-06 and 08-07-06 dates of sowing, respectively on soybean crop.

5.3.2 Severity of foliage sucking insect pest

From the two consecutive year data, the highest mean severity percentage of the aphid 1.02±0.04 (Scale-1) was recorded at Yarikhah and 0.82±0.02 (Scale-1) as lowest at Kunzer in Baramulla district. However, the highest mean severity percentage of the aphid 1.14±0.02 (Scale-1) was recorded at Yonus and lowest of 1.01±0.03 (Scale-1) at Budnambal in district Kupwara. At Bandipora, Sumbal location receives the highest mean per cent severity of 1.08±0.009 (Scale-1) whereas, a lowest mean severity percentage of the aphid 0.89±0.02 (Scale-1) was recorded at Gurez location. The above findings suggest that severity index of the aphid was low at all nine locations in north Kashmir falling in Scale-1 which

indicates that aphids do less damage to potato crop. The present findings are in close proximity with Trivedi and Verma (1990) who reported that the aphid population was significantly different on 27, 38, 50 and 63 days crop and there was no significant differences in 63 and 69 day old crop. It clearly indicates that stages of crop and its new emerging leaves are having significant role on landing, settling and population build up of the aphid on potato in that region of India. Verma *et al*. (1998) reported that aphid *M. persicae* not serving as an efficient vector as there was lack of the virus source for PVY and PLRV in and around the seed crop under the prevailing conditions. However, Hooker *et al*. (1983) has listed *M. euphorbiae* as a minor pest of potato crop in Brazil.

5.3.3 Severity of collar feeding insect pests

From the present findings, it was noted that Pattan location having severity percentage of 5.00±0.56 as highest but 4.0±1.00 per cent as lowest at Yarikhah location in Baramulla district. Whereas, equal range of severity percentage 4.37±0.62 was recorded as highest at Yonus and Handwara locations and 3.50±0.49 as lowest at Budnambal location in Kupwara district. However, in Bandipora, Sumbal location receives high severity percentage of 5.62±0.62 whereas, Ajas and Gurez locations shared equal 4.37±0.62 per cent severity. These findings suggest that pest pressure was almost equal at all nine locations in north Kashmir which is supported by number workers Das (1988), Sing (2002) and Khan *et al.* (2009) who reported cutworm as a devastating pest that causes heavy losses in potato. Chandla and Chandel (2005) reported cutworm to be a major constraint in potato production in higher hills of Himachal Pradesh as polyphagous pests causing heavy damage and yield losses to many horticulture crops including potato.

5.3.4 Infestation of tuber feedings insect pests on white and red skinned potato tubers

Infestation percentage on number basis of tuber feeders on white and red peeled varieties in Baramulla district, revealed that white peeled variety exhibited

15.00±1.00, 19.00±1.00 and 15.00±1.00 per cent infestation by white grub at Pattan, Kunzer and Yarikhah, respectively. Whereas, red peeled variety recorded infestation percentage of 3.00±1.00 at each locations. Overall damage by wireworm on white and red peeled varieties was recorded only at Pattan location with infestation percentage 7.00±1.00 and 1.00±1.00, respectively on number basis. However, the pest was absent at Kunzer and Yarikhah locations. However, earwig showed per cent infestation 9.00±1.00 and 3.00±1.00 on number basis for white and red peeled varieties, respectively at Pattan and remained absent at Kunzer and Yarikhah locations in Baramulla district.

On weight basis, the overall infestation percentage on white peeled variety by white grub at Pattan, Kunzer and Yarikhah locations was recorded 14.22±1.48, 17.77±0.95 and 14.85±0.26, respectively. Whereas, red peeled variety recorded infestation percentage of 3.12±0.83, 3.25±0.97 and 3.34±1.04 at Pattan, Kunzer and Yarikhah locations, respectively by white grub. Wireworm damage on white and red peeled varieties was observed only at Pattan with infestation percentage 8.59±1.43 and 1.48±1.48, respectively. However, the pest was absent at Kunzer and Yarikhah locations of Baramulla district. Damage by earwig on weight basis was recorded only at Pattan location with per cent infestation 8.54±0.84 and 2.94±0.95 on white and red peeled varieties, respectively. While as, the pest was completely absent at Kunzer and Yarikhah locations in Baramulla district.

Infestation pooled percentage of tuber feeders on white and red peeled varieties revealed that white peeled variety exhibited 13.00±1.00, 13.00±1.00 and 19.00±1.00 per cent infestation by white grub on number basis at Yonus, Handwara and Budnambal, respectively. Whereas, red peeled variety observed 3.00±1.00, 3.00±1.00 and 5.00±1.00 per cent infestation at the respective locations. Infestation percentage by wireworm on white peeled variety was recorded 5.00±1.00, 5.00±1.00 and 20.00±2.00 on number basis at Yonus, Handwara and Budnambal, respectively. Whereas, red peeled variety found to have 2.00±0.00, 2.00±0.00 and 7.00±1.00 per cent infestation at Yonus,

Handwara and Budnambal, respectively. Earwig, showed pooled infestation percentage of 9.00±1.00 each on number basis at Yonus and Handwara on white peeled varieties and remained absent at Budnambal location. Whereas, red peeled variety observed 5.00±1.00 and 3.00±1.00 per cent infestation at Yonus and Handwara, respectively on number basis and was completely absent at Budnambal location in Kupwara district.

On weight basis, overall pooled infestation percentage recorded on white peeled variety by white grub at Yonus, Handwara and Budnambal locations was 11.99±0.78, 12.63±0.48 and 18.00±1.23, respectively. Whereas, red peeled variety recorded per cent infestation of 3.26±0.99, 2.94±0.74 and 5.14±1.02 at Yonus, Handwara and Budnambal locations, respectively. Infestation percentage by wireworm on white peeled variety was noted 6.18±1.07, 6.05±1.12 and 21.17±2.48 at Yonus, Handwara and Budnambal, respectively. Whereas, red peeled variety recorded 2.71±0.12, 2.47±0.08 and 7.95±0.68 per cent infestation at Yonus, Handwara and Budnambal, respectively. Earwig showed infestation percentage of 8.62±0.57 and 7.75±0.68 at Yonus and Handwara, respectively on white peeled varieties and remained absent at Budnambal location. Whereas, red peeled variety recorded 5.05±0.49 and 2.94±1.28 per cent infestation at Yonus and Handwara, respectively on weight basis and were completely absent in both the years at Budnambal location in Kupwara district.

Infestation pooled percentage of tuber feeders on white and red peeled varieties during 2011 and 2012 in Bandipora district revealed that white peeled variety exhibited 13.00±1.00, 17.00±1.00 and 13.00±1.00 per cent infestation by white grub on number basis at Sumbal, Ajas and Gurez, respectively. Whereas, red peeled variety recorded 3.00±1.00 infestation percentage each at respective locations. Infestation percentage by wireworm on white peeled variety was recorded 7.00±1.00, 7.00±1.00 and 5.00±1.00 on number basis at Sumbal, Ajas and Gurez, respectively. Whereas, red peeled variety recorded 1.00±1.00, 3.00±1.00 and 1.00±1.00 per cent infestation at Sumbal, Ajas and Gurez,

respectively. Another insect pest earwig, showed pooled infestation percentage 11.00±1.00 and 9.00±1.00 on number basis at Sumbal and Ajas locations, respectively on white peeled varieties and remained absent at Gurez location. Whereas, red peeled variety recorded 3.00±1.00 per cent infestation each at Sumbal and Ajas locations on the number basis and was completely absent in both the years at Gurez location in Bandipora district.

On weight basis, pooled infestation percentage recorded on white peeled variety by white grub at Sumbal, Ajas and Gurez locations was 12.26±0.36, 18.49±1.19 and 13.17±1.00, respectively. Whereas, red peeled variety recorded per cent infestation of 3.04±1.04, 3.48±1.13 and 3.24±0.97 at Sumbal, Ajas and Gurez locations, respectively. Infestation percentage by wireworm as a pooled on white peeled variety was recorded 8.37±0.24, 7.34±0.77 and 5.35±1.19 at Sumbal, Ajas and Gurez, respectively. Whereas, red peeled variety recorded 1.09±1.09, 3.70±1.19 and 1.19±1.19 per cent infestation at Sumbal, Ajas and Gurez, respectively. Earwig showed infestation percentage of 9.65±0.41 and 8.24±1.36 at Sumbal and Ajas, respectively on white peeled varieties and remained absent at Gurez location. Whereas, red peeled variety recorded 2.67±0.85 and 2.92±1.00 per cent infestation at Sumbal and Ajas, respectively on weight basis and were completely absent in both the years at Gurez location in Bandipora district.

The above findings suggest that white grub recorded the highest infestation percentage among the tuber feeding insect pests ranging from 2.94 to 19.00 infested tubers followed by earwig with infestation percentage ranging from 2.67 to 11.00 infested tubers. However, wireworm recorded lowest per cent infestation ranging from 1.00 to 8.59 at all nine locations in north Kashmir except Budnambal (Kupwara) were the pest registered highest 21.17 per cent infested tubers. These findings are in close conformity with Tyagi and Misra (1987) and Kumar (2004) who reported white grub as a major pest of potato in various parts of Himachal Pradesh. Mishra (1995) reported that *Holotrichia corciacea* was the predominant species in north-western hills of Himachal Pradesh. He further

reported that the damage to potato tubers ranged from 15.50 to 80.00 per cent (based on the weight of total and damaged potatoes). Khan *et al.* (2009) mentioned white grub (*Brahmina coriacea* and *H. longipennis*) as a major pest that causes heavy yield losses in potato. It was further noted that red peeled variety were highly resistant to tuber feeders compared to white peeled variety. This resistance in red peeled variety was believed due to hard flash and presence of glycoalkaloids especially liptines and commersonine (Sinden *et al.,* 1980).

5.3.5 Severity of tuber feedings insect pests on potato tubers

Mean severity of infestation by tuber feeders on potato during the year 2011 and 2012 at different locations of district Baramulla, Kupwara and Bandipora on final harvest revealed that severity percentage of 4.94±0.34, 4.78±0.29 and 4.38±0.17 was recorded as highest at Ajas (Bandipora), Budnambal (Kupwara) and Kunzer (Baramulla), respectively falling under Scale-1. Whereas, lowest severity 2.94±0.13, 3.32±0.19 and 3.41±0.29 was recorded at Sumbal (Bandipora), Yarikhah (Baramulla) and Yonus (Kupwara), respectively by white grub falling under Scale-1. Wireworm recorded severity percentage of 4.02±0.61 as highest at Budnambal (Kupwara) and 1.08±0.19 as lowest at Gurez (Bandipora) both falling under Scale-1. However, the pest was completely absent at Kunzer and Yarikhah locations in Baramulla district. Severity percentage by earwig was recorded highest 5.28±0.31 at Sumbal (Bandipora) whereas, lowest 3.48±0.03 per cent severity was recorded at Handwara (Kupwara) falling under Scale-1. However, the pest was completely absent at Kunzer and Yarikhah (Baramulla), Budnambal (Kupwara) and Gurez (Bandipora) locations. The damage level by wireworm was noted very low which may be because the pest is known to make narrow tunnels inside the potato tuber. These finding were supported by Singh *et al*. (2004) who reported that larvae of *H. longipennis* feed on live roots thereby plants show stunted growth, yellowing, wilting and drying up. They further observed significant symptoms of damage that were not observed on the apical parts of potato, although the tubers were severally damaged with the extent of

damage 5.67-65.16 and 4.96-62.92 per cent in high and mid hills, respectively but very high hills showed lower mean damage (2.28- 12.62%).

5.4 Management of white grub

White grubs were managed by using different treatments and their performances were calculated on the basis of per cent good tubers at final harvest as the criterion of pesticides/cultural practice efficacy at three locations in north Kashmir. Observations recorded at Kunzer (Baramulla) during the year 2012 on the basis of per cent good tubers suggest that Imidacloprid 70WS (seed treatment) exhibited maximum per cent good tubers 97.33 followed by *Bacillus thuringiensis* 94.00, *Metarrhizium anisopliae* 90.66, and *Beauveria bassiana* 89.33 per cent and were statistically on par. Treatments like Cultural practices and Neem cake showed intermediate performances and were statistically on par yielding 80.66 and 80.00 per cent good tubers, respectively. However, Phalada-111 C1, Mustard cake and Control (untreated) were on par recording lowest 76.66, 76.00 and 74.66 per cent good tubers, respectively.

Similar observations were recorded at Budnambal location of district Kupwara during the year 2012 which suggested that Imidacloprid 70WS as seed treatment is effective control measure, recording 96.66 per cent good tubers followed by *B. thuringiensis* 93.33, *M. anisopliae* 91.33 and *B. bassiana* 90.00 per cent and were statistically on par. Cultural practices and Neem cake were statistically on par yielding 84.00 and 83.33 per cent good tubers, respectively. Whereas, Phalada-111 C1, Mustard cake and Control (untreated) exhibited minimum 77.33, 76.66 and 75.33 per cent good tubers, respectively and were statistically on par.

At Ajas location of Bandipora district, similar performances were recorded in which Imidacloprid 70WS as seed treatment was the most effective treatment recording 96.66 per cent good tubers followed by *B. thuringiensis* 93.33, *M. anisopliae* 91.33 and *B. bassiana* 88.66 per cent good tubers and were statistically

on par. Cultural practices and Neem cake were statistically on par recording 79.33 and 78.66 per cent good tubers, respectively. Treatments like Phalada-111 C1, Mustard cake and Control (untreated) were statistically on par yielding minimum 77.33, 76.66 and 74.66 per cent good tubers, respectively.

The study indicated the descending order on performance basis of various pesticides/cultural practices based on per cent good tubers at final harvest as Imidacloprid > *B. thuringiensis* > *M. anisopliae* > *B. bassiana* > cultural practices > *Azadirachta indica* > Phalada-111 C1 > *Brassica species* > control (untreated).

Present findings are in line with the work conducted by Pawinska and Turska (1995), Sharma *et al*. (1998), Chandla and Chandel (2005, 2007), Chandel *et al.* (2005), Lucero *et al*. (2006), Yaginuma *et al.*(2006), Zaki *et al*. (2006, 2007), Keller and Schweizer (2007), Pozenel and Rot (2007), Wani (2009) and Chelvi *et al.* (2011) reported that imidacloprid was the effective control measure followed by bioagents for the control of white grubs infesting potato in India and other parts of the world.

Chapter – 6

SUMMARY AND CONCLUSION

Investigations on the "Pest complex of potato (*Solanum tuberosum* L.) with special reference to management of white grub in northern districts of Kashmir Valley" were carried out during the two cropping seasons of 2011 and 2012, at nine representative localities viz., Pattan, Kunzer and Yarikhah (Baramulla); Yonus, Handwara and Budnambal (Kupwara) and Sumbal, Ajas and Gurez (Bandipora) districts in north Kashmir. The findings and conclusions drawn are summarized here under:

For the pest complex of potato, the survey was conducted in northern districts of Kashmir valley. From survey a total of 12 pests including 7 insect pests and 5 nematode genera were found associated with the crop right from sowing/germination of potato seeds upto harvest which are Flea beetle (*Chaetocnema* spp.), Semilooper (*Thysanoplusia orichalcea*), Aphid (*Macrosiphum euphorbiae*), Cutworm (*Agrotis ipsilon*), White grub (*Brahmina coriacea* and *B. poonensis*), Wireworm (*Melanotus horticornis*), Earwig (*Euborellia annulipes*), Stunt nematode (*Tylenchorlynctus kashmiriensis* Mahajan), Lens nematode (*Basirolaimus indicus* Shamsi), Spiral nematode (*Helicotylenchus dihystera* Sher. and *H. indicus* Siddiqi), Root lesion nematode (*Pratylenchus* spp.) and Dagger nematode (*Xiphinema basiri* Siddiqi).

Incidence of above ground insect pests carried out during 2011 and 2012 revealed that above ground pests appeared in 1st to 2nd week of May and attained peak in June in plains and midhills. Whereas, at high hills the pests appeared by the end of May to 1st week of June with a peak incidence by end of June to 1st week of July. It is also evident from the data that overall incidence percentage of above ground insect pests of 57.77±2.22 was recorded to be highest at Yarikhah (Baramulla) and Budnambal (Kupwara) for flea beetle followed by 23.33±1.10 per cent incidence at Gurez (Bandipora). Whereas, the lowest incidence

percentage 11.66±0.55 was recorded at Pattan (Baramulla).Semilooper recorded its highest incidence percentage 12.77±1.66 at Kunzer (Baramulla) and lowest incidence percentage 7.77±1.10 at Sumbal (Bandipora). However the pest was completely absent at Budnambal (Kupwara) and Gurez (Bandipora). Incidence percentage for cutworm was observed highest 7.21±0.55 at Ajas (Bandipora) and lowest 4.99±0.55 at Gurez (Bandipora) which suggest that the pest remains consistent at all locations in northern region of Kashmir valley. While as, the aphid registered highest incidence percentage 15.77±0.21 at Pattan (Baramulla) and lowest 8.44±0.43 at Gurez (Bandipora). However, rest locations shared intermediate incidence percentage against each insect pest.

Incidence of below ground insect pests revealed that below ground insect pests started their activity in last week of May to 2nd week of June with peak in July to August in plains and midhills. Whereas, they first appear in last week of June to 2nd week of July and attains peak towards the harvest of crop at higher hills in northern Kashmir. From the data it was evident that white grub registered highest incidence percentage 18.88±1.11, 14.44±1.10 and 14.44±1.10 at Budnambal (Kupwara), Kunzer (Baramulla) and Ajas (Bandipora), respectively, Whereas, Sumbal (Bandipora) registered lowest 7.77±1.10 per cent incidence. Wireworm recorded highest 19.99±1.11 per cent incidence at Budnambal (Kupwara) and 5.55±1.10 as lowest incidence percentage at Ajas (Bandipora). However, the pest was not seen at Kunzer and Yarikhah locations in Baramulla district. Earwig registered 7.77±1.10 per cent incidence as highest at Pattan (Baramulla) and lowest 5.55±1.10 at other locations, except Kunzer and Yarikhah (Baramulla), Budnambal (Kupwara) and Gurez (Bandipora) were the crop was free from earwig damage.

Severity of foliage feeders indicated that these pests start their feeding activity from May and attained peak in June at Pattan (plain) and Kunzer (mid hill). Whereas at Yarikhah (high hill), flea beetle starts its feeding activity in May and semilooper in June with both attaining peak in July with mean per cent

severity as highest 20.56±0.49 (Scale-2) at Yarikhah and lowest 10.56±0.46 (Scale-1) at Pattan for flea beetle While as, semilooper recorded highest 15.26±0.17 (Scale-1) at Pattan and lowest 5.06±0.19 (Scale-1) in Yarikhah of Baramulla district. The results from Kupwara suggest that these pests start feeding activity from May and attained peak in June at Yonus (plain) and Handwara (mid hill). Whereas, at Budnambal (high hill), flea beetle starts its feeding activity in May attaining peak in July. Whereas, semilooper was absent at Budnambal. Per cent severity was highest 24.81±0.11 (Scale-2) at Budnambal and lowest 13.83±0.49 (Scale-1) at Yonus for flea beetle. However, semilooper registered the highest mean severity of infestation 14.20±0.03 (Scale-1) at Yonus followed by Handwara 11.03±0.62 (Scale-1) in Kupwara district. Similarly from district Bandipora, these pests start feeding activity from May and attained peak in June at Sumbal and Ajas. Whereas, flea beetle starts its feeding activity in June attaining peak in July at Gurez and another pest semilooper was found absent at Gurez. The results recorded in Bandipora suggest that highest mean severity of infestation was recorded 18.12±0.61 (Scale-1) at Gurez and 9.39±0.51 (Scale-1) as lowest at Sumbal for flea beetle. However, semilooper recorded the highest mean severity of infestation of 5.27±0.02 (Scale-1) at Sumbal and lowest 5.12±0.29 (Scale-1) at Ajas in Bandipora district.

From the two year data, the highest mean severity percentage of the aphid 1.02±0.04 (Scale-1) was recorded at Yarikhah and 0.82±0.02 (Scale-1) as lowest at Kunzer in Baramulla district. However, the highest mean severity percentage of the aphid 1.14±0.02 (Scale-1) was recorded at Yonus and lowest of 1.01±0.03 (Scale-1) at Budnambal in district Kupwara. At Bandipora, Sumbal location receives the highest mean per cent severity of 1.08±0.009 (Scale-1) whereas, a lowest mean severity percentage of the aphid 0.89±0.02 (Scale-1) was recorded at Gurez location.

Cutworm registered 5.0±0.56 per cent severity as highest at Pattan location and 4.0±1.00 per cent as lowest at Yarikhah location in Baramulla district.

Whereas, equal range of severity percentage 4.37±0.62 was recorded as highest at Yonus and Handwara locations and 3.5±0.49 as lowest at Budnambal location in Kupwara district. However, in Bandipora, Sumbal location receives high severity percentage of 5.62±0.62 whereas, Ajas and Gurez locations shared equal 4.37±0.62 per cent severity.

Infestation pooled percentage of tuber feeders on white and red peeled varieties in Baramulla district, revealed that white peeled variety exhibited 15.00±1.00, 19.00±1.00 and 15.00±1.00 per cent infestation by white grub on number basis at Pattan, Kunzer and Yarikhah, respectively. Whereas, red peeled variety recorded infestation percentage of 3.00±1.00 at each locations. Overall damage by wireworm on white and red peeled varieties was recorded only at Pattan location with infestation percentage 7.00±1.00 and 1.00±1.00, respectively on number basis. However, the pest was absent at Kunzer and Yarikhah locations. However, earwig showed per cent infestation of 9.00±1.00 and 3.00±1.00 on number basis for white and red peeled varieties, respectively at Pattan and remained absent at Kunzer and Yarikhah locations of Baramulla district.

On weight basis, the overall infestation percentage on white peeled variety by white grub at Pattan, Kunzer and Yarikhah locations was recorded 14.22±1.48, 17.77±0.95 and 14.85±0.26, respectively. Whereas, red peeled variety recorded infestation percentage of 3.12±0.83, 3.25±0.97 and 3.34±1.04 at Pattan, Kunzer and Yarikhah locations, respectively by white grub. Wireworm damage on white and red peeled varieties was observed only at Pattan with infestation percentage 8.59±1.43 and 1.48±1.48, respectively. However, the pest was absent at Kunzer and Yarikhah locations of Baramulla district. Damage by earwig on weight basis was recorded only at Pattan location with per cent infestation 8.54±0.84 and 2.94±0.95 on white and red peeled varieties, respectively. While as, the pest was completely absent at Kunzer and Yarikhah locations in Baramulla district.

Infestation pooled percentage of tuber feeders on white and red peeled varieties revealed that white peeled variety exhibited 13.00±1.00, 13.00±1.00 and

19.00±1.00 per cent infestation by white grub on number basis at Yonus, Handwara and Budnambal, respectively. Whereas, red peeled variety recorded 3.00±1.00, 3.00±1.00 and 5.00±1.00 per cent infestation at the respective locations. Infestation percentage by wireworm on white peeled variety was recorded 5.00±1.00, 5.00±1.00 and 20.00±2.00 on number basis at Yonus, Handwara and Budnambal, respectively. Whereas, red peeled variety recorded 2.00±0.00, 2.00±0.00 and 7.00±1.00 per cent infestation at Yonus, Handwara and Budnambal, respectively. The earwig, showed pooled infestation percentage 9.00±1.00 each on number basis at Yonus and Handwara on white peeled varieties and remained absent at Budnambal location. Whereas, red peeled variety recorded 5.00±1.00 and 3.00±1.00 per cent infestation at Yonus and Handwara, respectively on number basis and was completely absent at Budnambal location in Kupwara district.

On weight basis, overall pooled infestation percentage recorded on white peeled variety by white grub at Yonus, Handwara and Budnambal locations was 11.99±0.78, 12.63±0.48 and 18.00±1.23, respectively. Whereas, red peeled variety recorded per cent infestation 3.26±0.99, 2.94±0.74 and 5.14±1.02 at Yonus, Handwara and Budnambal locations, respectively. Infestation percentage by wireworm on white peeled variety was recorded 6.18±1.07, 6.05±1.12 and 21.17±2.48 at Yonus, Handwara and Budnambal, respectively. Whereas, red peeled variety recorded 2.71±0.12, 2.47±0.08 and 7.95±0.68 per cent infestation at Yonus, Handwara and Budnambal, respectively. Earwig showed infestation percentage 8.62±0.57 and 7.75±0.68 at Yonus and Handwara, respectively on white peeled varieties and remained absent at Budnambal location. Whereas, red peeled variety recorded 5.05±0.49 and 2.94±1.28 per cent infestation at Yonus and Handwara, respectively on weight basis and were completely absent in both the years at Budnambal location in Kupwara district.

Infestation pooled percentage of tuber feeders on white and red peeled varieties during the year 2011 and 2012 in Bandipora district revealed that white

peeled variety exhibited 13.00±1.00, 17.00±1.00 and 13.00±1.00 per cent infestation by white grub on number basis at Sumbal, Ajas and Gurez, respectively. Whereas, red peeled variety recorded 3.00±1.00 infestation percentage each at respective locations. Infestation percentage by wireworm on white peeled variety was recorded 7.00±1.00, 7.00±1.00 and 5.00±1.00 on number basis at Sumbal, Ajas and Gurez, respectively. Whereas, red peeled variety recorded 1.00±1.00, 3.00±1.00 and 1.00±1.00 per cent infestation at Sumbal, Ajas and Gurez, respectively. Another insect pest earwig, showed pooled infestation percentage 11.00±1.00 and 9.00±1.00 on number basis at Sumbal and Ajas locations, respectively on white peeled varieties and remained absent at Gurez location. Whereas, red peeled variety recorded 3.00±1.00 per cent infestation each at Sumbal and Ajas locations on the number basis and was completely absent in both the years at Gurez location in Bandipora district.

On the weight basis, pooled infestation percentage recorded on white peeled variety by white grub at Sumbal, Ajas and Gurez locations was 12.26±0.36, 18.49±1.19 and 13.17±1.00, respectively. Whereas, red peeled variety recorded per cent infestation of 3.04±1.04, 3.48±1.13 and 3.24±0.97 at Sumbal, Ajas and Gurez locations, respectively. Infestation percentage by wireworm as a pooled on white peeled variety was recorded 8.37±0.24, 7.34±0.77 and 5.35±1.19 at Sumbal, Ajas and Gurez, respectively. Whereas, red peeled variety recorded 1.09±1.09, 3.70±1.19 and 1.19±1.19 per cent infestation at Sumbal, Ajas and Gurez, respectively. Earwig showed infestation percentage of 9.65±0.41 and 8.24±1.36 at Sumbal and Ajas, respectively on white peeled varieties and remained absent at Gurez location. Whereas, red peeled variety recorded 2.67±0.85 and 2.92±1.00 per cent infestation at Sumbal and Ajas, respectively on the weight basis and were not found in both the years at Gurez location in Bandipora district.

Mean severity of infestation by tuber feeders on potato for 2011 and 2012 at different locations of district Baramulla, Kupwara and Bandipora on final

harvest revealed that severity percentage 4.94±0.34, 4.78±0.29 and 4.38±0.17 was recorded as highest at Ajas (Bandipora), Budnambal (Kupwara) and Kunzer (Baramulla), respectively falling in Scale-1. Whereas, lowest severity 2.94±0.13, 3.32±0.19 and 3.41±0.29 was recorded at Sumbal (Bandipora), Yarikhah (Baramulla) and Yonus (Kupwara), respectively by white grub falling in Scale-1. Wireworm recorded severity percentage 4.02±0.61 as highest at Budnambal (Kupwara) and 1.08±0.19 as lowest at Gurez (Bandipora) both falling in Scale-1. However, the pest was not observed at Kunzer and Yarikhah locations in Baramulla district. Severity percentage by earwig was recorded highest 5.28±0.31 at Sumbal (Bandipora) whereas, lowest 3.48±0.03 per cent severity was recorded at Handwara (Kupwara) falling in Scale-1. However, the pest was completely absent at Kunzer and Yarikhah (Baramulla), Budnambal (Kupwara) and Gurez (Bandipora) locations.

White grubs were managed by using different treatments and their performances were calculated on the basis of per cent good tubers at final harvest as the criterion of pesticides/cultural practices efficacy at three locations in north Kashmir during 2012. Observations recorded at Kunzer (Baramulla) during the year 2012 on the basis of per cent good tubers suggest that Imidacloprid 70WS as seed treatment exhibited maximum per cent good tubers 97.33 followed by *Bacillus thuringiensis* 94.00, *Metarrhizium anisopliae* 90.66, and *Beauveria bassiana* 89.33 per cent which were statistically on par. Treatments like Cultural practices and Neem cake were statistically on par showed intermediate performances with 80.66 and 80.00 per cent good tubers, respectively. However, Phalada-111 C1, Mustard cake and Control (untreated) were statistically on par yielding 76.66, 76.00 and 74.66 per cent good tubers, respectively. Similar observations were recorded at Budnambal location of district Kupwara during the year 2012 which suggested that Imidacloprid 70WS (seed treatment) was effective control measure recording 96.66 per cent good tubers followed by *B. thuringiensis* 93.33, *M. anisopliae* 91.33 and *B. bassiana* 90.00 per cent and were statistically

on par. Cultural practices and Neem cake were statistically on par recording 84.00 and 83.33 per cent good tubers, respectively. Whereas, Phalada-111 C1, Mustard cake and Control (untreated) were on par yielding 77.33, 76.66 and 75.33 per cent good tubers. Ajas location of Bandipora district, recorded similar performances in which Imidacloprid 70WS as seed treatment was the most effective treatment recording 96.66 per cent good tubers followed by *B. thuringiensis* 93.33, *M. anisopliae* 91.33 and *B. bassiana* 88.66 per cent good tubers which were statistically on par. Cultural practices and Neem cake recorded 79.33 and 78.66 per cent good tubers, respectively and were statistically on par. Treatments like Phalada-111 C1, Mustard cake and Control (untreated) were statistically on par with 77.33, 76.66 and 74.66 per cent good tubers. The present study indicated the descending order on performance basis of various pesticides/cultural practices based on per cent good tubers at final harvest as Imidacloprid > *B. thuringiensis* > *M. anisopliae* > *B. bassiana* > cultural practices > *Azadirachta indica* > Phalada-111 C1 > *Brassica species* > control (untreated).

Conclusion

- A total of 12 pests comprising 7 insect and 5 nematode genera viz., flea beetle (*Chaetocnema* spp.), semilooper (*Thysanoplusia orichalcea*), Aphid (*Macrosiphum euphorbiae*), cutworm (*Agrotis ipsilon*), white grub (*Brahmina coriacea* and *B. poonensis*), wireworm (*Melanotus horticornis*), earwig (*Euborellia annulipes*), stunt nematode (*Tylenchorlynctus kashmiriensis* Mahajan), Lens nematode (*Basirolaimus indicus* Shamsi), spiral nematode (*Helicotylenchus dihystera* Sher. and *H. indicus* Siddiqi), root lesion nematode (*Pratylenchus* spp.) and dagger nematode (*Xiphinema basiri* Siddiqi) were associated with potato crop in northern districts of Kashmir valley.
- Some insect pests which were not been mentioned as pests of potato crop earlier in Kashmir valley have appeared to cause more damage on both the

above and below ground parts of the potato crop viz., flea beetle, semilooper as foliage feeders and Earwig as tuber feeder.

- Pests like aphid and wireworm, although present throughout the crop season but the status of their damage is negligible.
- Pests like white grub and cutworm are seemingly two major constraints in the successful cultivation of potato crop as were found to infest the crop at each location in north Kashmir.
- Below ground pests resulted in yield loss by rendering the damaged tubers unfit for marketing.
- For the management of white grub, seed treatment with imidacloprid followed by bioagents and cultural control practices provided better results on comparing with the untreated (control).

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***Original not seen**

Annexure – 1 : Fortnight incidence of potato insect pests at Pattan (Baramulla)

Year	Observation date	Flea beetle	Semilooper	Aphid	Cutworm	White grub	Wireworm	Earwig
2011	1st April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	16th April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st May	10.00	0.00	8.00	0.00	0.00	0.00	0.00
	16th May	10.00	10.00	20.00	30.00	0.00	0.00	0.00
	31st May	20.00	20.00	36.00	20.00	0.00	0.00	0.00
	15th June	40.00	40.00	48.00	10.00	20.00	20.00	0.00
	30th June	20.00	30.00	24.00	0.00	20.00	20.00	20.00
	15th July	10.00	0.00	4.00	0.00	40.00	20.00	40.00
	30th July	0.00	0.00	0.00	0.00	20.00	40.00	20.00
2012	2nd April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	17th April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2nd May	10.00	10.00	12.00	0.00	0.00	0.00	0.00
	17th May	20.00	20.00	28.00	20.00	0.00	0.00	0.00
	1st June	20.00	30.00	36.00	20.00	0.00	20.00	0.00
	16th June	30.00	30.00	40.00	10.00	20.00	20.00	0.00
	1st July	10.00	20.00	20.00	0.00	20.00	20.00	0.00
	16th July	0.00	0.00	8.00	0.00	20.00	20.00	20.00
	31st July	0.00	0.00	0.00	0.00	20.00	20.00	40.00

Data based on 10 random plants for foliage and collar feeder insects; 5 random plants with 25 leaves for foliage suckers and 5 random 30-30 cm^2 pits upto depth of 20cm for tuber feeders.

Annexure – 2 : Fortnight incidence of potato insect pests at Kunzer (Baramulla)

Year	Observation date	Flea beetle	Semilooper	Aphid	Cutworm	White grub	Wireworm	Earwig
2011	3rd April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	18th April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3rd May	0.00	0.00	8.00	0.00	0.00	0.00	0.00
	18th May	20.00	10.00	20.00	30.00	0.00	0.00	0.00
	2nd June	30.00	20.00	32.00	20.00	20.00	0.00	0.00
	17th June	50.00	50.00	36.00	10.00	20.00	0.00	0.00
	2nd July	10.00	20.00	16.00	0.00	40.00	0.00	0.00
	17th July	0.00	0.00	4.00	0.00	40.00	0.00	0.00
	1st August	0.00	0.00	0.00	0.00	20.00	0.00	0.00
2012	1st April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	16th April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1st May	0.00	0.00	4.00	0.00	0.00	0.00	0.00
	16th May	10.00	20.00	16.00	20.00	0.00	0.00	0.00
	31st May	30.00	40.00	28.00	20.00	20.00	0.00	0.00
	15th June	70.00	50.00	32.00	10.00	20.00	0.00	0.00
	30th June	10.00	20.00	24.00	0.00	20.00	0.00	0.00
	15th July	0.00	0.00	8.00	0.00	20.00	0.00	0.00
	30th July	0.00	0.00	0.00	0.00	40.00	0.00	0.00

Data based on 10 random plants for foliage and collar feeder insects; 5 random plants with 25 leaves for foliage suckers and 5 random 30-30 cm^2 pits upto depth of 20cm for tuber feeders.

Annexure – 3 : Fortnight incidence of potato insect pests at Yarikhah (Baramulla)

Year	Observation date	Flea beetle	Semilooper	Aphid	Cutworm	White grub	Wireworm	Earwig
2011	30th May	20.00	0.00	12.00	0.00	0.00	0.00	0.00
	14th June	60.00	0.00	28.00	30.00	0.00	0.00	0.00
	29th June	90.00	10.00	40.00	20.00	0.00	0.00	0.00
	14th July	100.00	30.00	16.00	10.00	0.00	0.00	0.00
	29th July	100.00	20.00	8.00	0.00	20.00	0.00	0.00
	13th August	90.00	10.00	8.00	0.00	20.00	0.00	0.00
	28th August	60.00	0.00	0.00	0.00	20.00	0.00	0.00
	12th September	20.00	0.00	0.00	0.00	20.00	0.00	0.00
	27th September	0.00	0.00	0.00	0.00	20.00	0.00	0.00
2012	28th May	10.00	0.00	8.00	10.00	0.00	0.00	0.00
	12th June	40.00	0.00	32.00	30.00	0.00	0.00	0.00
	27th June	70.00	10.00	44.00	10.00	0.00	0.00	0.00
	12th July	100.00	20.00	20.00	0.00	0.00	0.00	0.00
	27th July	100.00	40.00	12.00	0.00	0.00	0.00	0.00
	11th August	80.00	10.00	4.00	0.00	20.00	0.00	0.00
	26th August	70.00	0.00	0.00	0.00	20.00	0.00	0.00
	10th September	30.00	0.00	0.00	0.00	20.00	0.00	0.00
	25th September	0.00	0.00	0.00	0.00	20.00	0.00	0.00

Data based on 10 random plants for foliage and collar feeder insects; 5 random plants with 25 leaves for foliage suckers and 5 random 30-30 cm^2 pits upto depth of 20cm for tuber feeders.

Annexure – 4 : Fortnight incidence of potato insect pests at Yonus (Kupwara)

Year	Observation date	Flea beetle	Semilooper	Aphid	Cutworm	White grub	Wireworm	Earwig
2011	5th April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	20th April	0.00	0.00	4.00	0.00	0.00	0.00	0.00
	5th May	10.00	0.00	12.00	0.00	0.00	0.00	0.00
	20th May	20.00	0.00	20.00	20.00	0.00	0.00	0.00
	4th June	40.00	30.00	24.00	10.00	20.00	20.00	0.00
	19th June	70.00	50.00	36.00	10.00	20.00	20.00	0.00
	4th July	20.00	20.00	20.00	0.00	20.00	20.00	0.00
	19th July	0.00	0.00	8.00	0.00	20.00	20.00	20.00
	3rd August	0.00	0.00	0.00	0.00	20.00	20.00	20.00
2012	3rd April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	18th April	0.00	0.00	4.00	0.00	0.00	0.00	0.00
	3rd May	10.00	0.00	8.00	0.00	0.00	0.00	0.00
	18th May	20.00	0.00	28.00	30.00	0.00	0.00	0.00
	2nd June	30.00	20.00	28.00	20.00	0.00	0.00	0.00
	17th June	80.00	40.00	40.00	10.00	20.00	20.00	0.00
	2nd July	30.00	20.00	24.00	0.00	20.00	20.00	0.00
	17th July	0.00	0.00	8.00	0.00	20.00	20.00	40.00
	1st August	0.00	0.00	0.00	0.00	20.00	20.00	20.00

Data based on 10 random plants for foliage and collar feeder insects; 5 random plants with 25 leaves for foliage suckers and 5 random 30-30 cm^2 pits upto depth of 20cm for tuber feeders.

Annexure – 5 : Fortnight incidence of potato insect pests at Handwara (Kupwara)

Year	Observation date	Flea beetle	Semilooper	Aphid	Cutworm	White grub	Wireworm	Earwig
2011	6th April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	21st April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6th May	0.00	0.00	8.00	0.00	0.00	0.00	0.00
	21st May	30.00	0.00	16.00	20.00	0.00	0.00	0.00
	5th June	50.00	20.00	28.00	30.00	0.00	0.00	0.00
	20th June	60.00	40.00	40.00	10.00	20.00	20.00	0.00
	5th July	20.00	30.00	24.00	0.00	20.00	20.00	0.00
	20th July	0.00	0.00	8.00	0.00	20.00	20.00	40.00
	4th August	0.00	0.00	0.00	0.00	20.00	20.00	20.00
2012	5th April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	20th April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5th May	0.00	0.00	4.00	0.00	0.00	0.00	0.00
	20th May	20.00	0.00	16.00	10.00	0.00	0.00	0.00
	4th June	40.00	20.00	32.00	20.00	0.00	0.00	0.00
	19th June	60.00	40.00	44.00	20.00	20.00	20.00	0.00
	4th July	20.00	20.00	24.00	0.00	20.00	20.00	0.00
	19th July	0.00	0.00	8.00	0.00	40.00	40.00	20.00
	3rd August	0.00	0.00	0.00	0.00	20.00	20.00	20.00

Data based on 10 random plants for foliage and collar feeder insects; 5 random plants with 25 leaves for foliage suckers and 5 random 30-30 cm^2 pits upto depth of 20cm for tuber feeders.

Annexure – 6 : Fortnight incidence of potato insect pests at Budnambal (Kupwara)

Year	Observation date	Flea beetle	Semilooper	Aphid	Cutworm	White grub	Wireworm	Earwig
2011	28th May	20.00	0.00	0.00	0.00	0.00	0.00	0.00
	12th June	60.00	0.00	12.00	20.00	0.00	0.00	0.00
	27th June	80.00	0.00	20.00	30.00	20.00	20.00	0.00
	12th July	100.00	0.00	32.00	10.00	40.00	20.00	0.00
	27th July	100.00	0.00	16.00	0.00	20.00	20.00	0.00
	11th August	80.00	0.00	8.00	0.00	20.00	40.00	0.00
	26th August	40.00	0.00	4.00	0.00	40.00	40.00	0.00
	10th September	10.00	0.00	0.00	0.00	40.00	20.00	0.00
	25th September	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	30th May	30.00	0.00	0.00	0.00	0.00	0.00	0.00
	14th June	80.00	0.00	12.00	30.00	0.00	20.00	0.00
	29th June	90.00	0.00	24.00	10.00	20.00	20.00	0.00
	14th July	100.00	0.00	36.00	10.00	20.00	20.00	0.00
	29th July	100.00	0.00	20.00	0.00	20.00	40.00	0.00
	13th August	80.00	0.00	12.00	0.00	40.00	40.00	0.00
	28th August	60.00	0.00	8.00	0.00	40.00	40.00	0.00
	12th September	10.00	0.00	0.00	0.00	20.00	20.00	0.00
	27th September	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Data based on 10 random plants for foliage and collar feeder insects; 5 random plants with 25 leaves for foliage suckers and 5 random 30-30 cm^2 pits upto depth of 20cm for tuber feeders.

Annexure – 7 : Fortnight incidence of potato insect pests at Sumbal (Bandipora)

Year	Observation date	Flea beetle	Semilooper	Aphid	Cutworm	White grub	Wireworm	Earwig
2011	2nd April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	17th April	0.00	0.00	4.00	0.00	0.00	0.00	0.00
	2nd May	10.00	0.00	12.00	0.00	0.00	0.00	0.00
	17th May	30.00	0.00	16.00	20.00	0.00	0.00	0.00
	1st June	50.00	20.00	28.00	20.00	0.00	0.00	0.00
	16th June	60.00	30.00	36.00	10.00	0.00	20.00	0.00
	1st July	10.00	10.00	20.00	0.00	20.00	20.00	0.00
	16th July	0.00	0.00	8.00	0.00	20.00	20.00	20.00
	31st July	0.00	0.00	0.00	0.00	20.00	20.00	20.00
2012	4th April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	19th April	0.00	0.00	8.00	0.00	0.00	0.00	0.00
	4th May	10.00	0.00	12.00	0.00	0.00	0.00	0.00
	19th May	30.00	0.00	20.00	20.00	0.00	0.00	0.00
	3rd June	40.00	20.00	28.00	40.00	0.00	20.00	0.00
	18th June	50.00	40.00	32.00	0.00	0.00	0.00	0.00
	3rd July	10.00	20.00	16.00	0.00	20.00	20.00	0.00
	18th July	0.00	0.00	4.00	0.00	40.00	40.00	40.00
	2nd August	0.00	0.00	0.00	0.00	20.00	20.00	20.00

Data based on 10 random plants for foliage and collar feeder insects; 5 random plants with 25 leaves for foliage suckers and 5 random 30-30 cm^2 pits upto depth of 20cm for tuber feeders.

Annexure-8 : Fortnight incidence of potato insect pests at Ajas (Bandipora)

Year	Observation date	Flea beetle	Semilooper	Aphid	Cutworm	White grub	Wireworm	Earwig
2011	4th April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	19th April	0.00	0.00	4.00	0.00	0.00	0.00	0.00
	4th May	30.00	0.00	20.00	0.00	0.00	0.00	0.00
	19th May	50.00	0.00	28.00	20.00	0.00	0.00	0.00
	3rd June	70.00	30.00	40.00	20.00	0.00	0.00	0.00
	18th June	50.00	50.00	32.00	20.00	20.00	0.00	0.00
	3rd July	10.00	10.00	16.00	0.00	20.00	20.00	0.00
	18th July	0.00	0.00	4.00	0.00	40.00	20.00	20.00
	2nd August	0.00	0.00	0.00	0.00	40.00	0.00	20.00
2012	6th April	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	21st April	0.00	0.00	8.00	0.00	0.00	0.00	0.00
	6th May	10.00	0.00	24.00	0.00	0.00	0.00	0.00
	21st May	40.00	0.00	28.00	30.00	0.00	0.00	0.00
	5th June	50.00	20.00	36.00	20.00	0.00	0.00	0.00
	20th June	70.00	40.00	24.00	20.00	20.00	0.00	0.00
	5th July	20.00	20.00	8.00	0.00	40.00	20.00	20.00
	20th July	0.00	0.00	0.00	0.00	40.00	20.00	40.00
	4th August	0.00	0.00	0.00	0.00	40.00	20.00	0.00

Data based on 10 random plants for foliage and collar feeder insects; 5 random plants with 25 leaves for foliage suckers and 5 random 30-30 cm^2 pits upto depth of 20cm for tuber feeders.

Annexure – 9 : Fortnight incidence of potato insect pests at Gurez (Bandipora)

Year	Observation date	Flea beetle	Semilooper	Aphid	Cutworm	White grub	Wireworm	Earwig
2011	10th June	0.00	0.00	0.00	10.00	0.00	0.00	0.00
	25th June	20.00	0.00	8.00	20.00	0.00	0.00	0.00
	10th July	40.00	0.00	16.00	10.00	20.00	0.00	0.00
	25th July	70.00	0.00	28.00	0.00	0.00	20.00	0.00
	9th August	30.00	0.00	12.00	0.00	20.00	20.00	0.00
	24th August	20.00	0.00	4.00	0.00	20.00	40.00	0.00
	8th September	20.00	0.00	4.00	0.00	20.00	20.00	0.00
	23rd September	0.00	0.00	0.00	0.00	20.00	20.00	0.00
	8th October	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	8th June	0.00	0.00	0.00	10.00	0.00	0.00	0.00
	23th June	30.00	0.00	12.00	20.00	0.00	0.00	0.00
	8th July	50.00	0.00	16.00	20.00	0.00	20.00	0.00
	23rd July	80.00	0.00	24.00	0.00	0.00	20.00	0.00
	7th August	30.00	0.00	16.00	0.00	20.00	20.00	0.00
	22nd August	20.00	0.00	8.00	0.00	20.00	0.00	0.00
	6th September	10.00	0.00	4.00	0.00	40.00	20.00	0.00
	21st September	0.00	0.00	0.00	0.00	40.00	20.00	0.00
	6th October	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Data based on 10 random plants for foliage and collar feeder insects; 5 random plants with 25 leaves for foliage suckers and 5 random 30-30 cm^2 pits upto depth of 20cm for tuber feeders.

Sher-e-Kashmir
University of Agricultural Sciences & Technology of Kashmir
Division of Entomology, Shalimar Campus, Srinagar – 190 025

CERTIFICATE

Certified that all the corrections/amendments as suggested by External Examiner Prof. N.N. Singh, Professor-cum-Senior Scientist, Banaras Hindu University, Varnasi have been incorporated in the manuscript entitled **"Pest complex of potato (*Solanum tuberosum* L.) with special reference to management of white grub in northern districts of Kashmir Valley"** submitted by **Mr. Mohmmad Munib (Regd. No. 2010-296-D).**

Chairman
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