Management options for white grub in apple and potato

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Introduction

Brahmina (*Lachnosterna, Holotrichia*) (Hope) 1839 (Coleoptera: Scarabaeidae: Melolonthinae) is a cosmopolitan genus with 127 known species worldwide. Among these, *Brahmina coriacea* (Hope) 1839 has been recorded from most of the northwestern Indian hills, occupying Himachal Pradesh (Chander et al., 1995); Uttarakhand (Singh et al., 2003; Dixit and Sharma, 2010) and Jammu and Kashmir (Bhat et al., 2005). The species has also been notified in Nepal (Thapa 2000; Ahrens, 2005) and Pakistan (Zahoor et al., 2003; Ratcliffe and Zubair, 2010). Being polyphagous, B. coriacea causes huge economic losses to large number of crops.

In hills of Shimla, Himachal Pradesh, *B. coriacea* constitutes 90% of total beetle population in apple orchards (Mehta et al., 2010; Pathania, 2014). It is highly polyphagous feed voraciously on variety of host plants (fruits/forest trees, their nurseries, vegetables, lawns and various field crops) in different part of country (Gupta et al., 1977; Chandel et al., 1994; Kumar et al., 2007). Chander and Singh (1985) reported the beetle as the major insect pest of potato and apple in higher hills.

Adult of the beetle after emergence in June, July feed on foliage of apple wild rose, walnut, apricot, Robinia and polygonum etc. of while grubs feed on roots and tubers. Third instar grubs are reported to cause maximum yield loss (Sharma and Bhalla, 1964). High economic loss and different feeding behavior of adult beetles and grubs necessitates integration of different tools viz., mechanical, chemical, cultural etc. for effective management of this pest (Singh et al., 2002).

Management of Adult beetles

Unlike other white grub species, whose adults mainly feed on wild crop, adult of *B. coriacea* feed on foliage of economically important crops like apple and potato which makes its management very crucial. Aggregation behavior of adult beetles on host foliage during night time can be effectively exploited to kill them by spraying foliage with insecticide.

Chemical control options recommended to farmers include spraying methyl parathion, carbaryl or monocrotophos (Chandel et al. 1994b; Chandla et al. 1988; Anonymous 2000) but these insecticide are going to be banned or going to be phased out. Dimethoate has been found to be extremely effective in potato in Himachal Pradesh (Anonymous, 2002). Chlorpyriphos 20EC @ 400g a.i/ha after mixing it with the sand should be applied at the time of first earthing up operation in potato crops (All India Project on Soil Arthropods pests). But care should be taken that there should be enough moisture in the soil so that it is translocated sufficiently to root zone where insect is actually present.

Manual collection of adult beetles during time of emergence and destruction helps in reducing egg laying and further population built up. Use of most preferred host as attractant crop or trap crop could be one of cultural method to control *B. coricea* (Veeresh, 1977). At Fagu in the Shimla, Himachal Pradesh, about one lakh beetles were collected using attractant crops like apple, apricot etc. and killed in an endemic area of about 20 ha of potato fields, and the pest was managed within 3 years of operation (Anonymous, 2004).

Management of grubs or larval stage

White grubs typically are controlled by applying a soil insecticide. During the 1970s and 1980s, long residual chlorinated insecticides like aldrin, DDT and heptachlor dusts were used for grub control (Singh, 1964; Pushkarnath, 1966; Rataul and Misra, 1979) but these fast-acting, persistent insecticides were restricted or banned for agricultural usage during the 1990s in response to the environmental concerns and the food safety. Currently among insecticides chlorpyriphos, phorate and carbofuran are widely used in potato.

Chandla et al. (1988) reported that the grubs of *B. coriacea* in potato fields can be controlled effectively by application of phorate 10G or carbofuran 3G at 2.5–3.0 kg a.i./ha in furrows at the time of planting but use of phorate is recently banned by Government of India. In mid-hills of Himachal Pradesh, soil drenching with chlorpyriphos at 5 kg a.i. /ha has been found to be effective resulting in 83.30–100.00% mortality of eggs and grubs of *B. coriacea* (Chandel et al.,1993). Further, Sharma and Chandla (2013) reported that combination of phorate 10G at 10 kg/ha at planting followed by spray of chlorpyriphos (0.1%) on ridges at earthing up in June resulted in 90% reduction in tuber damage. Recently studies in Shimla concluded that clothianidin 50 WDG to be more effective at a very low dose (120 g a.i./ha) than conventional granular insecticides like phorate and carbofuran. Chandel et al. (2008) dip treated seed size tubers in insecticide solution for 30 min and observed 80.1–93.6% control of B. coriacea grubs with chlorpyriphos (0.1%) and imidacloprid (0.05%).

Target weak link of insect life cycle

Weak links in insect life cycle is the time when particular insect stage is more susceptible to insecticides and other control strategies. Missing the appropriate treatment window can lead to little or no insect control. To obtain the best results, insecticide application should occur soon after adult emergence and should coincide with egg laying or egg hatching (Chandel et al., 2008). If the field has a history of whitegrub problem, a preventive treatment may be the best approach. Applying the preventive insecticide around the third week in June will have the insecticide in place when eggs begin to hatch.

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Cultural Management

There are certain cultural practices which are highly effective in suppressing whitegrubs. Chandel and Kashyap (1997) suggested that the best way to clean grubs out of a field is to pasture the land with pigs, as when pigs are allowed to forage on heavily infested land, they will usually root out and eat the grubs.

Crop rotation in potato with crops like clover and alfalfa reduce the *B. coriacea* population because of the fact that adults do not deposit eggs in clover and alfalfa unless there is a considerable admixture of grasses or other weeds (Chandel and Chandla, 2003).

In the summer crop of potato, especially in hilly states, the most critical period in the dynamics of the whitegrub infestation lies between August and September and timely harvest can avoid huge losses.

Biological control

Whitegrubs are naturally infested by various entomopathogenic fungi. *Metarhizium anisopliae* (Metsch.) and *Beauveria bassiana* (Bals.) when tested in combination with insecticides are reducing the whitegrubs population considerably in potato in Himachal Pradesh (Chandel and Mehta, 2005). Pathogenicity of *M. anisopliae* and *B. bassiana* is affected by soil temperature and water content. Infected beetles do not die for several days, so there is potential for auto-dissemination within populations.

Many entomopathogenic nematodes genera like *Steinernema carpocapsae* (Weiser), *Steinernema feltiae* (Filipjev), *Heterorhabditis indica* Poinar and *Heterorhabditis bacteriophora* Poinar can be effective biocontrol agents for controlling whitegrubs in potato. Soni et al. (2018) reported that *Beauveria brongniartii* (Saccardo) is considerably effective in managing this voracious pest because this particular species is native to the region and so sustain well in soil. They also found out that method of treatment (dip and oral feeding) did not affect susceptibility of *B. brongniartii* in different instars of B. coriacea, but the susceptibility of younger instars was marginally higher than older instars. Chandel et al. (2005) observed less *B. coriacea* grubs in *H. indica*-treated potato fields in Shimla. The efficacy of nematodes for grub control may be enhanced by using them in combination with certain insecticides. H. indica interacts synergistically with imidacloprid. Sluggishness of imidacloprid-treated grubs facilitates host attachment and subsequent penetration of infective juvenile nematodes.

Several species of predatory birds prey upon both the grubs as well as beetles. Amongst the avian predators, Indian myna (*Acridotheres tristis* L.) and jungle crow (*Corvus macrorhynchos* Wagler) are the major predators feeding on whitegrubs at the time of ploughing (Singh et al., 2003). Spotted owlet (*Athene brama*) settles on walnut trees during night and preys upon beetles (Mishra 2001a). These important predatory birds need to be conserved in the potato ecosystem and be exploited using appropriate management practices.

Integrated Pest Management (IPM)

As stated above integration of different pest management tools is crucial as individual efforts may not be very successful. Hence IPM practices for management of this pest can be as follows:

1. **Collection and Destruction of Adult Beetles:** The adult emergence is synchronous; thus, the collection and killing of beetles have been found to be one of the most effective techniques. This large scale beetle collection technique is cost effective and area wide mass campaign is effective in endemic area. Light trap, though a tool for population monitoring, can be used in reducing the population for this strongly phototactic species.
2. **Spraying Insecticides on the host Trees:** As like most of scarab beetle, B. coriacea after emergence congregate on preferred host plant for mating and feeding. These beetles can be conveniently killed by spraying the trees with insecticides. The beetles which settle on treated hosts would be killed before they return to the soil the next morning for egg laying.
3. **Exposing grubs of beetle:** Fields having a history of whitegrub attack should be tilled several times in April–May or in September. Tilling or discing soil macerates grubs and exposes them to predators such as birds.
4. **Use of Soil Insecticides:** The insecticides should be applied in endemic localities to bring down the population below the economic threshold level. The most effective insecticides are chlorpyriphos or phorate and are recommended for soil application against neonate tiny grubs. The older grubs are hard to control as they move deep into the soil, and the insecticides usually do not penetrate the soil well enough to kill the grubs.
5. **Biological Control:** Entomopathogenic fungi and nematodes can effectively combat the infestation of whitegrubs. Entomopathogenic fungi include M. anisopliae and B. bassiana, and usually, the fungi are used in combination with farm yard manure. The strains of nematodes which are available for field application are S. carpocapsae, S. feltiae, H. indica and H. bacteriophora but care should be taken that soil must be well soaked before applying nematodes as they need water for transport down to the root system.

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