Monograph No. 5

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WHITE GRUBS AND THEIR MANAGEMENT

By
S. K. PAL

CENTRAL ARID ZONE RESEARCH INSTITUTE
JODHPUR

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AND
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FOREWORD

In arid and semi-arid areas, crop productivity is generally limited by water availability. In order to improve crop yields, additional water supplies are arranged in these areas by various means including dugwells, tubewells and canals. It is generally realized that alongwith irrigation, other inputs like fertilizers, pesticides, herbicides and other improved practices have to be used for obtaining optimum results from the additional water supplies. Recently, there is appreciation for provision of drainage against water logging. But, generally it is not realized that the introduction of irrigation water in such areas, particularly the arid areas, influences environmental conditions and consequently, there appears a number of plant pests and diseases. It has been observed that white grubs under irrigated conditions seriously affect the productivity of not only the sown crops but also shrubs and trees. Recognizing the importance of this pest, Shri S. K. Pal, a Scientist of this Institute has studied this pest problem extensively. Besides fundamental studies of this pest, e.g., life cycle, practical recommendations for their control and management have also been evolved and the same have been summarized in this publication. It is hoped that this monograph will serve the intended purpose.

H. S. MANN
Director,
Central Arid Zone Research Institute,
Jodhpur (India)

PREFACE

White grub is a polyphagous and nefarious pest of specific significance as it adversely affects the economic status of the farmers. It has threatened the entire **Kharif** production in the country and especially in the arid and semi-arid regions. For over a decade, this pest has spread over a large area and has become almost a menace. Accordingly, it is evident that the problem is serious in nature and merits immediate attention of the research scientists for its effective control in the field conditions. Realising its importance, the ICAR has recently formulated a special group to study this problem and has decided to initiate a National Programme for Pest Management.

Scientists working at the Central Arid Zone Research Institute, Jodhpur have given due attention to this problem and have studied both the biology of the pest species and the various effective control measures to check white grubs as well as their adults. Scientific findings have revealed that for effective control of this pest, control measures are more effective on beetles than the grubs which have a peculiar behaviour and are difficult to control. Soil application of pesticides in heavy doses has been found to be expensive and also poses residue problem in the soil as well as in the plants. However, the pest can be managed effectively through an integrated approach and the details concerning the nature and extent of damage, behaviour of different species and the effective control measures are described in this monograph. The objective of this monograph is to collate the knowledge on this pest including its management.

It is expected that this monograph will prove to be of benefit to both the research scientists and extension workers.

S. K. PAL
Jr. Plant Protection Officer
Central Arid Zone Research Institute,
Jodhpur

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INTRODUCTION

WHITE GRUBS

White grubs are larvae of melolonthinae (Scarabaeidae : coleoptera) but the term includes larvae of Rutelinae, Dynastinae, Cetoniinae and other families of Scarabaeidea superfamily. A mature larva (Fig. 1) is soft bodied, fleshy creamy or dingy white in colour with brown head and body remains curved like an incomplete arc in the form of letter 'C'. The average length 38.6 mm and breadth across thorax is 7.6 mm in case of ***Holotrichia*** **consanguinea.** The true white grubs can be easily distinguished from similar looking grubs by the presence of two rows of minute hairs on the underside of the last segment. The hind part of the body is smooth and shiny with dark body contents showing through the skin.

The **Head** is large light brown and downwardly inclined, strongly sclerolized, smooth dorsally, having average width 6.7 mm. There are 4 segments in an antenna. Head, thorax and first five abdominal segments remain straight, rest of the body bends.

Mouth parts : The labrum is slightly asymmetrical, broader than long distal free margins hairy. Seven tactile setae present in each half of dorsal surface. The mandibles have a characteristic ventral process and most grubs of this family possess cribriform spiracles. The mandibles are powerful and exposed and the maxillae terminate either one or two lobes. **Thorax** is convex dorsally flat on ventral side. Spiracle present in prothorax, meso and metathorax devoid of spiracle, the three thoracic segments are short, bringing the legs closely together, coxa trochanter of each thoracic leg bear black dots. The legs are well developed but are rarely used for locomotion.

Abdomen : There are ten segments, dorsum of each of the first 8 segments divided into three folds. The folds of 7th and 8th very faint. Dorsum of ninth and tenth undivided. The later is indistinct in the posterior segments. The prothorax and first eight abdominal segments each have a pair of spiracles. Peculiarly arched body of the grubs with large and smooth apical segments facilitate active movements underground but render them incapable of locomotion above surface.

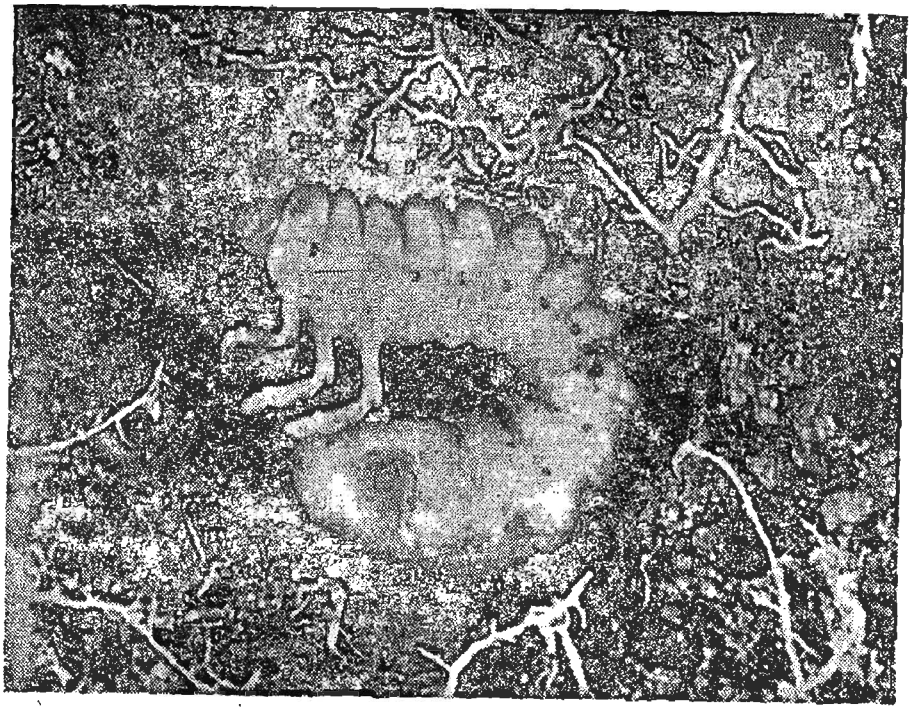

Fig. 1 Mature grub of Holotrichia

White grubs—Their national importance in agriculture

The adults of root grubs or white grubs are generally known as Chafers, May or June beetles all over the World and are of World wide occurrence.

White grubs are among the most destructive and troublesome of soil insects, threatening the entire crop production nullifying the gains of high yielding variety programme in the country.

White grubs have become a challenging subject for our farmers and scientists in various parts of the country. No crop is completely free from or resistant to the attack of these grubs. The loose soils with moderate to low rainfall provide favourable conditions for the survival and multiplication of these insects and they have become destructive particularly in parts of Rajasthan, Gujarat, Maharashtra, Karnataka and Bihar.

The pest is becoming more and more severe every year as they are spreading to regions where they had not been recorded as a pest in the past. In recent years in several states of Indian Union endemic grub pockets have developed (Table 1). The problem is of very serious nature and merit urgent attention for control. Until and unless concerted efforts or integrated pest control measures are made in endemic grub pockets, it would not be possible to suppress this menace.

Nature and extent of damage

The rainy season provides favourable conditions for grub attack. In case of severe infestation the entire plant stand is destroyed and sometimes the field needs resowing.

White grubs (Melolonthid larvae) feed underground on the roots of host plants, while the adult beetles are observed feeding on the foliage of certain other choice plants in the vicinity during the night. The damage done by grubs to Kharif crops is sometimes more than imagination. The losses inflicted to the various crops by this pest range between 40 and 80 per cent in endemic pockets.

Vasu (1970) recorded that 64.7% plants of Castor **(Ricinus communis)** were damaged and each plant harboured 2-14 grubs. The adults of **Orycetes rhinoceros** feed on palm leaves. The pest destroy the tissue at the leaf base and provide for the onset of decay. Coconut white grubs feed on the apical tender parts of the coconut roots especially around the bole region of palms. In case of severe attack, shedding of immature nuts results great loss to yield.

TABLE 1

Endemic grub Holotrichia spp. po ckets in various states of India

Name of the State	Endemic grub pockets	Area/ha affected and crop affected
Andhra Pradesh	Sandy soils Tracts of Gutty, Kalyandurg and Uravakonda taluks	500 ha (Groundnut, Jowar)
	Karnool Distt. (Dhone and Pattıkonda Taluks) Nizamabad Distt.	Sugarcane
Gujarat	Kaira, Mehsana, Sabarkantha and Banaskantha Distt.	2000 ha (Groundnut and cereal crops, Jowar)
Haryana		1000 ha Potato, Bajra, Maize
Karnataka	Distt. Mysore (Gundlupet, Nanjangud) Bangalore, Kolar and Belgaum Distt.	Figures not available
Kerala	Sandy loam tracts of Trivan_drum Alleppey, Quilon, Kottayam Calicut and Cannanore Distt.	Coconut, Tapoica, Sweetpotato and Sweetpotato
Maharashtra	Kaotha, Ratoli, Mugaon (Naded Distt.) Swargaon, Deolagnon Raja, Sindhkhed Raja (Buldhana Distt.) Kasbe digrus, Asthi (Sangli Distt.) Parbani and Osmanabond Distt.	54,000 ha Moong, Tur, Chillies, Bajra, Jowar, Paddy, Sugarcane, Groundnut
Punjab		300 ha Jowar, Bajra
Rajasthan	Lalsot, Didwana, Jodhpur and Pal_ Sawai Madhopur	7000 ha Groundnut, Sesamum, Maize, Jowar, Chillies, Bajra, Castor
Tamilnadu	Coimbatore Distt. North Arcot Distt.	Sugarcane Crop
Uttar Pradesh	Badaun, Moradabad Hardoi Unnao Rampur, Daurala (Distt. Meerut)	5000 ha Groundnut, Maize, Sugarcane, Bajra, Jowar

Tender roots of sprouting **Tapoica** cuttings are completely eaten up and thus causing the destruction of crop. Grubs feed on the fleshy portion of tubers and rhizomes of crops.

Veeresh (1974) recorded an unusual damage to guava trees (six to eight year old) due to white grubs. The developing grubs scrapped all the bark and thus caused the death of trees.

The retelid beetle (imagines) often devour the leaves and blossoms of roses and fruit trees and also eat away the fruits like peach, plum and apricot.

Srivastava (1971) reported that **Chiloloba acuta** (beetle) damage to the inflorescescens of **bajra** ear heads and feed gregariously on the anthers and stigma of **bajra** in large proportions.

Bhatnagar (1971) reported the occurrence of adult beetles of Dynastid beetle, **Pentodon bispinifrons.** Reitter damaging sugarcane shoots by burrowing in below the ground level.

Oxycetonia albopunctata F. feeds on leaves and flowers of rose, making the plant unsightly and this species also eats shoots and flowers (Chandra and Rai, 1967) recorded this species for the first time on **bajra** hybrid.

The species viz., **Rhinyptia meridionalis** and **R. laeviceps** (adult beetle) suck the milky juice of bajra ear head in the night (Pal and Sharma, 1973).

Rhinyptia laeviceps feeding on anther, stigma and grains in milky stage of bajra was also recorded (Yadava **et al.,** 1973).

Some beetles **Holotrichia longipennis, Anomala,** and **Adoretus** sp. and **Brahmina coriacea** belonging to this group do damage by eating semi-ripe fruits like apple, peach, palm and apricot in Himachal Pradesh and hilly areas of U.P. (Singh, 1964). The adult of Cetonidae beetles are mostly diurnal and cause damage to flowers and are of fruit eating habits like **Clinteria spilota.**

Other Chafer beetles viz., adults of **Schizonycha ruficollis** F. **Adoretus brachypygus** Burm. **A. duvavceli** Bl. and **Pachyrrhina-doretus frontatus** Burm. feed on grapevines **Vitis vinifera** during night (Batra **et al.,** 1973). In case of severe infestation, the entire vine may be defoliated. The adult congregate on the plants for feeding on foliage during night. Their damage is characterised by holes in the leaves.

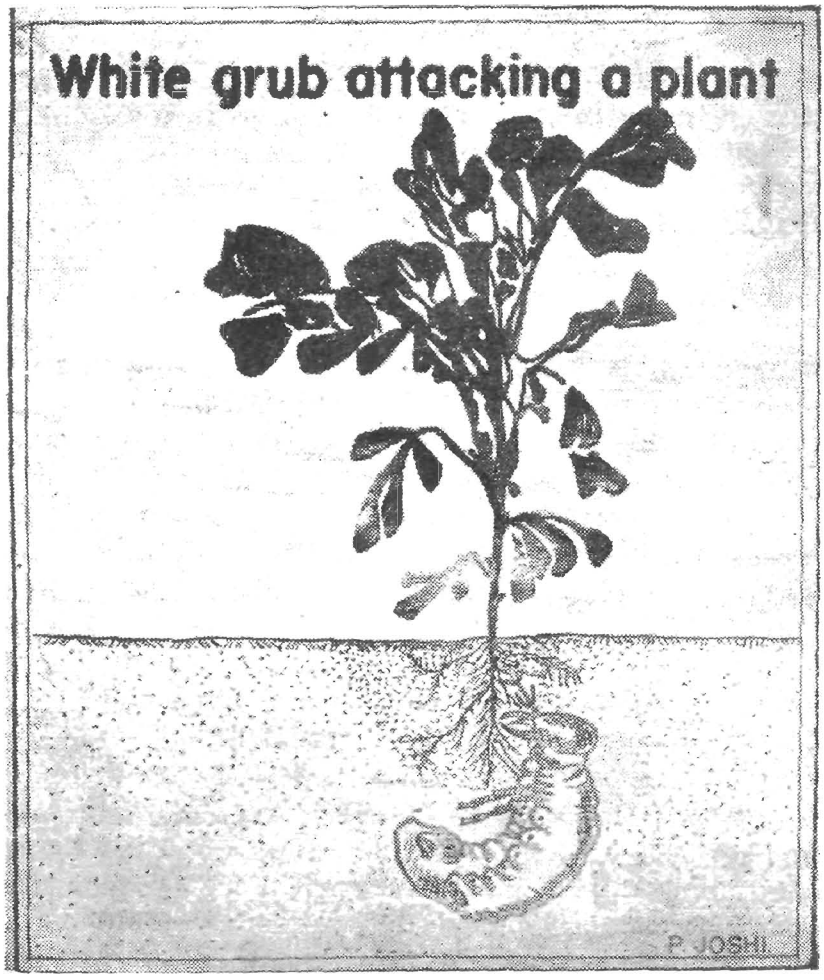

Fig. 2. White grub attacking a plant

Symptoms of Attack

The pest is subterrainian, the damage caused by this pest is not commonly noticed.

An attacked plant becomes pale, gives wilted appearance and finally dries which can easily be pulled out (Fig. 2). In heavy infestation, fields show patchy appearance due to withering of plants (Rai **et al.,** 1969).

The grubs eat away the nodules, fine root lets and girdle the main root of the leguminous crops. Due to this type of damage in groundnut plants which have a tap root system, are highly susceptible to grubs, attack whereas crops like **bajra, Pennisetum typhoides;** sorghum and maize, **Zea-mays** having adventious root system can withstand considerable grub population. Young plants on pulling from the soil come out easily with only tap root and devoid of tertiaries and seconderies.

The adult beetles feed on the leaves at night, first by making holes and later feed on the entire leaf leaving mid ribs only.

Host Plants for Grubs and Adult Beetles

A. Crops

Almost all the **Kharif** crops like jowar, bajra, maize, groundnut, chillies, potato, cotton, pulses, sugarcane, tobacco, brinjal, cucurbit, okra, cowpea, moong, grasses and sometimes early sown Rabi crops wheat and peas are attacked by the grubs.

B. Trees

Adults of various species of genus **Holotrichia** (white grub) are noctural feeders on the foliage of plants such as **Neem, Azadirachta indica,** Ber, **Zizyphus** spp. Khejri **Prosopis cineraria,** grapevine, **Vitis vinifera,** guava, **Psidium guajava** sonjana, **Moringa oleifera,** Mango **Mangifera indica,** Babul, **Acacia** spp. Jamun, **Eugenia jambolana,** phalsa, **Grewia asiatica,** Anar, **Punica granatum,** Karonda, **Carrisa carandas,** fig, **Ficus carica,** pipal, **Ficus religiosa,** gular, **Ficus glomerata** and other lac host trees.

The adults of different species have some preferred hosts like Neem, **Azadirachta indica (Holotrichia serrata** F.) drum stick, **Moringa**

oleifera (H. insularis) and tamarind, **Tamarindus indica (Schizonycha ruficollis).**

The major host plants of white grubs and adult beetles are predominant species of grubs in different states of our country are given below vide Table 2 & 3.

Work done in India

In India, interest in white grubs remained only of academic nature till 1956, when a serious grub attack identified as **Holotrichia consanguinea** Bl. in sugarcane was noted at Dalmianagar, Shahaband Bihar (Gupta and Avasthy, 1957). Since then a number of grubs have been recorded damaging other crops. Earlier **Leucophilis coneophora** Burm was recognized as an important pest to coconut in Kerala (Nirula **et al.,** 1952).

Since 1961, serious efforts were made by the State entomological laboratory, Jaipur (Rajasthan) to find out effective economic control measure to combat this noxious polyphagous pest. An intensive work on root grubs was initiated in the year 1969 in the University of Agricultural Sciences, Bangalore, to find out suitable solution to this national problem.

In Gujarat, the pest was first recorded during 1957 causing heavy damage to groundnut and jowar crops in Amreli distt.

Studies on white grubs were also initiated at CAZRI, Jodhpur since 1969 to ascertain the number of species of white grubs occurring in different bioclimatic zones of Western Rajasthan and to study their ecology and biology in detail. Control studies were also conducted to find out suitable insecticidal formulation their dosage mode of application.

A large-scale compaign was launched by the Marthwada Agricultural University at Ratoli village of Nanded district in Maharashtra during May to August 1974 and they achieved a greater success in controlling this menace on compaign basis.

TABLE 2

Major Host plants of white grubs in various states of India

State	Species	Host (grub)	Adult beetle
Andhra Pradesh	**Holotrichia serrata** F.	Tabacco, jowar groundnut	
Bihar	**Holotrichia serrata** F.		Guava, red gram, french bean
Gujarat	**Holotrichia consanguinea** Bl.	Groundnut	Neem
Haryana	**Lachnosterna fissa** Br. **Holotrichia insularis** Br. **Anomala** spp.	Bajra, Groundnut	Ber
Karnataka	**Holotrichia serrata** F.	Food crops, coffee and tobacco	Neem **(Azadirachta indica) Acacia arabica**, **Zizyphus jujuba**
Kerala	**Leucopholis coneophora** Burm.	Coconut, colocasia	
Maharashtra	**Holotrichia serrata** F.	Jowar	**Acacia arabica** and Neem
Punjab	**Schizonycha** sp. **Apogonia uniformis** Bl. **Anomala** spp.	Sweet potato	Adults defoliate bajra, rinjal, groundnut, sugarcane, guava, peach, phalsa and rukmanjii
Rajasthan	**Holotrichia consanguinea** Bl. **Holotrichia insularis** Br. **Anomala bengalensis** Bl. **Adoretus** spp. **Rhinyptia meridionalis** Arr. **Rhinyptia laeviceps** Arr.	Kharif crops viz., jowar, bajra, maize, chillies, groundnut, sugarcane	Ber, neem, khejri, karonda, sonjana, guava, babool, jamun, mehndi, gular, rose Adult beetle feed on nother stigma and grains in milky stage of bajra
Tamil Nadu	**Holotrichia serrata** F.	Sugarcane	**Azadirachta indica Ailanthus** spp **Dedonia** sp. guava and **sonjana**
Uttar Pradesh	**Holotrichia serrata** F.	Groundnut & sugarcane	Neem

TABLE 3

Predominant white grub species, various host in different states of India

States	Predominant species	Hosts
Andhra Pradesh	**H. consanguinea** Bl. ***H. serrata** F.	Tobacco, jowar and groundnut
Bihar	***H. consanguinea, *H. serrata, Anomala biharensis**	Sugarcane —do—
Delhi	**H. serrata** Fbr., **H. consanguinea**	Khas **(Vetiveria zizanioides** Castor)
Gujarat	***H. consanguinea, Schizonycha ruficollis, H. insularis**	Groundnut, jowar, bajra, maize, sugarcane, cotton
Haryana	**Lachosterna fissa**	Bajra and groundnut
Himachal Pradesh	***Holotrichia longipennis, Brahmina coriacea, Melolontha indica, Autoserica sp., Anomala sp.**	Paddy, maize, potato other millets apple and other fruits, temperate fruit plants
	Anomala spp., **Adoretus** spp.	Plum, walnut, peaches
Karnataka	***Holotrichia serrata** F.	Pulses, cereals, millets, oilseeds, vegetables, sugarcane, tobacco
	H. nilgria, Leucopholis coneophora Burm.	Coffee, areca
Kerala	***Leucopholis coneophora** Burm. **Anomala marginipennis**	Coconut Tapoica, yam, sweet potato
Maharashtra	**H. consanguinea, *H. serrata** F.	Jowar, bajra, wheat, groundnut, sugarcane all cultivated crops of Kharif and some Rabi crops
Orrisa	***Holotrichia serrata** F.	Various **Lac** hosts
Punjab	**Holotrichia consanguinea, H. insularis, Schizonycha ruficollis**	Sugarcane and other ornamental plants, sugarcane

States	Predominant species	Hosts
Rajasthan	***H. consanguinea*, *H. insularis Schizonycha ruficollis Anomala bengalensis, Aserica** spp., **Serica assamensis** Br.	Chillies, bajra, groundnut vegetable and napier grasses all Kharif crops. Fruits and ornamental plants, Forest nursery seedlings.
		Groundnut, bajra, chillies, napier grasses and vegetables apple, peaches and Roses.
Tamil Nadu	***H. serrata, H. consanguinea Anomala bengalensis**	Sugarcane
Uttar Pradesh	***H. consanguinea, H. serrata Schizonycha** spp., **Popillia** spp.	Groundnut, bajra, chillies, napier grasses and vegetables apple, peaches and Roses
West Bengal	**Alissonotum inpressicollae**	

*Status—serious

MAJOR WHITE GRUB SPECIES

Occurrence and their ecological distribution

Ecological evaluations made by Central Arid Zone Research Institute Jodhpur in this tract have established the occurrence, frequency and economic status of major species of Grubs Fig. 3. in relation to their distribution. The Coleopterans were found to be predominating whereas, family Scarabaeide (to which white grub belongs was found to be codominating Pal and Sachan, 1973). However, Pal (1976) stated that in Scarabaeid beetle trap catches over 1971-72, **Rhinyptia meridionalis** and **Schizonycha ruficollis** were dominating over others.

1. Holotrichia spp.

Though white grubs are distributed throughout the country but **Holotrichia serrata** is a major pest in States like Andhra Pradesh, Bihar, Karnataka, Maharashtra, Tamil Nadu and Uttar Pradesh and exhibits preference for sugarcane, Jowar, Groundnut, Tobacco and Coffee and also have Neem, **Azadirachta indica,** Ber, **Zizyphus jujuba, Acacia** as plants of choice for defoliation during night. Other dominant species are **H. consanguinea, H. insularis** causing havoc in Gujarat, Rajasthan **Leucopholis conecophorais** restricted to areca growing area; and **H. nilgiria** in coffee growing area respectively (Khan and Ghai, 1974).

Pal and Doval (1970) found that peak population density of grubs, **H. insularis** was found to be 61000/ha in the month of August and intensity of the pest was highest in localities where intensive farming is in practice with the use of FYM, sheep manure and irrigation facilities. The population of the grubs has been recorded behaving differently in the field under cropped area and field applied with heavy doses of F.Y.M. The grubs preferred sandy loam and river bed soil rather than black sticky soil or pebble soil. The grub population was appreciably high in areas of grass or weed zones. The **Holotrichia** sp. have assumed a menacing situation in about ten states the country, their endemic pockets area and crops affected are summarized in Table 1.

2. Anomala spp.

The species viz., **Anomala dorsalis, A. elata** and **A. biharensis** and **A. bengalensis** are of common occurrence in various states. In Rajasthan, **Anomala bengalensis** (Kharif crops), in Bihar, **A. biharensis,** in Kerala **A. marginipensis** (Tapoica and Yam) and in Himachal, **Anomala** spp. (temperature fruits) damaged considerably the hosts mentioned in brackets. The adult beetles defoliate the foliage of fruit and ornamental plants.

3. **Adoretus** spp.

The larvae occur in moist humus soil and in grasslands. The species commonly found in this group are: **Adoretus bicolor** in Andhra Pradesh damaging grapevines. **A. lasiopygus** in U.P. on guava and other fruits trees. **Adoretus** sp. in Himachal Pradesh cause damage to plum, walnut and peaches. The adults defoliate the foliage at night and when in large number skeletonise the leaves. The adult beetle emerge in the month from April to June in large proportions.

4. **Rhinyptia meridionalis and R. laeviceps**

These Rutelids are serious pest of **bajra** earheads occurring in all parts of Rajasthan. These suck the milky juice of bajra. The species are abundantly found during late September to October. The beetles prefer dark nights for their activity and 20-30 beetles are found on each earhead.

5. **Schizonycha ruficollis and S. fuscescens**

These species (adult beetle) attack fruit trees like citrus, guava and other plants namely Rose, **Rasa indica,** amaltas, **Cassia fistula, Prosopis cineraria,** Kachnar, **Bauhinia** spp. and temperate fruits viz., apple, peach and Falsa, **Grewia asiatica.** They have not been found from crop fields. Grubs of these are not of much economic importance. But **Schizonycha** grubs are reported to cause injury to young sorghum plants, **Dolichos** lablab. The beetles emerge from the soil during 2nd fortnight of June to July.

6. **Aserica** sp. and **Serica assamensis** Br.

These species have annual life cycle and beetles are found in top soil (15-20 cm). The grubs of these beetle damage the forest nursery seedlings (Pal, 1971) at 10-15 cm soil level and adult feed voraciously on **Prosopis cineraria** and **Acacia** spp. The grubs of these species attack the plants in early stage of growth when the root system in tender. Adults are not attracted much to the source of light.

7. **Autoserica insanabilis** Br.

The beetle of this species damage ornamental plants. The detailed biology has not been worked out.

8. **Schizonycha** spp.

This is serious pest of apple and other fruit in HP. A chart (Table 4) depicting taxonomic position of the mentioned species is appended.

TABLE 4

Taxonomic chart of white grub group

Order — COLEOPTERA

Family — Scarabaeidae

S.F. Melolonthidae (Cock chafers)	**S.F. Rutelinae**
Holotrichia insularis Br.	Anomala spp.
H. serrata F.	Anomala elata Fabr.
H. consanguinea Bl.	Anomala dorsalis var. fraterna F.
Holotrichia spp.	Anomala bengalensis Bl.
Schizonycha fuscescens Bl.	Adoretus spp.
S. spp. nuruficollis F	A. lasiopygus Burm.
Schizonycha sp.	
Aserica sp	Rhinyptia meridionalis Arr.
Serica assamensis Br.	R. laeviceps Arr.
Autoserica sp.	Mimela macleayana Vigors.
Autoserica insanabilis Br.	Pachyrrhinadoretus frontatus Burm.
Maladera insanabilis Br.	
Maladera sp.	
Apogonia sp.	
S. F. Cetontinae	**S.F. Dynastinae**
Protaetia sp.	Phyllognathus dionysius F.
P. peregrina Herbst.	Pentodon algerinum Herbst.
Oxycetonia versicolor Fbr.	Pentodon sp.
Clinteria sp.	Podalgus sp.

Major white grub species

1. **Holotrichia insularis** Br.
2. **Schizonycha ruficollis** F.
3. **Rhinyptia meridionalis** Arr.
4. **Adoretus lasiopygus** Burm.
5. **Serica assamensis** Br.
6. **Aserica** sp.

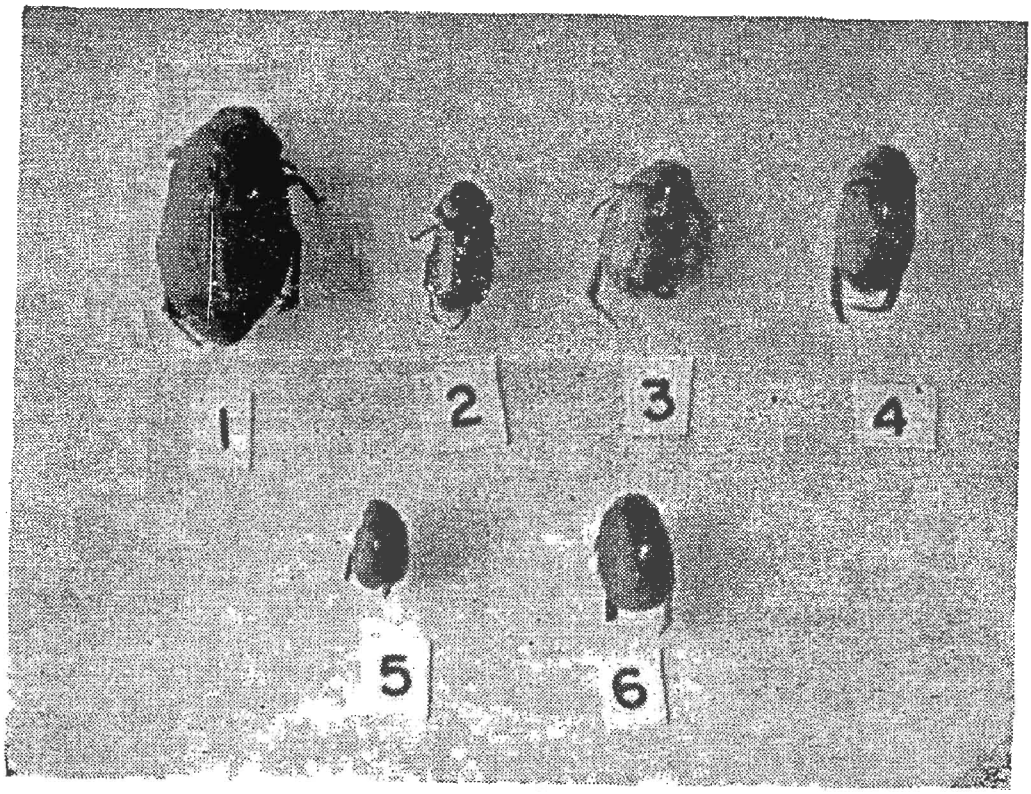

Fig. 3. Major white grub species

Salient features of Life cycle

The most widely destructive species of white grub in the Indian Sub-continent is **Holotrichia** spp. Nearly one hundred species of **Holotrichia** have been recorded from the various Zoogeographical parts of the country. The knowledge of biology and ecology of pest species is essential for devising efficient control measures.

In India, root grubs have one year life cycle (Fig. 4 & 5). The different species have similar pattern of life cycle but may vary according to the climatic factors, in their time of emergence, egg laying, active larval period, time of pupation not only in different parts of country but also at different places of the state.

The biology of **Holotrichia consanguinea** Bl. has been worked out in Gujarat State (Desai and Patel, 1965) and Patel **et al.** (1967), whereas in Rajasthan (Rai, **et al.,** 1969).

The life history of **H. nilgiria** Arv. has been studied by Venkataraman (1969) in Tamil Nadu and the biology of **H. insularis** was reported by Srivastava and Khan (1963), Pal and Doval (1970) from Rajasthan. The biology of **H. serrata** has been studied by Majumdar and Teotia (1965) in Bihar. Pal and Misra (1973) studied the biology of **Aserica** sp., an important pest of vegetables in W. Rajasthan.

Over-wintering adults are stimulated to activity from March to June when they emerge from the soil after a good shower of rain wether premonsoon or monsoon (Fig. 4). Mating takes place either on the day of emergence or after a feeding period of about a fortnight. The beetles emerge from the soil between 7.30 to 8 P.M. and immediately fly to their host plants almost in swarm and start feeding on the foliage. During this period, if the nearby host plants are sprayed with toxicants, good number of adults can be killed, or there emerging adults can be collected mechanically or through employing light traps. The eggs are laid usually during June-July when soil has been moistened by the rains. The adult beetles lay eggs either singly or in batches in soil upto the depth of 5 to 15 cm soil. The eggs are oval, creamy white.

The incubation period varied from 7 to 10 days. The eggs are oval, creamy white in colour. There are 3 grub instars of the pest **Holotrichia consanguinea** Bl. the mean body length and width are 11.73 mm and 2.91 for 1st instar, 17.88 mm and 4.73 mm for the second instar and 32.23 mm and 7.71 mm respectively for third instar. The 2nd and

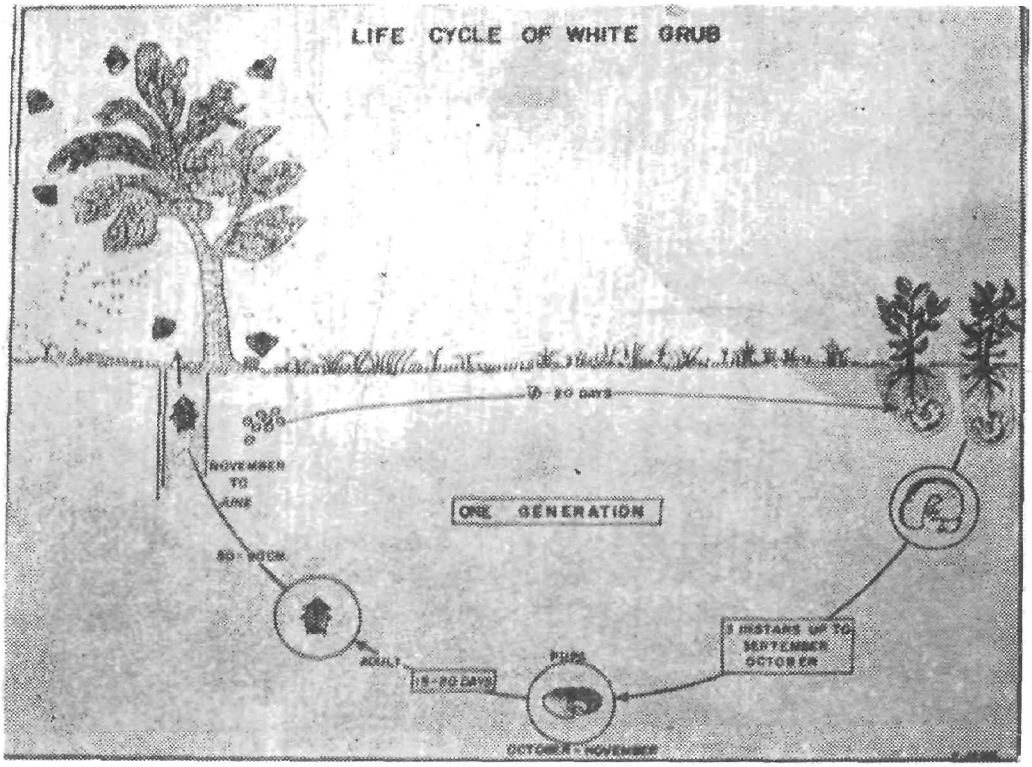

Fig. 4. Life cycle of white grub

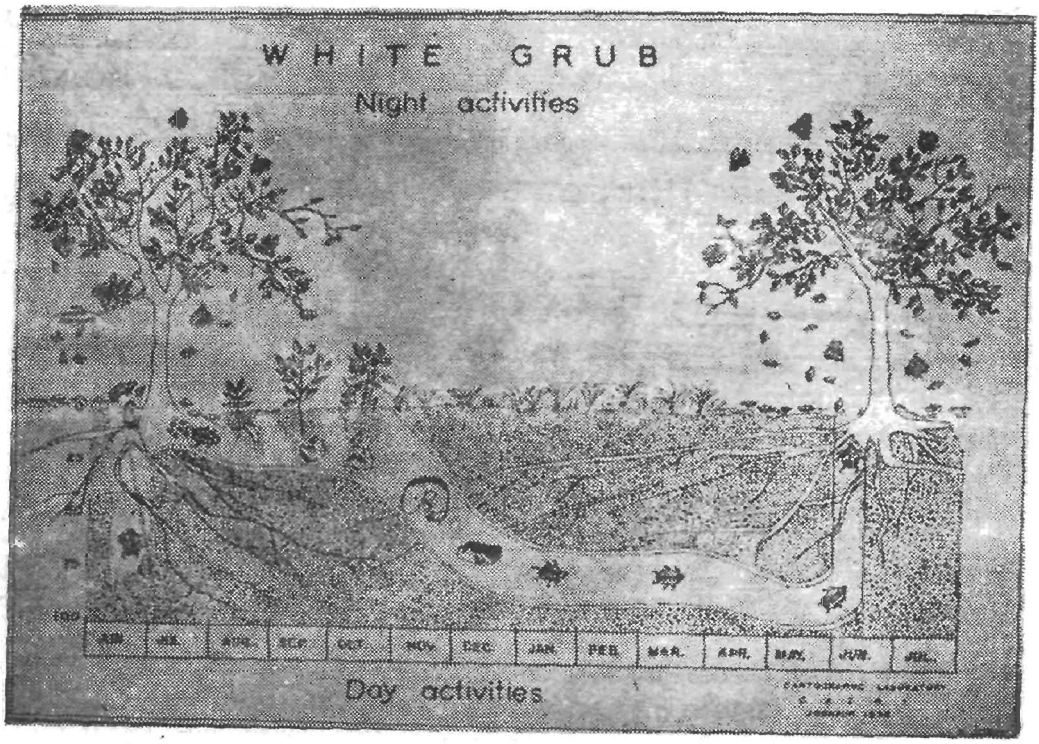

Fig. 5. White grub activities

3rd instar grubs feed on the roots of plants from July to September. Newly hatched grub mostly feeds on waste organic matters.

The full grown grubs measuring 35 mm long white in colour with brown mandibles and very prominent thoraacic legs, and head width in 7 mm go deep in soil ranging from 20 cm to 90 cm and pupate in October-November. The grubs make earthen cell individually for pupation; within 2-3 weeks pupae becomes adults. The beetles hibernate in soil in the pupal cell till they come out of soil with premonsoon showers. Hibernation may also take place in the pupal stage before adult emergence in some of the cases. There is overlaping in generation of the pest. Adult beetle measures about 18 mm in length and 7 mm in width at thorax and has dull brown coloured elytra and yellowish white abdomen.

PEST MANAGEMENT STRATEGY AND RECOMMENDATION

It is rather difficult to eradicate this polyphagous and noxious pest because of its peculiar behaviour and nature of damage to the various crops.

The pest can be managed effectively only by integration of several methods. The control of adult beetles during June to July alongwith the control of the white grub larvae in the soil during July-August becomes inevitable in the endemic areas. The effective control measures to combat white grub menace to be adopted are given at appendix I. Here it is worthwhile to mention that Raodeo **et al.,** (1976) carried out a large scale compaign for the control of white grubs **H. serrata** F. in Maharashtra State. Measures adopted in this compaign resulted significantly to the control of this pest.

Chemical control

The control of white grubs by chemicals have been tried by several workers in India (Kalra and Kulshreshtha, 1961; Srivastava & Khan, 1963; Desai and Patel, 1965; Kaul **et al.,** 1966; Patel **et al.,** 1967; Joshi **et al.,** 1969; Rai **et al.,** 1969, Sharma, 1969, Pal and Doval 1970; Pal, 1971; Pal and Misra, 1973; Sharma and Shinde, 1970; David and Kalra, 1966; Veeresh, 1973; Sachan & Pal, 1974, 1976) Bindra and Singh, 1971; Bindra **et al.,** 1973; Yadava and Yadava. 1973).

The grubs are very hardy and move to a great depth in the soil. Effective control is possible only if chemical is applied, when the grubs are tiny or young.

Calendar of Operations

Chemical control

(a) **Presowing treatment** (15th June-15th July)

Soil application of BHC 10% Dust @ 100-125 kg/ha may be mixed in the soil 10-15 cm deep with the spade or Kassi as a pre-sowing soil treatment. It is relevant to state that in a study by Pal and Kushwaha (1976) found that BHC 10 kg a.i./ha got dissipated in 5 months (88%) and

residues in Chilli fruits was below tolerance level at all stages of sampling.

However, application of BHC can not be recommended for fields where groundnut, tobacco and other root crops are grown.

At the time of sowing of **bajra**, sevidol granules (Carbaryl + Gamma BHC 4:4) @ 20-25 kg/ha or thiodemeton or phorate 10 G @ 25-30 kg/ha may be applied alongwith furrows. But keeping in view of effectiveness, economics BHC is recommended. This recommendation has also been adopted in National Programme for White Grub Management.

Sachan and Pal (1974, 1976) tried Cakes namely Muhua **(Madhuca indica)**, Karanj **(Pongamia glabra)**, Tumba **(Citrulucolosynthasis)** and Neem **(Azadirachta indica)**, in chillies crop @ 250 and 1000 kg/ha, it was found that the cakes failed to give any protection to the crop from grub damage.

(b) **Post-sowing treatment** (August-September)

If a crop is attacked by the grubs in the already treated fields, a second application of same insecticide may be given at half of already applied dose.

(c) **Control of Rhinyptia** spp. (Earhead sucking beetle)

These beetles belonging to white grubs occur in large numbers during dark fortnight and feed on the anther, stigma and the milky grain earheads of **bajra** in Rajasthan State. For keeping down the population and economic levels of the pest, the following methods may be adopted.

(i) Light trap or petromax may be employed for the collection of adult beetles (October-November).

(ii) Carbaryl or Malathion or BHC Dust may be dusted during evenings for effective control.

(iii) Pilling of trash at several places around the field during day and burning it after sunset was found quite effective in killing the beetles as they are attracted towards the flame and got burnt in the fire. This practice, if followed regularly for few days, reduces the population of the beetles to a great extent.

Cultural control

1. Well rotten manure possibly treated with insecticides, BHC Dust should be applied.

2. A repeated ploughing during May-June may be carried out so that hibernating population of grubs are exposed to natural enemies like birds, pigs and dogs.

3. As the crop ramnants, stalk, Khankhla etc. are breeding grounds (Vulnerable points) for white grubs, these may be cleared from the field during May-July.

4. The weed **Boerhavia diffusa** which harbour early stage of grubs (Pal, 1974) may be removed and destroyed.

5. During tillage, the grubs may be hand picked and destroyed.

6. Flooding of fields wherever possible to reduce the grub population. This does not allow egg laying or kills the grubs or the grubs go deeper to avoid stagnated water (David and Kalra, 1966).

Annihilation of Adult beetle

(June to July)

The trees inside and on the border of the field may be sprayed (During the emergence of beetle) at the sunset with the following insecticide :

Carbaryl 50 W.P. @ 0.15 to 0.2%

OR

BHC EC @ 0.2%

OR

DDT 50% W.P. @ 0.2% or

Bindra and Singh (1971) reported that foliar sprays of fenitrothion (0.05%) and Carbaryl (0.1 per cent) proved very effective in controlling beetles of **Lachnosterna consanguinea** Bl. congregating on Rukmenjee bushes. Bindra, **et al.,** (1973) also reported that carbaryl 0.15 per cent and endosulfan 0.04 per cent consistently proved effective in minimising the chaffer beetle damage to grapevine.

Mechanical control

Use of light trap or patromax (June-July)

The use of Light Trap during beetle flight period offers an excellent mode of preventing the build up of a large scale incidence.

(a) The light trap, petromax or lantern may be employed collectively by all the farmers of the village near tubewell huts or on irrigation channels or in the fields near bush or trees at 7.30 P.M. to 8.30 P.M. daily for 7-10 days. Light Traps are effective only if employed on community basis. If an individual farmer employs the light trap, it may in fact accentuate the white grub damage in his field. The collected beetles may be killed by dipping them in Kerosinized water.

The adult beetle may also be collected by vigorous shaking or twigs of trees and bushes like Ber, Khejri, Neem etc. from 8.30 P.M. onwards and killing the adult beetle, thus collected by drowning them in Kerosinized water. After eggs hatch this will obviate the problem of mixing insecticide deep into the soil to reach grown up grubs in order to kill them.

(b) The insecticidal treated green twigs of bushes of **Neem** or **Bordi** etc. may be put in the field at several places in the evening where ever feasible so as to attract emerging adult beetles which would die on feeding the foliage.

The peak period of adult catch in the light during June-July gives clue for time of insecticide application in the soil. If the insecticides are applied in the top 5 cm to 10 cm soil depth at the time of peak emergence of beetle there is every likelihood of the young grub being killed.

Gupta (1973) found that **Neem (Azadirachta indica)** attract adults of **Holotrichia serrata** and **H. insularis** and **H. consanguinea.**

Biological control

The control of adults and grubs through their natural enemies has not so far been attempted in India though some parasites and predators have been recorded by some workers.

Kalra and Kulshreshtha (1961) recorded entomogenous **Scoliid** parasites viz., **Scolia aureapennis** and **Compsomeris collaris** on the adults of

H. consanguinea from Rajasthan. One beetle of **Anthia sexguttata** Fb. can prey on six beetles in one night.

Other non arthopod pre-dators are birds like mynah, crow, gecko; dog, hedgehog and common Indian toad **(Bufo melanosticus).** Birds feed & grubs when explosed by tillage operations.

Shinde and Sharma, 1971 (a) recorded **Diplococcus** sp. **Bacillus** cerus, ***B. thurigiensis*** and **Clostrodium** sp. from the grubs of **H. consanguinea.**

Shinde and Sharma 1971 (b) Shekher and Venkataramaiah (1964) found effective control of grubs in the laboratory by using **B. thurigiensis** and **B. popilliae** respectively at different doses.

Rao & Vijaylakshmi (1959) reported mortality of adults by **Metarrhizium anisopliae, Beauveria brassiana** and **Aspergillus parasiticus,** Ranganathaiah, **et al.** (1973) claimed that **Beauveria brongniartii parasitizes** and kills all stages of **Holotrichia serrata** and brings down the pest population considerably.

Sources of Availability of Pesticides and app. costs

Some of the firms manufacturing or formulating more common pesticides are :

1. Bayer (India) Limited, pesticides Division, Express Towers Nariman point, Bombay 400001.

2. Bharat Pulverising Mills Private Ltd., Hexamar House 28 Sayani Road, Bombay 400025.

3. Hindustan Insecticides Ltd. (A Govt. of India Enterprise) E3 Defence Colony, New Delhi 110024.

4. Union Carbide India Ltd. (Agril. Products Division) Kalli Parade, Beresia Road, Bhopal.

5. CIBA Geigy of India Ltd. Khetan Bhavan 198 J. Tata Road, P.O. Box 11014, Bombay 400020.

6. Cyanamid India Limited Agril. Division Post Box 9109, Bombay 400025.

7. Sandoz (India) Ltd. Agrochemical Division, Sandoz House, Dr. Annie Besant Road, Worli, Bombay 400018.

8. I.C.I. (India) Pvt. Ltd. 34 Chowringhee, Calcutta-16.

9. Rallis India Ltd., 21 A Ashock Marg Lucknow, 226001.

10. Prakash Pulverising Hills, Industrial Area, Alwar (Raj.).

11. Pesticides India, Post Box 20, Udaisagar Road, Udaipur (Raj.).

12. Mysore Insecticide Company Pvt. Ltd., Post Box No. 1835 6 Linghi Chetty Street, Madras-600001.

13. Hyderabad Chemical Supplies Pvt. Ltd., Bank Street, Hyderabad-500001.

TABLE

Pesticides	Available from firms (S. no.) entitled above	App. Cost
BHC 10% Dust	2, 3, 7, 8, 9, 10, 11, 12, 13	Rs. 1350/tonne
DDT, 50% W.P.	2, 3, 7, 9, 10, 11, 12, 13	Rs. 2000/tonne
Thiodemeton G	1; 7	Rs. 15/- per kg
Sevidol G	2, 4	Rs. 10/- per kg
Phorate G.	4, 11	Rs. 20/- per kg
Malathion E.C.	2 (Malamar), 6, 10, 11, 12, 13	Rs. 50/- per kg
Carbaryl 50 WP	2 (Hexavin), 4, 7, 11	Rs. 4/- per kg
Fenitrothion	1, 2, 9	Rs. 100/- per lit.
Monocrotophos	5	Rs. 110/- per lit.
Quinalphos	7	Rs. 90/- per lit.
Trichlorphon	1	Rs. 90/- per lit.

PESTICIDES—USES AND SAFETY

Some pesticides are highly toxic, some moderately and others are relatively low in toxicity, but it is always wise to be cautious with them in handling, storing and using the pesticides. The following precautions should be taken at the time of handlings and using these pesticides.

1. Store all pesticides in original containers and in a locked cupboard or closet where they are out of reach of children, pets or livestock.

2. Keep all pesticides away from food or feedstuffs.

3. Use pesticides when necessary, and be sure you use the correct material for the job.

4. Read the entire label on the pesticides container and follow the directions and precautions EXACTLY.

5. Avoid inhaling pesticide sprays or dusts when mixing or applying them.

6. Avoid spilling pesticides on skin or clothing. If spilled, wash off at once with soap and water. Clothing wet with spray materials should be removed at once. Particles or drops of pesticides which may accidentally get into the eyes should be flushed out immediately with large volumes of clean water.

7. Do not eat or smoke when working with pesticides. Wash hand and face and change clothing after handling pesticides, wash contaminated clothing daily.

8. Discard any pesticide container without label or with damaged label. DO NOT GUESS AT CONTENTS.

9. Avoid spray and dust drift on adjacent crops or fields. Cover feed and water containers in livestock areas.

10. Wear protective masks and clothing if so directed on the label.

11. Use pesticides ONLY at the recommended dosages and timing to keep residues on crops and animals below permissible limits. Food and feed products are subject to Government inspection.

12. Be particularly careful in filling and emptying spray equipment and spraying on sloping land to avoid contaminating streams, ponds or other bodies of water.

13. DESTROY all empty pesticide containers. Break or puncture all glass and metal containers to prevent reuse. Burn paper or carboard containers (avoid coming in contact with smoke) and bury all ashes, unburned residues and broken containers.

14. If symptoms of illness occur during or shortly after the spraying or dusting the patient should be sent to the nearest hospital immediately or a physician be called.

Insecticidal Hazards

Human hazard	Plant hazards		Wild life hazards including Fish
1. During manufacture	In the field during application of insecticides	Residual hazards	
2. Loading			
3. Transportation			

First aid measures and Antidotes

1. In case of poison Swallowing :—

   (a) Empty stomach immediately by giving emetic warm salt solution, (ground mustard one tea-spoonful in a glass of warm water).

   Or

   Insert the index finger or press the tongue for down the throat to make the patient vomit.

CAUTIONS : Do not induce vomitting if the patient is in a Coma or Unconscious or is having convulsions.

After emptying stomach : give raw eggs or milk.

2. Skin contamination : Wash the skin with soapy warm water several times.

3. Eye contamination : Hold the eyelid open, wash the eyes gently with water immediately.

4. Poisoning by inhalation : Remove the patient to open air and supply artificial respiration.

All the plant protection workers are however may be suggested to note the following simple method of first-aid in case of poisoning.

1. Vomitting mechanically either by finger or by giving common salt solution (2 teaspoon-ful in a glass of water).

2. Wash by soda bicarb solution.

3. Give universal anti-dote if possible.

4. Manage artificial respiration.

For reference : Clinical Hand Book of Economic poisons (1963) by W. J. Hays (Jr.) may be consulted for additional informations.

ANTIDOTES

The compounds which are used to neutrilize the effect of poison are called antidote. They are of two types.

1. General or Universal antidote.

2. Specific antidotes.

UNIVERSAL ANTIDOTES

It is used as general antidotes which consists :

1. Activated charcoal - 2 parts.

2. Magnesium oxide (MgO) - 1 part.

3. Tanic acid 1 part.

(A) Antidotes for Chlorinated hydrocarbon insecticides

To neutrilize the effect of the poisoning caused by Chlorinated hydrocarbon insecticides, give a dose of universal antidote, described above followed by 1 oz. magnesium sulphate (Epsomsalt) in a glass of water and if necessary inject 10 cc. of 10% calcium gluconate.

Physician may administer phenobarbital or pentabarbital to control convulsions.

(B) Antidotes for Organiphosphate Compounds

These compounds are absorbed by skin and respiratory tract. The symptoms of poisoning may be headache, giddiness, nervousness, weakness, nausea, diarrhoea and discomfort in chest.

In usual case (1) Administer atropine sulphate-1 to 2 mg. if symptoms appear. If the excessive respiratory secretions occur keep the patient fully atropinised. Give atropine sulphate every hour upto 25-50 gm. in a day, (2) 2-PAM may be administered intravenously (1 gram for adult if the patient fails to respond satisfactorily to atropinesulphate).

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APPENDIX I

Control measures

Grubs	App. Cost per ha (Rs.)	Adults			
Use of Pesticides in soil/F.Y.M.		Cultural	Mechanical	Chemical	Biological
1. BHC 10% dust @ 100 kg/ha OR	135.00	1. Repeated ploughing in May/June for exposure and destruction of pest.	1. Tree shaking	1. Spraying of trees with Carbaryl 0.2% 50 W.P. OR Monocrotophos 0.05% OR Quinalphos 0.025% OR Trichlorphon 0.15% OR BHC. EC. 0.2% OR Fenitrothion 0.05% OR DDT W.P. 0.2%	1. Encouraging Non-arthopod predators viz. Dogs, Pigs, Birds to feed on grub/adult.
2. Phorate 10 G @ 20-25 kg/ha OR	450-550	2. Destruction of crop ramnants/stalks etc.	2. Light trapping (a) Patromax (b) Lantern (c) Electric bulb	2. Dusting with BHC or Malathion dust during Sept./Oct. on bajra earhead for the control of *Rhinyptia* Beetles.	2. Introduction of parasite and predators.
3. Disulfoton 5 G @ 40-50 kg/ha OR	500-600	3. Use of well rotten manure treated with insecticides.	3. Use of baits (green twigs dipped in insecticides).		
4. Thiodemeton 5 G @ 40-50 kg/ha OR	300-360	4. Destruction of weeds			
5. Sevidol (Carbaryl+Gamma BHC 4 : 4 G) @ 25 kg/ha	250.00	5. Hand picking of grubs during tillage operations.			

APPENDIX II

Chart showing the Calender of Operations

Control Operation

Control in endemic pockets

Mechanical collection (June-July)

- By shaking the trees (after the first monsoon showers) (Continuous for a week)
- Light trapping or Patromax (7.30 to 8.30 pm) daily for 7-10 days.

Control in individual farm by farmers

- Spraying of the host trees after the emergence of adult beetle with carbaryl 50 W.P. @ 0.2%
  or
  DDT 50% W.P. @ 0.15%
- Application of soil insecticide (Presowing treatment viz. BHC Dust 10% @ 100 kg/ha.)
  or
  Phorate 10 G @ 25-30 kg/ha.
  or
  Thiodemeton 5 G @ 40-50 kg/ha.
- (2) Dusting with BHC 5% or Malathion 5% Dust during Sept.-October for *Rhinyptia* control in bajra earheads.

May, June-July after rains :

(i) spraying of host trees for control of Adult beetles.
(ii) presowing soil treatment for grub control.
(iii) dusting the bajra earhead during Sept.-October.