Journal of Agricultural Science; Vol. 8, No. 3; 2016
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

Pest Complex of Potato (*Solanum tuberosum* L.) with Special Reference to Management of White Grub in Northern Districts of Kashmir Valley

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Received: October 26, 2015 Accepted: January 18, 2016 Online Published: February 15, 2016

doi:10.5539/jas.v8n3p151 URL: http://dx.doi.org/10.5539/jas.v8n3p151

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 cropright 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). *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-111C1(77.10%) > Brassica species (76.44%) against control (74.88%).

1. Introduction

Potato, *Solanum tuberosum* L. the king of vegetables also known as white or Irish potato is a native of South America. As per literature it is the most important vegetable crop ranking fourth after rice, wheat and maize being a major staple food crop. 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 4th in terms of area and 3rd 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). 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).

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, white grub etc. while as nematode species, *Globodera* and *Meloidogyne* are among the nematodes that are also reported as endoparasitic on potato crop (Waliullah, 1992). Among the insect pests, white grubs of *Holotrichia* species belonging to soil pests have been noticed 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 2nd and 3rd instars grubs 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).

2. Materials and Methods

2.1 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:

Table 1. Study area

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

2.2 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.

2.3 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 (10 ml), acetic acid (1 ml) glycerol (3 ml) and water (100 ml) as hot fixative (Cobb, 1918; Christie & Perry, 1951). Roots of potato crop were examined under binocular at 40X in the economic laborarory/Nematology laboratory of Division of Entomology, SKUAST-K, Shalimar campus.

2.4 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:

Table 2. Treatments of white grub damaging potato

Treatments		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 at 200 kg/ha, hoeing, mass collection of beetles at dusk on light traps/host trees) were followed.	
T_9	Untreated check (control)	

2.5 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. Results and Discussion

3.1 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 to be 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*), (Figure 1) 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 3 and Figures 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).

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 3.

Table 3. 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).

Table 3. Continued

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)

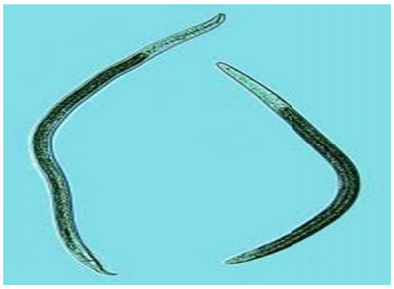
White grub (*Brahmina coriacea* Hope)

White grub (*Brahmina poonensis* Frey)

Wireworm (*Melanotus horticornis* Blyth)

Earwig (*Euborellia annulipes* Lucas)

Spiral nematode (*Helicotylenchus* spp.)



Stunt nematode (*Tylenchorhynchus* spp.)

Root lesion nematode (*Pratylenchus* spp.)

Dagger nematode (*Xiphinema* spp.)

Lens nematode (*Basirolaimus indicus*)

Figure 1. Pest complex of potato (*Solanum tuberosum* L.) in northern Kashmir

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), Sharma and Bhalla (1964), Escalante (1975), Butani and Verma (1976), Misra and Agrawal (1988), Parihar et al. (1995), 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.

3.2 Management of White Grub Infesting Potato

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.

Observations on per cent good tubers recorded at Kunzer (Baramulla) (Table 4) 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 5) 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 6) 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, respectively and were on par against Control (untreated) which yielded 74.66 per cent good tubers and differed significantly with all treatments.

The overall performance as presented (Table 7 and Figure 2) 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%).

Present findings are in line with the work conducted by Sharma et al. (1998), Chandla and Chandel (2005, 2007), Chandel et al. (2005), Zaki et al. (2006, 2007), Keller and Schweizer (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.

Table 4. 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 at 200 kg/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**			

Note. *Data based on mean of three replications each; No. of tubers examined 50; Values in parenthesis are Arcsine transformed values.

Table 5. 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 at 200 kg/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**			

Note. *Data based on mean of three replications each; No. of tubers examined 50; Values in parenthesis are Arcsine transformed values.

Table 6. 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 at 200 kg/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**			

Note. *Data based on mean of three replications each; No. of tubers examined 50; Values in parenthesis are Arcsine transformed values.

Table 7. 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 at 200 kg/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**

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

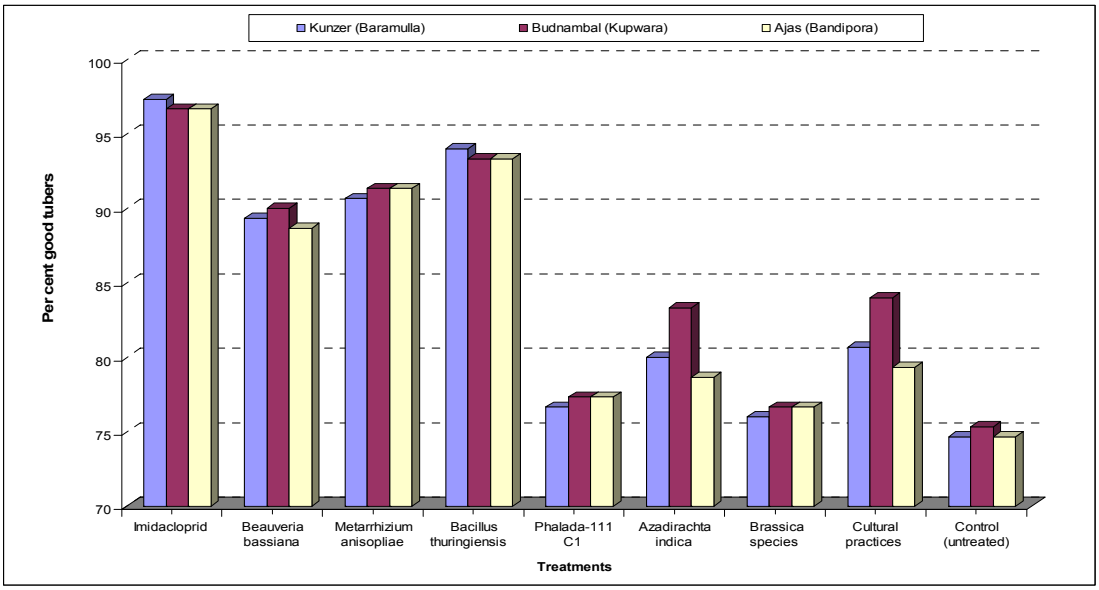


Figure 2. Performance of different pesticides/cultural practices against white grub in northern districts of Kashmir during 2012

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