

**SCREENING OF GROUNDNUT GENOTYPES AGAINST
POD BORERS IN *KHARIF* SEASON**

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B.Sc. (Agriculture)

**MASTER OF SCIENCE
IN
AGRICULTURE
(AGRICULTURAL ENTOMOLOGY)**



DEPARTMENT OF AGRICULTURAL ENTOMOLOGY

**COLLEGE OF AGRICULTURE, LATUR
VASANTRAO NAIK MARATHWADA KRISHI VIDYAPEETH
PARBHANI - 431 402 (M.S.) INDIA**

2022

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POD BORERS IN *KHARIF* SEASON**

**BY
MAGAR SANGITA MADHAVRAO**

B.Sc. (Agriculture)

**A thesis Submitted to
Vasantnao Naik Marathwada Krishi Vidyapeeth, Parbhani
in partial fulfillment of the requirement for the Degree of**

**MASTER OF SCIENCE
IN
AGRICULTURE
(AGRICULTURAL ENTOMOLOGY)**



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VASANTRAO NAIK MARATHWADA KRISHI VIDYAPEETH
PARBHANI – 431 402 (M.S.) INDIA**

2022

DECLARATION BY THE CANDIDATE

I hereby declare that the thesis entitled, “**SCREENING OF GROUNDNUT GENOTYPES AGAINST POD BORERS IN KHARIF SEASON**” submitted by me is based on the actual work carried out by me under the guidance and supervision of **DNYANDEO SHAMRAO MUTKULE**. The extent of information derived from the existing literature have been duly cited and referenced. The existing research work or its any part is not submitted anywhere else for the award of any degree or diploma.

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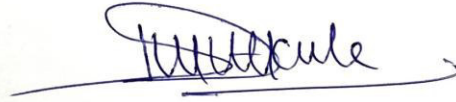
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Research Guide and
Chairman
Advisory committee

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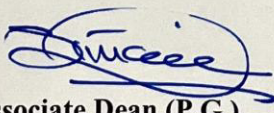

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1 CHAPTER-I INTRODUCTION
Groundnut (*Arachis hypogaea* L.) an important oilseed and ancillary food crop of the world belongs to genus *Arachis* tribe *Aechynomeneae*, family *Fabaceae*, is a tetra foliate legume crop with yellow sessile flowers and subterranean pods. Groundnut is native to South America. It was found in Brazil or Peru as early as 950 BC and later spread to Africa, North America, Europe and Asia. It is an important oil seed crop that contributes a major role in economy around the world (FAO, 2006; Narada et al., 2003; Nwokolo, 1996; Wiess, 2000). The major groundnut producing countries are China, Nigeria, U.S.A, Taiwan, Indonesia, Senegal, Ghana, Argentina and Brazil. In India, groundnut is mostly grown in five states viz., Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra. *Arachis hypogaea* is derived from two Greek words “*Arachis* means “legume” and “*hypogaea*” means below the ground level”.

Groundnut is actually a stinging plant and requires an extended and hot growing period with optimum temperature (25 to 30°C) and optimum rainfall (500 mm) (Weiss, 2000). Groundnut is cultivated in tropical, subtropical and warm temperature climates (Carley and Fletcher, 1995). It is the most important commercial crop mostly grown in semi-arid tropical regions like India. Groundnut crop is grown as rain-fed in bulk during kharif season but it is also taken during the summer season, wherever, the irrigation facilities are available. The crop can be grown successfully in area receiving rainfall from 600 mm to 1200 mm. A well-drained sandy loam soils (pH 6.0-6.5) best thrive for groundnut (Basu and Ghosh, 1995). It is a valuable cash crop for millions of small scale farmers in the semi-arid tropics and is the principle oilseeds crop in India. It is cultivated on subsistence and commercial bases for food and industrial purposes (Thakur et al., 2013; Mohammed et al., 2018). Groundnut is considered as poor man’s badam due to their dual qualities.

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“Achievement is of no mean, without the sense of gratefulness and the recognition of this is the beginning of wisdom.”

I think it is the matter of pleasure to glance back and recall the way one traverse, the days of hard work and perseverance. It is still great at the juncture to recall all the faces and spirits in the form of teachers, friends, near and dear once. In my opinion, this work is nothing more than incomplete, without attending to the task acknowledging to overwhelming help I received during this endeavour of mine.

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Date : 30/11/2022

Place: Latur


(S. M. MAGAR)

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ABBREVIATIONS

<i>A.hypogaea</i>	:	<i>Arachis hypogaea</i>
Sub. ants	:	Subterranean ants
C. D	:	Critical difference
C. V.	:	Coefficient of variaton
SMW	:	Standard Meteorological Week
i. e	:	that is
Lit	:	Liter
<i>et al.</i>	:	<i>Et alia</i> , and others
Fig.	:	Figure
Ha	:	Hectare
Ms	:	Maharashtra
sp.	:	Species
%	:	Per cent
Cm	:	centimeter (s)
M	:	meter (s)
PP	:	Pages
<i>Viz.</i> ,	:	Vide licet, namely
<i>M. vitrata</i>	:	<i>Maruca vitrata</i>
<i>G.bimarginatus</i>	:	<i>Glyphonyx bimarginatus</i>
<i>M. communis</i>	:	<i>Melanotus communis</i>
<i>E.annulipes:</i>	:	<i>Euborellia annulipes</i>
<i>H. consanguinea</i>	:	<i>Holotrichia consanguinea</i>
<i>M.obesi</i>	:	<i>Microtermes obesi</i>
<i>O.latigula</i>	:	<i>Odontotermes latigula</i>
<i>O. orientalis</i>	:	<i>Odontotermes orientalis</i>
<i>O. parvidens</i>	:	<i>Odontotermes parvidens</i>
<i>H.fissa</i>	:	<i>Holotrichia fissa</i>
<i>H. serrata</i>	:	<i>Holotrichia serrata</i>
<i>S. spontaneum</i>	:	<i>Sugarcane spontaneum</i>
<i>E. grandis</i>	:	<i>Eucalyptus grandis</i>

<i>M. melolonta</i>	:	<i>Melolontha melolonta</i>
<i>H. covifrons</i>	:	<i>Holotrichia covifrons</i>
<i>A. lineatopennk</i>	:	<i>Anomala lineatopennk</i>
<i>H. longipennis</i>	:	<i>Holotrichia longipennis</i>
<i>C. parallela</i>	:	<i>Cyclocephala parallela</i>
<i>X. gideon</i>	:	<i>Xylotrupes gideon</i>
<i>A. dimidata</i>	:	<i>Anomala dimidata</i>
<i>H. seticollis</i>	:	<i>Holotrichia seticollis</i>
<i>B. corica</i>	:	<i>Brahmina Corica</i>
<i>C. vespertinus</i>	:	<i>Conoderrus vespertinus</i>
<i>A. indica</i>	:	<i>Azadirachta indica</i>

THESIS ABSTRACT

Title of the thesis	: Screening of groundnut genotypes against pod borers in <i>kharif</i> season
Full name of the candidate	: Magar Sangita Madhavrao
Full name of the Research Guide	: Dnyandeo Shamrao Mutkule
Department	: Agricultural Entomology
College / University	: College of Agriculture Latur - 413 512 Vasantrya Naik Marathwada Krishi Vidyapeeth, Parbhani- 431 402, Maharashtra.
Degree to be awarded	: M.Sc. (Agricultural Entomology)

ABSTRACT

The present investigation on “**Screening of groundnut genotypes against pod borers in *kharif* season**” was conducted at the Oilseed Research Station Latur, Department of Agricultural Entomology, College of Agriculture (Vasantrya Naik Marathwada Krishi Vidyapeeth, Parbhani), Campus Latur, Dist: Latur (MS)-India during *kharif* 2021-2022.

Total eighty six groundnut genotypes along with one check LGN-1 were screened against pod damage due to earwig. The pod damage due to earwig infestation ranged from 0 to 13.88 per cent. Out of eighty six genotypes screened for earwig pod damage. Both the genotypes HOVTSB-I 2021-19 (0.00%) and IVK-I 2021-9 (0.00%) recorded 0 per cent pod damage. Whereas highest pod damage genotypes ISK-I 2021-4 (13.88%), ISK-I 2021-3 (12.84%), AVK-2021-3(12.24%), AVK-2021-2 (11.64%) and LGN-1(10.99%) recorded in the scale 3 having pod damage between 11 to 20 per cent. The genotypes HOVTSB-I 2021-19 and IVK-I 2021-9 recorded No pod damage and formed promising for earwigs.

Eighty six genotypes along with one check LGN-1 were screened for wireworm pod damage. Pod damage due to wireworms ranged between 0 to 18.07 per cent. Both the genotypes HOVTSB-I 2021-19 (0.00%) and LSVT-I 2021-2(0.00%) recorded 0 per cent pod damage. whereas, genotypes AVK-2021-2 (18.07%), ISK-I 2021-4 (15.68%), AVK-2021-5 (11.47%), AVK-2021-3 (11.20%) and LGN-1

(11.64%) recorded in the scale 3 having 11 to 20 per cent pod damage. The genotypes HOVTSB-I 2021-19 and LSVT-I 2021-2 recorded No pod damage and formed promising for wireworms.

Total eighty six genotypes along with one check LGN-1 were screened for subterranean ant pod damage. The one genotype HOVTSB-I 2021-19 (0.00%) recorded 0 per cent pod damage. whereas, highest pod damage genotypes ISK-I 2021-26 (12.26%), ISK-2021-10 (11.17%), AVK-2021-3(10.91%), AVK-2021-2 (10.99%) and check LGN-1 (10.91%) recorded in the scale 3 having 11 to 20 per cent pod damage. The genotype HOVTSB-I 2021-19 recorded No pod damage and formed promising for subterranean ants.

A research work to study the abundance of groundnut pod borers was carried out at Oilseed Research Station, Latur. The insect pests associated with groundnut in *kharif* season 2021-2022 was earwig, wireworm and subterranean ant. The earwig and wireworm was dominant in Oilseed Research Station, Latur. The pest was observed damaging the pods of groundnut. The incidence of groundnut pod borers was high ranged between 0 to 40 per cent in research plot. Earwig pod damage recorded between 0 to 40 per cent in *kharif* season, wireworm damage recorded in the range 0 to 36 per cent in *kharif* season, subterranean ants pod damage in the range of 0 to 33.33 per cent in *kharif* season 2021-2022. Damage symptoms of each groundnut pod borers was described based on position, size, shape of holes on pod, nature, extent of damage to kernel, and also other distinguishing features like type of excreta and nature of plugging in the pod. The pod damage due to earwig and wireworm was more in *kharif* season.

(Keywords: Earwig, Wireworm, Subterranean ants, Genotypes, Pod damage)

CHAPTER - I
INTRODUCTION

CHAPTER-I

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) an important oilseed and ancillary food crop of the world belongs to genus *Arachis* tribe *Aechynomeneae*, family *Fabaceae*, is a tetra foliate legume crop with yellow sessile flowers and subterranean pods. Groundnut is native to South America. It was found in Brazil or Peru as early as 950 BC and later spread to Africa, North America, Europe and Asia. It is an important oil seed crop that contributes a major role in economy around the world (FAO, 2006; Narada *et al.*, 2003; Nwokolo, 1996; Weiss, 2000). The major groundnut producing countries are China, Nigeria, U.S.A, Taiwan, Indonesia, Senegal, Ghana, Argentina and Brazil. In India, groundnut is mostly grown in five states *viz.*, Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra.

Arachis hypogaea is derived from two greek words “*Arachis* means “legume” and “*hypogaea*” means below the ground level”. Groundnut is actually a stifling plant and requires an extended and hot growing period with optimum temperature (25 to 30°C) and optimum rainfall (500 mm) (Weiss, 2000). Groundnut is cultivated in tropical, subtropical and warm temperature climates (Carley and Fletcher, 1995). It is the most important commercial crop mostly grown in semi-arid tropical regions like India. Groundnut crop is grown as rain-fed in bulk during *kharif* season but it is also taken during the summer season, wherever, the irrigation facilities are available. The crop can be grown successfully in area receiving rainfall from 600 mm to 1200 mm. A well-drained sandy loam soils (pH 6.0-6.5) best thrive for groundnut (Basu and Ghosh, 1995). It is a valuable cash crop for millions of small scale farmers in the semi-arid tropics and is the principle oilseeds crop in India. It is cultivated on subsistence and commercial bases for food and industrial purposes (Thakur *et al.*, 2013; Mohammed *et al.*, 2018). Groundnut is considered as poor man’s badam due to their dual qualities.

It is the 3rd most important source of vegetable protein and contains 50 per cent edible oil, 28 per cent digestible protein and 20 per cent carbohydrates (Bhatti and Soomro, 1996; Christensen *et al.*, 2004; Shah *et al.*, 2012). Groundnut is also called as earhnut, peanut, manilanut, moongfali and monkey nut also. Among all

the total fatty acids present in groundnut oil oleic acid and linoleic acid is 75-80 per cent. (Mercer *et al.* 1990). It is also known as “Indian Almond”. The nuts are used in soups, pastes, and other household diets where they provide dietary protein of up to 25%, oil/fat (40-50%), as well as essential vitamins. The haulms of groundnut plants are important as stock food (Johnson *et al.*, 1981). The cake that is left after the oil has been extracted from the kernels has a high protein content and is sold as a component of stock food concentrates. Groundnuts also contribute to improving soil fertility via biological nitrogen fixation and organic matter returns to the soil and its haulms provide valuable feed for livestock especially during the long dry season.

The groundnut seeds (raw, sundried and roasted) contain moisture content of 7.40%, 3.40%, 1.07% ; ash content of 1.48%, 1.38%, 1.41% ; Crude protein of 24.70%, 21.80%, 18.40% ; Crude fat of 46.10%, 43.80%, 40.60%; Crude fibre of 2.83%, 2.43%, 2.41% ; Carbohydrate of 17.41%, 27.19%, 36.11%, respectively. Minerals included; Sodium (0.71%, 0.69%, 0.57%), phosphorus (0.68%, 0.65%, 0.69%), potassium (0.47%, 0.51%, 0.55%), zinc (0.44%, 0.42%, 0.50%), iron (0.40%, 0.47%, 0.43%). (Ayoola *et al.*, 2012).

Variety of value products like milk, chikki, burfi, peanut butter, bhujia, biscuits are made from groundnut. After the oil extraction, Groundnut shell is used in industries as fuel, filler in fertilizers and extraction of mustard facilitates better recovery and low energy consumption.

Groundnut (*A. hypogaea* L.) is a leguminous plant that is widely cultivated in the tropics and subtropics between 40°N and 40°S latitudes. Groundnut is not only an important oilseed crop of India but also an important agricultural export commodity. It is valued for its high-oil edible seeds and as such, it's the fourth important source of edible oil and third most important source of vegetable protein in the world. Globally groundnut covers 316 lakh hectares area with the production of 536 lakh tonnes with the productivity of 1699 Kg ha⁻¹ (FAOSTAT, 2021). India covers 61 lakh hectares area with the production of 99 lakh tonnes with the productivity 1631 Kg ha⁻¹(FAOSTAT, 2021). In Maharashtra, it is cultivated over an area of 309 thousand hectares with production of 407 thousand tonnes and with average productivity of 1318 kg/ha during *kharif* and *rabi* season, respectively. In Latur district it is cultivated over an area of 26 hectares with production of 18 tonnes and with average productivity of 697 kg/ha during *Kharif* season. (Anonymous,

2021). Groundnut cultivated in *khariif*, *rabi*, and summer seasons. Nearly 80% of acreage and production comes from *khariif* crop (June-October). India is a one among the top three producing countries of groundnut in the world. Total Oilseeds production in the country during 2020-21 is estimated record 36.10 million tonnes which is higher by 2.88 million tonnes than 2019-20. Further, the production of oilseeds during 2020-21 is 18% more than the 5 year average oilseeds production.

Several factors are responsible for economic losses to groundnut crop such as variable rainfall, low soil fertility, crop management practices, pests and diseases (Naab *et al.*, 2004). The biggest threat to groundnut cultivation is the vulnerable wide spread attack by more than 115 insects have been reported to occur on groundnut in India and few are quite destructive and reduce the yield considerably. Insect pests are recognized as one of the major constraints in groundnut production (Gibbons, 1980; Vikram Singh, 1980). The annual yield loss in groundnut due to insect-pests is approximately 15 per cent (Dhaliwal *et al.*, 2010; Jasrotia *et al.*, 2016).

Several insect pests attack the groundnut crop that may cause moderate to severe damage (Javed *et al.*, 2014). More recently Wightman *et al.* (1990) 2 categorized four cohorts of insects affecting groundnut, non-viruliferous foliage feeders, viruliferous foliage feeders (virus vectors), invertebrates living in the soil that feed on underground plant parts; and those that feed on the harvested and stored pods and kernels. Among groundnut producing countries of Asia the major insect pest of groundnut include leaf miner, white grub, jassid, aphid, thrips, red hairy caterpillars and termites (Salihah *et al.*, 1988; Sheirdil *et al.*, 2012). Soil insect pests cause serious economic losses to groundnut crop (Wightman *et al.*, 1990). In case of severe attack, termite can cause 5 to 45 per cent mortality of plants and 46 per cent damages to pod (Kaushal and Deshpandy, 1967; Painter, 1951; Roonwal, 1981; Salihah *et al.*, 1988).

The groundnut pod borers contain a wide group of insects which are associated with different class of insecta. They are mainly the earwigs, wireworms, false wireworms, termites, white grubs, and subterranean ants etc. The extent and intensity of damage are difficult to pinpoint in case of pod borers because they cause similar damage. Earwig feeding on groundnut kernal by boring into the pods (Cherian and Basheer, 1940). The larve of wireworms and false wireworms feed on groundnut roots. Subterranean ant also damage to kernal. White grubs damage groundnut roots

and pods, thereby lowering the quality and quantity of harvested kernels (Wightman and Wightman, 1994). Termites *O. obesus* (Rambur) are social insects, attack on the tap root, feed out all contents ultimately replacing it with mud (Rawat *et al.*, 1970). The use of termite resistant approved groundnut genotypes can be a very important dimension of integrated pest management (Painter, 1951). The major objective is to bridge the yield gap, ultimately making the groundnut as a profitable crop under rain fed conditions (Khan *et al.*, 2009).

The identification of pod borer resistant high yielding varieties through screening can provide a convenient way for farmers to grow pod borer resistant groundnut cultivars for better yield. This ultimately will help to reduce the excessive use of insecticides on the crop leading to reduce the hazards to human and animal health and environmental pollution around the world.

The losses caused by groundnut pod borers (earwigs-2.7 to 19.95 per cent (Cherian and Basheer,1940), termite 46% (Kaushal and Deshpande,1967), wireworms 35% (Wightman and Amin,1988) and subterranean ants 15-48%), while one white grub/3m.row caused a loss of pod equal to 44 kg/ha (Gough and Brown,1988), with an average of 31.6% (Keerati and Singha,1986).

Once penetrated by insects, pods are of little value because the kernels will be destroyed by the same insects or by members of another species, or by fungal contamination. Losses caused by boring insects can go undetected if they damage immature pods which rot, and disappear before harvest (Wightman and Amin, 1988). Determination of the pest is not an easy task unless one has a clear picture of the species involved.

Considering all above points, the present investigation on “Screening of groundnut genotypes against pod borers in *kharif* season” was carried out with following objectives/aspects.

OBJECTIVES

1. To screen different groundnut genotypes against groundnut pod borers.
2. To study the abundance of groundnut pod borers.

CHAPTER - II
REVIEW OF LITERATURE

CHAPTER - II

REVIEW OF LITERATURE

The relevant review on the screening of groundnut genotypes against pod borers in *kharif* season are presented under following headings.

2.1 To screen different groundnut genotypes against groundnut pod borers

2.2 To study the abundance of groundnut pod borers

2.1 To screen different groundnut genotypes against groundnut pod borers

Cherian & Basheer (1940) reported earwig as pod borers of groundnut. They found *Euborellia stali* Dohm. feeding on groundnut kernels by boring into the pods at Coimbatore, India.

Purushottaman *et al.* (1970) reported as high as 46.6 per cent pod infestation. The matured pods were infested to an extent of 44.1 per cent, the intensity of infestation in case of immature pods was 52.1 per cent in Asirya muitunde, a variety of groundnut. Similar high infestation of *Anisolabis annulipes* (= *E. stali*) to the extent of about 40 per cent of bored pods has been observed on the susceptible genotypes in a vertisol field at ICRISAT (ICRISAT, 1986).

Amin *et al.* (1985) conducted field screening to identify sources of resistance to groundnut pests. A total of 530 genotypes of groundnut were screened for resistance to the pod scarifying termites (*Odontotermes* spp.) genotypes with multiple resistance to these pests were identified from the 3 years field screening trials and some of them have been used in the breeding program at ICRISAT.

Das & Ray (1988) reported another species *E. annulipes* Lucas as pod borer in Tripura.

Reddy & Sammaiah (1988) observed *Odontotermes brunneus* (Hagen) to bore into the main stem close to ground level, tunnel down into the tap root and up into the stem, at Warangal, India. Termite also damaged pegs and scarified mature pods and occasionally penetrated into their shells.

Aslam *et al.* (2000) studied ten genotypes (ISB 1-99, FJ 1-99, Sehal 1-99, Bahatar 1-99, Jatli 1-99, Jhelum 1-99, Dena 1-99, Hysun-33, Sohawa 1-99 Triumph-573) screened against the attack *Odontotermes obesus* at Chaccanwali Deri Farms. Hysun -33 showed the highest number of termites per 30³ cm³ and also the percentage of plants damaged by this pest was highest. In Jhelum 1-99, both the number of termites as well as the percentage of plants damaged by *Odontotermes obesus* were the lowest. The results showed that on different genotypes, the number of termites varied and this information could help in evolving plants resistant to insect pests and thus by sowing the resistant genotypes, the dependence on the heavy use of insecticides will be minimized and ultimately the pollution problems due to injudicious use of insecticides will also be reduced. The number of termites and the damage done by them to the plants were positively correlated. It showed that as number of termites increased, the percentage of damage to plants by termites also increased.

Chillar *et al.* (2004) screened four genotypes out of which less incidence of earwig on JL-1 & CO1. Genotype JL-1 & CO 1 reported less damage due to wireworms and the variety JL-24, JL-1, TMV 2 & CO1 have been found less susceptible to subterranean ants.

Thylo & Adalla (2005) conducted a practical screening technique for sugarcane tolerance to damage of white grub was developed using commercial varieties PS-3, VMC 86-550, VMC 71-238, PHIL 75-44 and CP 29-116. Among the six age groups tested (30, 60, 90, 120, 150, and 180-day old plants), the 90-120-day old plants were most appropriate since signs of recovery from grub feeding damage were manifested within a shorter period upon termination of grub infestation. Maximum damage may be sustained but still capable of root regrowth whether based on 5, 10, 15 or 20 test plants/entry, with CP 29-116 as the most tolerant and PHIL 75-44, the least. Five plants per variety are adequate for identifying highly tolerant entries. However, for higher precision of identifying highly tolerant entries, thirty-six

plants per variety are needed for evaluation. Reduction in damage symptoms on above-ground plant parts and plant height increase can be used as Indicators of tolerance. Above-ground damage symptom was positively correlated with root damage. Five second instar grubs/plant was adequate for detecting significantly different tolerance levels. It was found more practical to conduct varietal screening for tolerance to *L. irrorata* in a greenhouse.

Virdi *et al.* (2005) Thirty genotypes of were evaluated against white grubs, *Holotrichia consanguinea* (Blanchard). The incidence of white grub ranged from 19.89 to 78.57 per cent. Six genotypes namely Ses-Pant-1, Ses PDCST-1, IC-277785, IC-277786, EC-95553 and EC-331973 were found moderately resistant, showing <25.0 per cent incidence of white grubs.

Sukla (2008) revealed that out of four varieties of wheat screened for their relative susceptibility against termites, the lowest infestation was found in variety LOK-I. The variety Raj-3077 showed higher infestation of termite. While G.W-173 and Raj-3765 were moderately susceptible to termites.

Abney & Kennedy (2011) conducted field studies to evaluate the relative susceptibility of commonly grown sweet potato varieties to wireworms (Coleoptera: Elateridae, various species). There was no clear evidence of varietal effect on the incidence of wireworm damage in the study. Results indicate that the severity of wireworm damage as measured by the size of feeding scars may be less in Covington than Beauregard.

Jackson & Harrison (2013) studied fifty-nine sweet potato cultivars, including 16 heirlooms, 11 near-heirlooms (developed in the 1960s and 1970s), 19 cultivars from the 1980s, and 13 modern varieties (since 1990), were evaluated for resistance to soil insects in field experiments during 2010 to 2011 at the U.S. Department of Agriculture - Agriculture Research Service, U.S. Vegetable Laboratory (USDA - ARS, USVL), Charleston, SC. These experiments included two insect-susceptible control cultivars (Beauregard and SC1149-19) and four insect-resistant control cultivars (Charleston Scarlet, Regal, Ruddy and Sumor) that were developed by the USDA-ARS, USVL sweet potato breeding program. Sweet potato genotypes differed significantly in resistance measured by the overall percentage of injured

roots, WDS (Wireworm, *Diabrotica* and *Systema*) index and the percentage of roots damaged by white grub larvae (including *Plectrisaliena* Chapin and *Phyllophaga* spp.). Twenty-three sweet potato cultivars had a lower percentage of injured roots than the susceptible control genotype, SC1149-19, while 14 varieties had a lower percentage of injured roots than Beauregard, one of the leading commercial orange-fleshed cultivars in the United States. Over the 2-year period, Ruddy (7.6%) had the lowest percentage of injured roots and Carolina Ruby (84.6%) the highest percentage of injured roots. Carolina Ruby (1.07%) also had the highest WDS index, but 15 genotypes had a significantly lower WDS index than either susceptible control, SC1149-19 (1.03%) or Beauregard (0.82%). Ruddy (0.07%) and Murasaki-29 (0.09%) had the lowest WDS indices. The highest per cent white grub infestation was for Caromex (19.6%), however none of the genotypes had significantly less white grubs than the susceptible controls. The moderate to high levels of resistance to soil insect pests exhibited by many of these traditional and heirloom cultivars may provide useful sources of germplasm for sweet potato breeding programs.

Larsen *et al.* (2013) studied eleven genotypes of sugarcane and a *S. spontaneum* genotype were subjected to corn wireworm, *Melanotus communis* (Gyllenhal) (Coleoptera: Elateridae), in greenhouse experiments evaluated potential host plant resistance. The experiments were designed to measure the effects of wireworms on the first 90 days of growth. Sugarcane stalk sections were planted in trays of soil with and without wireworms in 2010 and 2011. Stand count, dry weight, and percentage of nodes damaged were evaluated. Wireworms reduced stand and dry weight by 40–60 %. Several genotypes were able to produce acceptable stands in wireworm-infested trays by emerging quickly and producing many tillers. CP 88-1762, CP 89-2143, and CP 03-1912 did not suffer statistically significant losses of stand or biomass due to wireworms in either year.

Higginbotham *et al.* (2014) evaluated a diverse set of 163 wheat genotypes for tolerance to wireworm feeding. Entries were planted in replicated field trials over 3 year and evaluated for their performance when grown in the presence of wireworms. Entries were rated based on survival and given a tolerance score. Results indicated that differences exist among wheat genotypes in their level of tolerance to wireworm feeding. In particular, consistently high-ranking genotypes of interest

maybe BR18, Sonalika, Safed Lerma and Hollis. These genotypes, used in conjunction with other cultural or chemical control methods, may help provide an economic means of controlling wireworms.

Rahman *et al.* (2014) evaluated ten released sugarcane varieties *viz.*, Isd 31, Isd 32, Isd 33, Isd 34, Isd 35, Isd 36, Isd 37, Isd 38, Isd 39 and Isd 40 against their tolerances to major insect pests. The study was conducted at the experimental farm of Bangladesh Sugarcane Research Institute, Ishwardi, Pabna during the cropping season of 2009-2010. The tolerant characteristic was measured by observing their infestation level against stem borer and white grubs. The variety Isd 34 had the highest infestation of stem borer (54.66%), followed by rootstock borer (39.58%), top shoot borer (35.62%) and white grub (6.00%). These indicated higher susceptibility of the variety Isd 34 to insect pest attack.

Malik *et al.* (2015) evaluated six groundnut (*Arachis hypogaea* L.) cultivars i.e. Golden, BARI-2000, Australian, BARD-479, ICG-7326 and 2KCGC20 against the attack of *Odontotermes obesus* in terms of percentage infestation of workers and soldiers, their damage and impact on the yield. The maximum mean populations of *O. obesus* workers were recorded on 2KCGC20 (30.82±2.75 workers/plot) and Australian (30.65±2.92 workers/plot), followed by BARI-2000 (19.55±2.51 workers/plot), Golden (17.30±2.27 workers/plot) and BARD-479 (16.82±2.06 workers/plot). The minimum mean population of *O. obesus* workers was found on ICG-7326 cultivars (14.85±1.81) workers/plot. The maximum mean population infestation of *O. obesus* soldiers was recorded on 2KCGC20 cultivar (4.88±0.25 soldiers/plot) followed by Australian (4.15±.30, soldiers/plot), BARD479 (2.00±.17 soldiers/plot), ICG-7326 (1.70±.14 soldiers/plot) and BARD 2000 (2.40±.25 soldiers/ plot). The minimum mean population of *O. obesus* soldiers was found on Gold (1.87±.17 soldiers/plot). Population of *O. obesus* workers was positively related with the damage and negatively related with the yield in all the groundnut cultivars.

Nasiru *et al.* (2015) research was carried out to identify the occurrence and level of termite infestation in the study area. Simple cluster sampling technique was used to select the sample areas (A, B, C, D and E). A total number of ninety six trees were enumerated from the selected clusters, out of which 53% were infested

while 46% trees were not infested with termites. In cluster A 40% of trees were infested with termites while 60% were not infested. In cluster B, 61.1% of trees were infested with termites while 38.9% were not infested. In cluster C, 40.9% were infested with termites while 59.1% were not infested. In cluster D, 52.6% were infested with termites while 47.4% were not infested and in cluster E, 70.6% were infested while 29.4% were not infested. The infestation was attributed to large debris of litters around the tree plants, damaged vegetative parts and closeness of tree stands which favour growth, development and spread of the insect pests.

Bikash & Mainali (2016) conducted the experiment under farmers field conditions at Salija (2050 meters above sea level), Parbat in 2014 to identify economic pests of potato -based agro - ecosystem, assess the damage level of both red ant and white grubs and to screen the pipeline potato genotypes against the pests. The experiment was laid out under randomized complete block design (RCBD) with ten treatments each replicated four times. Data regarding total yield, damaged tubers numbers and weight as well as fresh tubers and weight were recorded. In red ant experiment, infested tubers number was not significantly different among the tested genotypes. However, Ms 35.9 incurred the lowest level of damage ($0.386 \pm 0.312\%$) and the highest level of damage ($7.567 \pm 7.857\%$) was calculated in PRP 25861.11. On the weight basis PRP 35861.18 incurred the lowest level of damage ($0.309 \pm 0.221\%$) and the highest level of damage ($9.973 \pm 10.556\%$) was observed in PRP 25861.11. Similarly in white grub screening trial, PRP 35861.18 incurred the lowest infestation ($0.126 \pm 0.063\%$) and PRP 25861.11 was affected much ($9.973 \pm 10.556\%$). And on the weight basis, result was found similar for PRP 35861.18 ($0.126 \pm 0.063\%$) and PRP 25861.11 ($0 \pm 0.221\%$). On the infestation of both white grub and red ant all the tested potato genotypes were statistically at par. However, the lowest tuber infestation ($0.525 \pm 0.063\%$) in number and damage by weight ($0.309 \pm 0.221\%$) and the highest number of tuber infestation was ($9.553 \pm 0.715\%$) as well as the damage by weight ($13.152 \pm 12.699\%$) was documented. It is concluded that the red ant infestation is maximum as compared to other insect pest. Based on the single season data, it can be concluded that the genotype PRP 35861.18 is suitable for the location.

Islam *et al.* (2016) An experiment was conducted with seven sugarcane varieties viz., Isd 33, Isd 34, Isd 35, Isd 36, Isd 37, Isd 38 and local variety (standard) to evaluate their response against some major insect pests at Chunarughat upazilla in Habigonj district under Akhaura Terrace soils (AEZ-30) during the cropping season 2009-2010. Termite infestation ranging from 30-72.66 (no. of population/5 clumps/plot) and the lowest population (30) was found in Isd 38. In case of white grub, infestation ranging from 4.40 to 5.38 (no. of population/5 clumps/plot) and the lowest population (4.4) was found in Isd 36. Isd 37 and Isd 38 were tolerant to root stock borer, stem borer, mealy bug, early shoot borer and termite. Therefore, Isd 37 and Isd 38 may recommended for commercial cultivation in terms of tolerance against insect pests and yield.

Gadhiya & Board (2017) studied the susceptibility of wheat cultivars against termite, an experiment was carried out at Anand Agricultural University, Anand during *rabi* season of 2010-11. Of the 14 cultivars of wheat screened for their relative susceptibility against termite, cultivars GW 411, Lok-1 and VA-07-13 were found superior to suppressing the termite damage and produced higher yield of grain and straw of wheat. The wheat cultivars GW 407, GW 391, GW 410, GW 273, GW 400 and GW 406 were less susceptible to termite incidence, whereas cultivars Raj-1555, GW 496, GW 396, GW 366 and GW 322 gave poor performance against termite. The evaluated cultivars did not affect the population of termite but prevented them from feeding on root/stem. Less termite population was observed in Raj-1555, whereas it was higher in the Lok-1.

Naresh *et al.* (2017) conducted screening of groundnut (*Arachis hypogaea* L.) genotypes against spotted pod borer, *Maruca vitrata* (Geyer) during *rabi* 2015-16 at dryland farm, S.V. Agricultural College, Tirupati. Twenty-five genotypes were screened against the spotted pod borer. Among these per cent infestation of *M. vitrata* was less in K-9, ICGV-86368, TCGS-1426, CS-19 genotypes and more in K-6, Dharani, Narayani and TCGV-1543. The experimental results indicated that spreading type and short stature groundnut cultivars were tolerant to the *M. vitrata* incidence. Physical parameters like chlorophyll content and specific leaf area showed significant effect on incidence of *M. vitrata* in groundnut crop. Chlorophyll content was negatively correlated ($r = -0.48$) with per cent infestation of

M.vitrata at 60 DAS. Specific Leaf area was positively correlated ($r=0.43$) with per cent infestation of *M.vitrata* at 60 DAS and also short stature plants groundnut cultivars were tolerant to *M.vitrata* incidence.

Langdon & Abney (2017) observed six potato (*Solanum tuberosum* L.) cultivars were exposed to the wireworms *Melanotus communis* (Gyllenhal) and *Glyphonyx bimarginatus* (Schaeffer) under no-choice conditions in the laboratory to determine the relative susceptibility of these cultivars to wireworm feeding under high and low soil moisture conditions. Feeding injury by *G.bimarginatus* was not affected by soil moisture but differed by cultivar. Percent injury, mean number of feeding holes, and volume of tuber consumed were significantly higher in Yukon Gold than all other cultivars. Neither head capsule width nor larval weight affected any of the feeding parameters measured for *G. bimarginatus*. Injury incidence and number of feeding holes caused by *M. communis* were significantly higher in high soil moisture conditions; soil moisture had no effect on the volume of tuber consumed. *Melanotus communis* consumed more tissue from Dark Red Norland and Yukon Gold than all other cultivars. Size of *M. communis* larvae did not affect any of the feeding parameters measured.

Chand *et al.* (2019) evaluated the susceptibility of different chickpea varieties based on the per cent termite damaged plants. Out of the 10 chickpea varieties, the lowest 10.91 per cent termite damaged plants were observed in variety RSG-807 followed by RSG-991 (12.31%) and GNG-663 (13.32%). The highest termite damaged plants were observed in GNG-1488 (34.09%) followed by GNG-1581 (29.09%) and RSG-973 (28.97%). In other varieties termite damaged plants were varied from 18.14 to 24.81 per cent. Based on per cent termite damaged plants, chickpea varieties RSG-807, RSG-901 and GNG-663 in which the termite damaged plants were noticed less than 13.42 per cent, are categorized as resistant. However, GNG-2144, CSJ-515, GNG-2171 and CSJD-884 recorded less than 28.88 but more than 13.42 per cent termite damaged plants, were considered as susceptible varieties whereas, RSG-973, GNG-1581 and GNG-1488 had more than 28.88 per cent termite damaged plants and categorized as highly susceptible.

Mahato *et al.* (2021) evaluated the infestation status of insect pest on different wheat variety. Five wheat variety (BARI GOM -24, BARI GOM-25, BARI GOM-27, BARI GOM-28 and BARI GOM-29) were used as a test crop to conduct the study. The experiment was laid out in Randomized Complete Block Design with three replications. Total 5 insect pests were found from this experiment among wheat aphid and wireworm as major and leaf hopper, grass hopper and cereal leaf beetle as minor insect of wheat. The highest insect pest was found in grain filling stage and lowest was found in panicle initiation stage. In grain filling stage, the lowest number of aphid (6.26%) was recorded from BARI GOM-29 and the highest number of wheat aphid (9.11%) was found in BARI GOM-24. Effect of different varieties of plant height, filled grain, unfilled grain, weight of 1000 grain and yield showed significant. The highest yield (3.56 t/ha) was recorded in BARI GOM-29 and the lowest yield (2.29 t/ha) was recorded in BARI GOM-25. The highest percentage of infested spike hill¹ was recorded in BARI GOM-27 and lowest was found in BARI GOM-29. The lowest yield loss (31.53%) was recorded in BARI GOM-29. This is might be due to physical resistance of the varieties. BARI GOM-29 recommended to wheat growers as it is found the most resistant/tolerant wheat cultivar against wheat insect pest with maximum grain yield as compared to other cultivars.

Pawar (2021) conducted screening of groundnut (*Arachis hypogaea* L.) genotypes against earwig, wireworm and subterranean ants pod damage during *rabi* 2019-2020 at Oilseed Research Station, Latur. Out of eighty six genotypes lowest earwig damage were recorded on STVT-I-2020-01(0.00%), STVT-I-2020-07 (0.00%), HOVTSTB-I-2020-07 (0.00%) and HOVTVG-I-2020-07 (0.00%). Highest number of pods damage by earwig were recorded on TSB-I-2020-09 (16.25%), followed by ISK-I-2020-06 (15%), ISK-I-2020-29 (15%). Lowest wireworm damage were recorded on STVT-I-2020-01 (0.00%), STVT-I-2020-07 (0.00%), HOVTSTB-I-2020-07 (0.00%), and HOVTVG-I-2020-07 (0.00%). Highest number of pods damage by wireworm were recorded on TSB-I-2020-09 (17.75%), followed by ISK-I-2020-29 (16.05%), ISK-I-2020-6 (16.25%). Lowest subterranean ant pod damage were recorded on STVT-I-2020-01 (0.00%), STVT-I-2020-07 (0.00%), HOVTSTB-I-2020-07 (0.00%), and HOVTVG-I-2020-07 (0.00%) respectively were highly promising genotype. Highest number of pods damage by subterranean ants were recorded on IVK-I-2020-05 (16.75%) followed by ISK-I-2020-12(16.5%).

Nakabonge & Matovu (2021) evaluated the susceptibility of four hybrid clones: GU7, GC796, GC550 and GC 796/2 and *E.grandis* Hill ex Maid. to the most damaging *Macrotermes bellicosus* (Smeathman) and *Macrotermes subhyalinus* (Rambur) to identify tolerant material that can be planted in high incidence areas. The study involved exposure of moisture dry pieces of wood from *E. grandis* and the four hybrid clones to damage by *M.bellicosus* and *M.subhyalinus*. Results confirmed that *M.bellicosus* is the most aggressive. Results further revealed that *E.grandis* and GC550 are the most susceptible whereas GC 796 is the most tolerant clone.

2.2 To study the abundance of groundnut pod borers

Cherian & Basheer (1940) observed earwigs as pod borers of groundnut. They found *Euborellia stali* Dohm. Feeding on groundnut kernels by boring into the pods at Coimbatore, India. They stated that Burr (1910) observed the association of this earwig with groundnut in Madras and Pondicherry in India. It has been suggested that it may be more widely distributed in southern India. More recently, Das and Ray (1988) reported another species *E. annulipes* Lucas as pod borer in Tripura. In Israel, *Anisolabi* spp. was reported boring into immature pods (Melamed-Madjar and Sholomo, 1970).

Purushottaman *et al.* (1970) reported as high as 46.6 per cent pod infestation. The matured pods were infested to an extent of 44.1 per cent, the intensity of infestation in case of immature pods was 52.1 per cent in Asirya muitunde, a variety of groundnut. Similar high infestation of *Anisolabis annulipes* (= *E. stali*) to the extent of about 40 per cent of bored pods has been observed on the susceptible genotypes in a vertisol field at ICRISAT (ICRISAT, 1986).

Roonwal (1975) studied another insect belonging to Hymenoptera which has been identified as a pod borer is the subterranean ant, *Dorylus orientalis* Westwood. This was found to penetrate or perforates the groundnut pods and consumes the internal contents, in Asia including India. This species was also observed for the first time associated with pod boring at ICRISAT (ICRISAT, 1987).

Bhattacharjee & Bhatia (1980) reported that groundnut was the most preferred host for *H. consanguinea* with a higher grub load of 8.00 grubs/9 m² in 1974 and 9.50 grubs /9m² in 1975. In the present study groundnut recorded higher grub load of 1.95/m² compared to other crops like maize (1.17/m²) and chilli (0.53/m²) with respect to groundnut as the most preferred host of *H. fissa*.

Johnson & Gumel (1981) field trial conducted in northern Nigeria between 1977 and 1979, *Microtermes lepidus* was found to cause extensive damage by attacking the pods, tap root and haulms.

Johnson *et al.* (1981) recorded the incidence of termite scarified groundnut pods and resulting kernel contamination in field and market samples were studied in northern Nigeria. Scarification was caused by *Microtermes lepidus* Sjostedt and restricted to the more mature pods. The incidence of scarification was much higher (40.9-87.9% of the pods) in the dead stands where the tap root had been invaded by *Microtermes*, than in healthy stands (7.9-31.6% of the pods). In the market samples, the number of scarified pods rarely exceeded 5%. 85-91% of the kernels from scarified pods were infected.

Lourencao *et al.* (1982) Observed damage to roots and pods of the groundnut plants by the larvae of the southern corn rootworm, *Diabrotica speciosa* was such that the crop had no commercial value in Brazil.

Keerati- kasikon & Singha (1986) study conducted in 1985 on the incidence of subterranean ants, *Dorylus orientalis* Westwood, reported to be a serious problem in Thailand, observed the damage to occur and increase from the 8th week until maturity. The observations were taken from the seventh through thirteenth week after emergence. Pod damage was found to range from 15-48 per cent, with an average of 31.6 per cent.

In a study conducted to study the distribution and habit of *D. orientalis* at Pak Chong, Nakho Ratchsima, Thailand, it was observed that the subterranean ant formed passage ways underground at a depth of 20-25 cm which may protrude underneath the groundnut plants. The ants bore into groundnut pods and fill the pods

with the soil after feeding on seeds. However, no ant nest was found at the site (Thailand Coordinated Groundnut Improvement Program Progress Report, 1987).

Das & Ray (1988) recorded pod borer incidence as high as 30 per cent and in some samples the average was 9 per cent in Tripura. The borers associated were *E. annulipes*, *D. orientalis*, and *Etiella zinckenella*. *Euborellia annulipes* was also reported as a major pest inflicting 63 per cent damage to pods in Manipur (Barwal, 1985), in a study on the seasonal incidence of the pod borer on fortnightly sowings from April through August. Barwal and Gupta (1991) indicated that the incidence was low in the first three sowings and increased in the summer with increased moisture availability due to rains and decreased from 15th July onwards.

Gough & Brown (1988) showed that one white grub (*Lepidiota* sp.)/3 m row (about 15 plants) caused a loss of pods equal to 44 kg ha⁻¹. Earlier to this 85 per cent loss was reported in Virginia (Bass and Arant, 1973) by the white grub *Strigoderma arboricola*.

Reddy & Sammaiah (1988) observed *Odontotermes brunneus* (Hagen) to bore into the main stem close to ground level, tunnel down into the tap root and up into the stem, at Warangal, India. Termite also damaged pegs and scarified mature pods and occasionally penetrated into their shells.

Wightman & Amin (1988) studied wireworms and false wireworms were found damaging groundnut pods and newly sown seed at ICRISAT Center, but their identity and those of others in Asia are not known. The false wireworm species boring pods in southern Africa has been identified as *Gonocephalum* spp. Wightman (1989) collected larvae of 14 wireworm species, including *Prosephus* spp., *Pseudolophoeus protensus* Gerstaecker, *Cardiophorus* spp. and *Dyakus* spp. at Malawi. None of the 16 possible species of false wireworms has been identified beyond the subfamily level. All these are primarily borers.

Wightman (1989) observed neat 3mm diameter holes in the pods were damage of *Dorylus* spp. In the botanic garden of ICRISAT. The seeds were removed from the pods.

Singh *et al.* (1990) identified *D. orientalis* as a major pest of groundnut showing pod boring habit at Indian Agricultural Research Institute, New Delhi. Another *Dorylus* spp. which is common throughout Southern Africa also showed similar damage symptoms as *D. orientalis* (Wightman and Amin, 1988).

Singh *et al.* (1990) found *Labidura bengalensis* Dohrn as a minor pest associated with groundnut crop from peg initiation to harvest at the Indian Agricultural Research Institute, New Delhi.

Wightman *et al.* (1990) concluded white grubs (Coleoptera: Scarabaeidae) the larvae of *Strigoderma arboricola* (F.) have been reported causing serious damage to peanuts in Virginia (Miller, 1943). The grubs attacked peanut pods and often devoured the kernels. Only two species were found to be important in India *Lachnosterna* (= *Holotrichia*) *consanguinea* Blanch. Mainly in the light alluvial soils of northern India and *L. serrata* F. throughout the subcontinent. *Maladera* spp. is the most abundant white grub in northern Thailand and another unidentified species has been found in northeast Thailand. The white grubs were found to destroy pods at all stages of development.

Nirmala *et al.* (1994) reported more than 20 species of beetles were trapped during different months. In both the years, *Anomala lineatopennk* Blanch. was abundant in June whereas *Holotrichia covifrons* Brenske appeared in July. *Melolontha melolontha* was recorded during July - August in 1992 only, whereas in 1993 it did not appear in Palampur. The emergence of *A. lineatopennk* was favoured by low rainfall as compared to *H. covifrons* and *M. melolontha*.

Eggleton *et al.* (1996) this paper presents data on the abundance, biomass and species richness of termites in the Mbalmayo Forest Reserve, southern Cameroon. Five plots of differing disturbance level (near primary forest, old secondary forest, young plantation, weeded *Chromolaena* fallow, and giving a total of ten sampling areas, plus one in the completely cleared plot in November 1992). Estimated abundance and biomass were extremely high in the near primary and old secondary plot (maximum estimated abundance, old secondary sampling area 1,

10488 m⁻², maximum biomass density, near primary sampling area 1,123.2 g m⁻²). In all cases termite abundance was highly clumped. Disturbance had apparently little effect on termite abundances and biomass in forested plots, but there were clear reductions in abundance and biomass in the cleared plots. In the completely cleared plot, abundance and biomass fell sharply from year 1 to year 2, presumably because colonies left after clearance had dried out and died. It is argued that the near primary forest plot may have higher microhabitat and concomitant termite assemblage heterogeneity than the more disturbed plots. In most cases over 90% of the overall abundance in a sampling area was due to a few species; extinction, and will make areas. This may be due to the unpredictable dynamics of colony foundation and extinction, and will make estimations of the effect of termites on overall ecosystem processes (from abundance and biomass data alone) problematical. There is no evidence of immigration of savanna termites into the forest reserve, and thus cleared areas have depauperate forest assemblages. It is concluded that this is the most accurate estimation of termite assemblage parameters yet attempted.

Mishra & Singh (1996) recorded the highest grub population of *H. longipennis* in the month of August (19.8 grubs/m²) in crates. He further reported decreasing trend in grub population in the month of September (17.4 grubs/m²) that continued till March (5.4 grubs/m²). Whereas barn yard millet recorded 11.2 grubs/m², 9.6 grubs/m², and 3.0 grubs/m² in August, September and March, respectively. This holds good with respect to record of maximum grub load of *H. fissa* (irrespective of locations) in the first fortnight of August (1.40 grubs/m²) and reduction towards first fortnight of September (0.60 grubs/m²) as observed in the present study.

Akhtar & Sarwar (1997) observed four species of termites, i.e. *Microtermes mycophagus*, *M. obesi*, *Odontotermes guptai* and *Eremotermes paradoxalis* were recorded foraging in wheat fields. Termite population density during 1992 and 1993 varied from 11.2/m super (2) to 3439/m super (2). During 1992, average damage to wheat in 4m super (2) varied from 0.58% to 2.5%. During 1993, average damage varied from 1.14% to 5.58%. Termite diversity in wheat fields was 56% on Simpson scale and 67% on Shannon scale of the maximum possible diversity in a system of four species.

Seal *et al.* (1997) studied seasonal abundance and spatial distribution of wireworm feeding damage were determined for sweet potato by examining storage roots. Wireworm feeding damage (deep, shallow and healed holes) increased as the season progressed. The distribution of wireworms in sweet potato fields was clumped as was feeding damage distribution. The spatial distribution of wireworm damage on sweet potato roots fits the negative binomial distribution. Values for the negative binomial parameter k for two fields indicated a clustered distribution of wireworm feeding damage. Greater χ^2 -values for healed feeding damage and total feeding damage than for deep and shallow feeding damage indicate that sample size could be adjusted, depending on seasons, to achieve optimal sampling efficiency. As feeding damage can predict wireworm populations, a sampling strategy based on early-season wireworm damage data is particularly timely, efficient and economical for evaluating wireworm damage data.

Umeh *et al.* (1999) resulted the mean percentages of plants attacked by termites, white grubs and millipedes in the surveyed groundnut fields were 39.4, 10.9, and 9.3% respectively. Yield loss due to termites, which predominantly damaged harvested kernels, was estimated at 9.6-30.4%, and was significantly correlated with percentage of plants damaged by termites ($r^2 = 0.73$).

Muhammad & Muhammad (2003) concluded that there was great difference in mean infestation of *Odontotermes obesus* during 2nd week of the year 2002. Mean infestation percentage was maximum (7.89%) during 2nd week of the year 2002. The infestation rate then declined somewhat and remained between 5.90% - 3.10% during next five weeks. Infestation trend during 9th week declined uncertainly. Then mean infestation decreased to minimum level (1.58%) during 9th week. The reason of this great difference might be that as the crop grew to maturity, it became more vigorous and became resistant to termite attack. During the observation of the environmental factors, it was seen that rainfall and temperature were negatively correlated with mean infestation indicating inverse relationship. Humidity was positively correlated with mean infestation of *Odontotermes obesus* indicating direct relationship.

Singh *et al.* (2004) reported the incidence of *H. longipennis* in different crops like ginger (3.57grubs/m²), finger millet (9.34grubs/m²), capsicum (8.28grubs/m²), amaranthus (3.75grubs/m²), tomato (2.48grubs/m²), cabbage (2.20 grubs/m²), black gram (4.46grubs/m²) and maize (4.67grubs/m²). This is in partial confirmation with the present study of the grub load recorded on maize (1.17/m²) and chilli (0.95/m²) with *H. fissa*.

Kumar *et al.* (2005) concluded that species of white grubs associated with maize and paddy crops and their extent of damage to these crops in Kullu and Mandi districts of Himachal Pradesh, India, between 2001 and 2003. The results revealed that *Melolontha furcicauda*, *M. nepalensis*, *Anomala dimidiata*, *Anomala rufiventris*, *Anomala lineatopennis*, *Phyllognathus dionysius*, *Heteronychus robustus*, *Holotrichia longipennis*, *Xylotrupes gideon*, *Brahmina coriacea* and *Brahmina* spp. caused variable extents of damage to maize crop; Among the beetles recorded, *M. furcicauda*, *M. nepalensis*, *Anomala rufiventris*, *Anomala lineatopennis*, *P. dionysius*, *X. gideon* and *Brahmina* spp. infesting maize; *B. coriaca*, *Maladera* spp., *Anomala dimidiata*, *Anomala rufiventris* and *Adoretus* spp. infesting upland paddy, and On average 28.53 and 36.58% plant damage in maize crop was recorded in Kullu and Mandi districts with the average number of 6.7 and 7.3 grubs/1 m² pit respectively. In Kullu and Mandi districts, the average plant damage to paddy crop due to white grubs was 22.42 and 16.40%, respectively.

Sushil *et al.* (2006) revealed that *A. dimidiata* was the most predominant species. Its relative abundance ranged between 12.78 to 51.96%. However, relative abundance of some of the species like *H. longipennis*, *H. seticollis*, *A. tristis*, *L. stigma* and *X. gideon* was found to be more than 10% at least during one year out of 3 years of experimentation.

Bhanot *et al.* (2009) studied population dynamics of termites in barley field during two years by recording their population at weekly intervals, on Kikar wood stakes. The termite species which attacked this crop were: *Microtermes mycophagus* Desneux, *M. obesi* Holmgren, *Microtermes* spp., *Odontotermes gurdaspurens* is Holmgren and Holmgren, *O. latigula* Snyder, *O. latiguloids* Roonwal & Verma and *O. obesus* (Ramb). A positive correlation between termite population

and mean maximum temperature was observed during both the years. Low populations of termites were observed, whenever heavy rains occurred in the preceding week. Only during one year, a positive correlation between termite population and termite damage was observed.

Dhoj *et al.* (2009) examined abundance and diversity of scarabaeid beetles at five different farming areas in Nepal. Light traps were used to monitor the beetles for 12 months. A total of 4708 scarabaeid beetles of 29 genera and 77 species were trapped during the one year duration of this study. The five most common scarabaeid species in the study areas were *Adoretus coronatus* Burmeister, *Maladera thomsoni* (Brenske), *Anomola bilobata* Arrow, *Holotrichia nigricollis* Brenske and *Anomola dimidiata* (Hope). They accounted for 58.81% of all individuals collected. An inventory of scarabaeid beetles associated with the five different farming areas in Nepal was developed.

Willis *et al.* (2010) conducted to determine the effect of preceding crop on wireworm (Coleoptera: Elateridae) abundance in the coastal plain of North Carolina. In all three studies, samples of wireworm populations were taken from the soil by using oat, *Avena sativa* L., baits. Treatments were depended by the previous year of crop and were chosen to reflect common crop rotations in the region. Across all three studies, eight wireworm species were recovered from the baits: *Conoderus amplicollis* (Gyllenhal), *Conoderus bellus* (Say), *Conoderus falli* (Lane), *Conoderus lividus* (Degeer), *Conoderus scissus* (Schaeffer), *Conoderus vespertinus* (F.), *Glyphonyx bimarginatus* (Schaeffer) and *Melanotus communis* (Gyllenhal). The effect of corn, *Zea mays* L.; cotton, *Gossypium hirsutum* L.; soybean, *Glycine max* (L.) Merr, sweet potato, *Ipomoea batatas* (L.) Lam.; and tobacco (*Nicotiana* spp.) was evaluated in a small-plot replicated study. *M. communis* was the most frequently collected species in the small-plot study and was found in significantly higher numbers following soybean and corn. The mean total number of wireworms per bait (all species) was highest following soybean. A second study conducted in late fall and early spring assessed the abundance of over wintering wireworm populations in commercial fields planted to corn, cotton, peanut (*Arachis hypogaea* L.), soybean, sweet potato, and tobacco in the most recent previous growing season. *C. lividus* was the most abundant species, and the mean total number of wireworms was highest

following corn and soybean. *C. vespertinus* was the most abundant species, and the mean total number of wireworms per bait was highest following corn.

Ahad *et al.* (2011) conducted experiment in free choice conditions at intermediate zone of Jammu and Kashmir, India during *kharif* season 2007. Various beetle populations *viz.* white grub (*Holotrichia consaguinea*) and wireworms (Gyllenhal) were observed at the experimental site. Among these pests *H. consaguinea* populations were found to be the dominating one. Correlation studies depicted that, both *H. consaguinea* adults and grubs were positively correlated with maximum and minimum temperatures. *M. communis* adults, were negatively correlated with relative humidity. As infestation of these insects is concerned wireworm, white grub larvae, white grub adult fed on germinating seedlings, roots, leaves and silk, respectively.

Thakare *et al.* (2011) conducted the survey of scarab beetle faunal diversity, abundance and composition were studied in Kolkas region of Melghat Tiger Reserve, Amravati, Maharashtra, during May to October 2009. Scarab beetles were collected by dung baited pitfall traps and handpicking in five transects with different vegetation type and microhabitat. Total 26 species of scarab beetles belonging to 14 genera and 8 subfamilies were reported. Scarabaeinae was the dominant subfamily with respect to species diversity (15 species) and abundance. *Onthophagus Latreille*, 1802 is the dominant genus observed.

Chandra & Gupta (2012) studied diversity and relative abundance of Pleurostict Scarabaeidae (Coleoptera: Scarabaeidae; Rutelinae, Melolonthinae, Dynastinae, Cetoniinae) were studied and analyzed in Achanakmar-Amarkantak Biosphere Reserve (AABR), Chhattisgarh. Scarab sampling during the years 2004 and 2008 yielded a total of 426 beetles belonging to 26 species distributed in 13 genera and four subfamilies. Between the two selected study areas *viz.* Atariya and Chhapparwa, the highest numbers of scarabs (n=346) were observed in Chhapparwa constituting 24 species under 12 genera and accounting 81.22% of the total number of beetles collected from the biosphere reserve. While from Atariya, 80 scarabs, comprising 13 species belonging to five genera and four subfamilies were collected. The subfamily Rutelinae with 16 species (71.12% of the total individuals) was

dominating over other subfamilies. *Anomala* (9 species) was found the most dominant genus in the scarab population of the biosphere reserve, accounting 57.51% of the total scarabs collected from the study area.

Khanal *et al.* (2012) conducted to study the abundance and distribution of white grubs in three districts representing different ecological dominies in the country during June-July 2010. The dominant species in Chitwan were *Anomala dimidiata* Hope (24%) followed by *Maladera affinis* Blanchard (23.75%), *Anomala varicolor* (Gyllenhal) Rutelinae (23%), *Heteronychus lioderus* Redtenbacher (14%) and *Holotrichia* spp. (7%).

Thakare *et al.* (2012) The paper presents an account of thirty two species of scarab beetles belonging to twenty genera, eight subfamilies and three families under superfamily Scarabaeoidea from Melghat Tiger Reserve, Vidarbha, Maharashtra (India). The family Scarabaeidae includes 30 species while both Geotrupidae and Hyborsoridae are represented by single species. Within Scarabaeidae, the dominant subfamily Scarabaeinae constitute 17 species followed by Cetoniinae (4 species), Melolonthinae (3 species) and Orphninae, Rutelinae and Dynastinae (each with 2 species).

Theurkar *et al.* (2012) reported white grubs became increasingly difficult pests in India for the last few years. White grubs are root feeders and their beetles feeds on the leaves of host plants. Their infestation has been reported throughout the country and magnitude of the problem has been widespread over the past years. Five major species of white grubs especially in Maharashtra namely *Holotrichia consaguinea* Blanchard, *Holotrichia serrata* Fabricius, *Holotrichia fissa* Brenske, *Leucopholis lepidophora* Blanchard, (Melolonthidae), *Anomola* spp. (Rutelidae) in distribution. The *Holotrichia serrata* is most abundant species found in Khed Taluka which is part of Northern Western Ghats (MS), India.

Dadmal *et al.* (2013) reported *Holotrichia* Hope is one of the most economically important genus of Coleoptera: Scarabaeidae: Melolonthinae, attacking Soybean, Sugarcane, Sorghum, Groundnut and many other field crops in Maharashtra. The specimens were collected from five different agro-climatic zones of Maharashtra

viz. South Konkan, Western ghat hills, Northern hills, Western Vidarbha plains and Eastern Vidarbha hills during 2012-2013. Studies revealed the presence of five species viz. *Holotrichia serrata* (Fabricius), *Holotrichia fissa* Brenske, *Holotrichia akolana* Khan and Ghai, *Holotrichia reynaudi* (Blanchard) and *Holotrichia nagpurensis* Khan and Ghai. Morphologically they were slightly varied. *Holotrichia serrata* (Fabricius) was found to be the most prevalent species in every agro-climatic zones of Maharashtra.

Theurkar *et al.* (2013) concluded that the white grubs are destructive and troublesome insect pest all over the world. White grubs have been defined as larvae of Melolonthidae. White grubs found in Khed Taluka particularly *Holotrichia serrata* and *Holotrichia fissa*. The attempt has been made to observed occurrence of white grub found in Southern region of Taluka. The southern regions occupy industries area. Around this region we observe the occurrence *Holotrichia serrata* is more as compared to *Holotrichia fissa*.

Tippannavar & Patil (2013) recorded the infestation of *H. serrata* and *H. fissa* on groundnut, soybean, maize and paddy at Hattarawata (Belagavi district). The mean grub load ranged from 0.50 to 1.56 per m² area with highest grub count of 1.56 per m² in groundnut followed by paddy (1.25/m²) maize (0.90/m²) and soybean (0.50/m²) respectively which is in line with the present study with respect to maximum grub load of *H. fissa* in groundnut (1.95/m²) than other *Kharif* crops like maize (1.17/m²) and chilli (0.95/m²).

Sreedevi *et al.* (2014) revealed that Melolonthinae and Rutelinae were represented with 6 and 7 species under 4 and 2 genera, respectively and Dynastinae was poorly represented with one species. In total, 14 species under 7 genera were attracted to the light traps and seasonal variations in the species diversity and abundance were observed. Whittaker rank abundance curve depicted the presence of *Holotrichia nagpurensis* Khan and Ghai, *Lepidiota mansueta* Burmeister followed by *Anomala dimidiata* (Hope) and *Maladera insanabilis* (Brenske) as common species.

Verma *et al.* (2014) reported that *Odontotermes* spp. are one of the most notorious wood termite which has been sampled in amazing abundance from the

bark of mango trees lower trunk of Ranchi city. On the basis of numerical counting of the sampled termite species during rainy season, the abundance proportion of these two species has been calculated to the tune of 79.33% for *O. obesus* and 20.67% for *O. parvidens* respectively in Zone I (East) whereas it was 78.41% and 21.36% in Zone II (South) of Ranchi. From this statistical analysis it can be inferred that *O. obesus* is dominant over *O. parvidens*.

Chandel *et al.* (2015) studied nearly 20 species of white grubs which attack potato in different parts of India. The most widely distributed and destructive species in India are *Brahmina coriacea*, *Holotrichia longipennis*, *Anomala dimidiata*, *Melolontha indica*, *Lepidiota mansueta* and *Holotrichia serrata*. *H. serrata* is found throughout Karnataka, Maharashtra, Tamil Nadu, Andhra Pradesh, Bihar and Uttar Pradesh, whereas *B. coriacea* and *H. longipennis* are restricted to the northern parts of India. The economic importance of chaffers is primarily due to feeding activity of the third instar grubs. The infected tubers have scooped out holes or half-eaten tubers which are rendered unfit for marketing. The damage to potato tubers has been reported to vary from 8.5 to 75.0% especially in hilly regions of the country.

Pathania *et al.* (2015) conducted the survey of scarabaeidae beetles from 8 landscapes from different zones in Himachal Pradesh India. In 2011 and 2012, surveys were conducted during 4 months period (May-August) by using UV light traps. A total of 13,569 scarabaeidae adults of 20 genera and 56 species belonging to subfamilies Melolonthinae, Rutelinae, Cetoniinae and Dynastinae were recorded. The five most common species were *Brahmina coriacea*, *Adoretus lasiopygus*, *lineatopennis insanabilis* and *Holotrichia longipennis*. They comprised 9.88-10.05, 7.18-7.76, 7.13-7.27, 6.80-7.62 and 5.22-5.30% during 2011-12, respectively. *Anomala* (10 species) was the most dominant genus in the study, whereas Melolonthinae was the most dominant subfamily accounting 53.23% of total scarabs collected from the study sites. Among different landscapes, Palampur had maximum diversity and abundance, while Shillaroo had least diversity but more abundance of single species *B. coriacea*. The value of alpha diversity indices viz., Shannon index was maximum ($H' = 3.01-3.03$) at Palampur. This indicates maximum evenness and abundance of species at Palampur. Shillaroo had lowest Shannon index ($H' = 1.12-1.17$) and Pielou's evenness index ($J' = 0.46-0.49$). This showed least species diversity and

higher unevenness of scarabaeidae beetles at Shillaroo. The results of beta diversity analysis revealed poor similarity of scarabaeid species between different sites confirming that the scarabaeidae community in the north western Himalayan regions is much diverse.

Singaravelu *et al.* (2015) recorded the occurrence of white grub *Brahmina mysoreensis* Frey (Coleoptera: Scarabaeidae) on sugarcane in India and second record of its occurrence in Tamil Nadu state, are reported in this communication. The pest was observed damaging the root system of the crop causing typical withering and drying symptoms in five and seven month old sugarcane crop (cv. Co 86032) in Villupuram district of Tamil Nadu in the last week of October 2015. The larvae maintained in the laboratory on sugarcane roots pupated and adults emerged from them. The possibility of the white grub assuming major pest status in relation to the predominant *Holotrichia serrata* F. (Coleoptera: Scarabaeidae) and groundnut cultivated in the area is discussed.

Shrilakshmi *et al.* (2016) studied white grub larvae cause severe damage to groundnut as well as other commercial crops like potato, sugarcane, pea, maize etc. whereas for plants like bajra, sorghum and maize have adventitious root system can withstand much. The affected plants show varying degrees of yellowing, wilting and death (Rai *et al.*, 1969). The affected plants can be pulled up easily. Patches of dead plants are seen throughout the field which later coalesces to produce intensive areas of damage (Veeresh, 1977). In endemic areas, the damage to groundnut ranges from 20-100 per cent. One grub/m² may cause 80-100 per cent plant mortality (Yadava and Sharma, 1995). White grubs also damage pods causing direct yield losses (Anitha, 1992). In recent times *Holotrichia fissa* Brenske is emerging as a major pest on groundnut and other crops under rain-fed situations of Belagavi district. *H. fissa* was economically important and found in large numbers as compared to other species in Hattarwat village of Chikkodi taluka on ber. Groundnut, soybean, maize and paddy were infested by *H. fissa* and *H. serrata* (Tippannavar and Patil, 2013).

Tanzubil (2016) field sampling were carried out between 2014 and 2015 in five districts *viz*; Tolon, Savelugu, West Mamprusi in the Guinea savannah as well as in Bongo and Builsa North in the Sudan Savannah. Most farmers (80%) were

able to mention and/or describe the key field pests and diseases often associated with groundnuts in Ghana, with termites, millipedes, white grubs and virus diseases and being most frequently mentioned. Though many of the observed pests and diseases (especially the foliar ones) proliferated in most farms sampled, the relative abundance scores (RAS) showed that their incidence and damage were generally low or moderate.

Bhattacharyya *et al.* (2017) evaluated species diversity and abundance of scarab beetles was studied from Assam, northeast India from 2007 to 2013. A total of 44 species of scarabs under 6 sub families and 21 genera were identified, out of which 41 species are new records. Majority of the phytophagous species belonged to the subfamily Melolonthinae and Rutelinae while the coprophagous species belonged to Dynastinae and Cetoniinae. Species profiling revealed that *Apogonia ferruginea* was the most predominant species and contributed 17.60 per cent out of the total number of beetles followed by *Anomala chlorosoma* (14.56%), *Adoretus* spp. (12.75%), *Apogonia area* (10.94%) and *Sophrops irridipennis* (10.63%) with peak population in the month of July (419.14%).

Kumar *et al.* (2017) revealed that 12 major species of Scarabaeidae. Of these, six species belonged to Melolonthinae viz., *Holotrichia serrata* (Fabricius), *Holotrichia consanguinea* (Blanchard), *Holotrichia reynaudi* (Blanchard), *Holotrichia fissa* Brenske, *Maladera insanabilis* (Brenske), *Schizonycha ruficollis* (Fabricius), five species to Rutelinae viz., *Anomala bengalensis* (Blanchard), *Anomala dorsalis* Uttar Pradesh, whereas *B. coriacea* and *H. longipennis* are restricted to the northern parts of india. The economic importance of chaffers is primarily due to feeding activity of the third instar grubs. The infected tubers have scooped out holes or half-eaten tubers which are rendered unfit for marketing. The damage to potato tubers has been reported to vary from 8.5 to 75.0% especially in hilly regions of the country.

Coulibaly *et al.* (2018) studied termites are one of the most abundant invertebrate groups in tropical ecosystems. Despite their important role, termites can cause considerable damage to wooden structures in most tropical countries. According to the standardized rapid estimation method (RAP) of biodiversity, a total

of 12 species of termite were collected. Fungus-growers group with 68% of termite total abundance were the mostly abundant group. The study of termite attacks showed that plants were strongly attacked by termites. Out of 294 trees visited, 274 trees showed traces of termite attacks, a rate of 93%. Termite damage caused leaf drop, dieback and / or death of the plant.

Cherry & Bhadha (2019) reported the wireworm, *Melanotus communis* (Gyllenhal), and the white grub, *Cyclocephala parallela* Casey, are important pests of Florida sugarcane. The objective of this study was to determine the orientation of fed and starved *M. communis* and *C. parallela* larvae to ethanol concentrations in soil. Tests were conducted in rectangular glass containers and circular aluminum containers containing sandy soil and marked off into zones with and without ethanol. Insects were held 48 hour in containers and insect movement among zones recorded. At a high ethanol concentration (10 ml ethanol/860 cm³ soil), both species became comatose, negating any measurement of movement. However, at a low ethanol concentration (2.5 ml ethanol/860 cm³ soil), both species were attracted to ethanol in the soil.

Deshwal *et al.* (2019) studied twelve insect species were found associated with basmati rice in this region, which belong to six orders *viz.* lepidoptera (yellow stem borer, leaf folder and swarming caterpillar), homoptera (green leaf hopper, brown plant hopper and white backed plant hopper), heteroptera (rice gundhi bug), coleoptera (rice root weevil and white grub), isoptera (termite) and orthoptera (grass hopper).

Farook *et al.* (2019) revealed that insect pests cause considerable loss in yield and change their status over time. The crops are heavily attacked by Armyworm, Cereal leaf beetle, Wheat aphid, Grasshopper, White grubs, Ghujia weevil, and Termites. This review endeavors to piece together all known information about the insect that attack on wheat.

Sreedevi *et al.* (2019) Surveys conducted in different parts of the country covering six states (Assam, Himachal Pradesh, Punjab, Kerala, Karnataka, Uttar Pradesh) during 2015-18 revealed the occurrence of white grubs on major fruit

crops like mango, grapes, pomegranate, guava, apple, peach and plum in considerable proportions. Though white grub adults and larvae are known to be pests of fruit crops, they were considered as minor pests. However, the survey results indicate that in the recent past, white grubs are causing considerable damage ranging from 15-40% in different fruit crops and diversity of species occurring also has widened. While young plantations of guava and pomegranate suffered root damage resulting in death of 10–25% plants, other crops were defoliated by adult beetles. White grubs encountered during these surveys mainly belonged to 11 species under six genera viz., *Holotrichia*, *Anomola*, *Maladera*, *Schizonycha*, *Adoretus* and *Popillia*.

Kumar *et al.* (2020) surveyed the termite infestation was started from 4th week after sowing i.e. 4th week of December [52nd standard meteorological week (SMW)] except in field no.13th, 16th and 17th where, it was started from 5th week after sowing. The lowest termite damage (<1%) was observed in 4th week after sowing and highest damage was observed (21.85-39.71%) in 13th week after sowing i.e. 4th week of February (9th SMW). Average termite damage was observed from 7.85 to 16.47%. The lowest termite damage was found in Khajuwala tehsil and highest termite damage was found in Bikaner tehsil of the Bikaner district. As per the identification report *Microtermes obesi*, (Holm) and *Odontotermes obesus* (Rambur) were found to damaging the wheat crop.

Murthy (2020) revealed the occurrence of 18 species of scarabaeid in different agroecological regions of Western ghats of Karnataka were surveyed to assess the diversity of scarabaeid beetles. The rutelinid *Anomola albopilosa* was more dominant (21.34%) followed by melolonthinid *Holotricha serrata* (19.22%). *Leucopholus* spp. was more predominant in the Malanad region. Species richness and abundance was determined by the diversity indices. Higher Shannon's Weiner diversity index (2.73) was registered during 2018.

Kumar *et al.* (2021) A survey had *Holotrichia* been conducted in Pantnagar, Uttarakhand during 2018-19 to ascertain its occurrence of various species from the locality. Light traps and manual scouting on different host trees collection revealed the occurrence of Khan and Ghai. It is a new distributional *Holotrichia nagpurensis* record to the Pantnagar and first report, from Terai region of

Uttarakhand. Their adult beetles feeding, shelter and mating activity was recorded from six host trees i.e *Azadirachta indica* L., *Mangifera indica* L., *Artocarpus heterophyllus* Lam., *Psidium guajava* L., *Zea mays* L., *Melia azedarach* L. from the locality. Overall, maximum occurrence and catches of was recorded from *Holotrichia nagpurensis* was recorded from *A.indica*.

CHAPTER - III
MATERIALS AND METHODS

CHAPTER - III

MATERIALS AND METHODS

The studies entitled, “Screening of groundnut genotypes against pod borers in *kharif* season” were conducted at the Department of Agricultural Entomology, Oilseeds Research Station, Latur (MS)-India during *kharif*, 2021-2022. The details of materials used and the methodology adopted during the course of studies are described under the following heads.

3.1 To screen different groundnut genotypes against groundnut pod borers

3.2 To study the abundance of groundnut pod borers

3.1 To screen different groundnut genotypes against groundnut pod borers

3.1.1 Experimental details

3.1.1.1 Preparatory Cultivation

A representative field of black clay loamy soil was selected, ploughed and levelled with tractor drawn implements thoroughly to obtain fine tilth suitable for seed germination.

3.1.1.2 Field layout

The field experiment to screen different groundnut genotypes against groundnut pod borers with using groundnut genotypes in *kharif*, 2021-2022 was conducted at the Research Farm of Department of Agricultural Entomology, Oilseeds Research Station, Latur, VNMKV, Parbhani (MS)-India.

The experiment was conducted in a randomized block design with Eighty six treatments (entry) with one check LGN-1 of five meter length with two replications. The groundnut crop was sown 8th July 2021 in a gross plot of 0.30 x 5.0 sq. m maintaining net plot of 0.30 x 4.8 sq. m. The row to row distance of 30 cm and plant to plant distance of 10 cm was maintained. The crop was sown under protective irrigation.

3.1.1.3 Sowing

Sowing was done manually and one seed was sown per hill (seed rate 100 kg/ha) with a spacing of 30 x 10 cm during second week of July.

3.1.1.4 Cultural Practices

All the agronomic practices were followed as per the recommendations of VNMKV, Parbhani in raising groundnut crop during the experimental period.

3.1.1.5 Cultural operations

Two hand weeding were done during the crop period to keep the crop free from weeds.

3.1.1.6 Fertilizers

The fertilizers were applied @ 20:40:40 NPK kg/ha as per the recommendations.

3.1.1.7 Experimental details

1. Location : Oilseed Research Station, Latur
2. Season : *Kharif*
3. Date of Sowing : 8/7/2021
4. Experimental design : Randomized Block Design (RBD)
5. Gross plot size : 0.30 m x 5.0 m
6. Net plot size : 0.30 m x 4.8 m
7. Spacing : 30 x 10 cm
8. Treatment(s) : 86 (Groundnut genotypes)
9. check : LGN-1
10. Replication(s) : Two (2)

The experiment was conducted during *Kharif* 2021, at research farm of Oilseeds Research Station, Latur. Genotypes of groundnut obtained from Oilseeds Research station, Latur. The 86 genotypes were screened in the field under natural condition to find out the resistance against groundnut pod borers with LGN-1 as check every 1st and after 12th entry with spacing of 30 x 10 cm in two replications. The groundnut crop was raised as per the recommended package of practices except plant protection measures for insect-pests.

3.1.1.8 Observations

- i. During the study, incidence of the groundnut pod borers (Earwig, Wireworms, White grubs, Termites, and Subterranean ants) across different genotypes will be recorded after harvesting of the groundnut crop.
- ii. After harvesting of groundnut genotypes, pods of each groundnut genotype will be observed for pod borer infestation.
- iii. The data will converted to per cent damage by using below mentioned formula. (suggested by Naresh & Singh (1984).

$$\text{Per cent damage} = \frac{\text{Total No. of pods infested by pod borers}}{\text{Total Number of pods in each genotype}} \times 100$$

- i. The observations for Earwig, wireworms & subterranean ants will be recorded as number of pods damaged.
 - a. Total plants from each growing will be uprooted and the damage will be assessed by the total number of pods damaged by pod borers. i.e. Earwigs wireworms & subterranean ants. The data obtained and per cent pod damages will be worked out, and will be categories as per 1 to 9 scale (**Rohilla R. H. 2004**) and extent of pod scarification on 1 to 9 scale as mentioned below:-

Table 3.1: Rating scale on the basis of per cent pod damage of pod borers

Sr. No.	Index scale	% Pods damaged
1	1	0
2	2	1 to 10
3	3	11 to 20
4	4	21 to 30
5	5	31 to 40
6	6	41 to 50
7	7	51 to 60
8	8	61 to 75
9	9	76 to 100

3.2. To study the abundance of groundnut pod borers

1. Location : Oilseed Research Station, Latur
2. Season : *Kharif*
3. Date of sowing : 10/07/2021
4. Crop : Groundnut
5. Experimental Design : Non-replicated
6. Gross plot size : 0.30 m x 5.0 m
7. Net plot size : 0.30 m x 4.8 m
8. Spacing : 30 x 10 cm
9. Variety : LGN-1
10. Seed rate : 100 kg/ha
11. Fertilizer dose : 20:40:50 NPK kg/ha
12. Irrigation : Protective Irrigation given.

All the package of practices were performed except insect pests management as per the recommendation of V.N.M.K.V. Parbhani for cultivation of groundnut.

A field experiment on to study the abundance of groundnut pod borers was carried out at the Research Farm of Oilseeds Research Station, Latur during *kharif* 2021-2022.

3.2.1 Observations

3.2.1.1 Sampling for extent of damage

- i. During the *kharif* season, weekly 25 plants will be observed for pod borer damage.
- ii. The sampling will be done after 60 DAS and will be continued till harvest of the crop. The damaged pods will be separated from the plants and will be collected in polythene bags for further examination.
- iii. The plants will be uprooted at random, following a zig- zag pattern to avoid bias. The damage will be assessed by counting the total number of pods/plant and total number of pods damaged by pod borers.

3.2.1.2` Collection of pod borers

- i. At the time of sampling groundnut plants for pod borer damage, the soil in the rhizosphere was examined for the present of insects associated with pod boring.
- ii. Soil examination was done with a magnifying lens by spreading the soil collected on polythene sheet. The pod borers so collected were preserved in glass vials containing 70 per cent alcohol and labeled.
- iii. This was done mainly to ascertain whether these insect associated with pod boring and also study the nature of damage by the particular species of the insect. Earwigs, wireworms and s.ants are collected in this manner.

3.2.1.3 Identification of pod borers

Earwigs, wireworms, subterranean ants, termites and white grub was identified on the basis of their damage symptoms. Termites were identified based on the key available at ICRISAT.

3.2.1.4 Nature of damage

- i. The pods collected in the research field for assessing the extent of damage. They were again examined for external symptoms in the fields. The bored pods were examined for the size and shape of the aperture, the position of bore, the most favoured spot of boring, any signs of scraping around the hole i.e., plugged with mud or its excreta or frass or without any of these.
- ii. Wherever the plugging was observed, the material used for plugging was carefully removed with a needle or forceps placed on a paper and its composition was ascertained.
- iii. For examination of internal symptoms the pod was split open and pattern of damage was studied under the microscope - whether the insect in question was directly feeding on the kernels or on the endocarp first.
- iv. The pods were examined for the presence of the kernels or for their remnants and for the pathways made from the entrance hole to the kernel. The pattern of damage, the first kernel to be attacked (i.e., preference), size and shape of feeding bore on kernel, and the presence of extraneous material like soil in the pod or the kernel - all these aspects were studied in detail under the microscope and the rough figures of these were noted down. Whenever a typical symptom was observed colour photographs were taken to aid the description.
- v. For the study of excreta, in the case of earwigs, a circular piece of white paper was cut to fit into the bottom of the plastic cup and an earwig was released into it with a pod for its food. The next day the paper was removed and examined for the presence of excreta.

All the package of practices will be performed except insect pests management as per the recommendation of V.N.M.K.V. Parbhani for cultivation of groundnut.



Plate 3.1: Experimental view of Screening of Groundnut genotypes against pod borers in *kharif* season.



Plate 3.2: Experimental view of to study the abundance of groundnut pod borers.

CHAPTER - IV
RESULTS AND DISCUSSION

CHAPTER - IV

RESULT AND DISCUSSION

The studies on screening of groundnut genotypes against pod borers in *kharif* season were conducted at the Research farm of Oilseed Research Station, Latur, Department of Agricultural Entomology, College of Agriculture (Vasantao Naik Marathwada Krishi Vidyapeeth, Parbhani), Campus Latur (MS)-India during 2021-2022. The results obtained during the present investigations are reported under the following heads.

4.1 To screen different groundnut genotypes against groundnut pod borers

4.2 To study the abundance of groundnut pod borers

4.1 To screen different groundnut genotypes against groundnut pod borers

Eighty six genotypes of groundnut along with check were screened for against earwig, wireworm and subterranean ants through a field trail during *kharif* 2021-2022. The data on per cent pod damage on earwig, wireworm, subterranean ants is presented in the table 4.1

Table 4.1: Per cent pod infestation of pod borers in different genotypes of groundnut

Sr. No.	Genotypes	Earwig	Wireworm	Sub. Ants
1	HOVTVG-I 2021-1	2.61 (9.30)	5.75 (13.81)	5.85 (13.81)
2	HOVTVG-I 2021-2	5.79 (13.88)	6.78 (15.07)	7.45 (15.83)
3	HOVTVG-I 2021-3	2.01 (7.86)	2.02 (8.10)	2.73 (9.23)
4	HOVTVG-I 2021-4	2.84 (9.65)	2.25 (8.58)	2.35 (8.44)
5	HOVTVG-I 2021-5	3.91 (11.38)	7.66 (15.74)	6.10 (14.28)
6	HOVTVG-I 2021-7	3.27	1.07	1.57

		(7.40)	(4.20)	(5.10)
7	HOVTVG-I 2021-8	3.26 (10.40)	2.51 (9.11)	3.82 (11.26)
8	HOVTVG-I 2021-9	3.50 (10.77)	5.00 (12.92)	4.40 (12.09)
9	HOVTVG-I 2021-10	4.66 (12.44)	4.24 (11.81)	5.51 (13.52)
10	HOVTSB-I 2021-1	3.72 (11.12)	3.34 (10.31)	3.02 (9.77)
11	HOVTSB-I 2021-2	3.53 (10.79)	2.93 (9.82)	2.52 (9.09)
12	HOVTSB-I 2021-3	2.43 (8.73)	2.73 (9.32)	2.66 (9.27)
13	HOVTSB-I 2021-4	4.73 (12.50)	4.20 (11.83)	3.91 (11.35)
14	HOVTSB-I 2021-5	4.04 (11.57)	4.60 (12.38)	3.26 (10.33)
15	HOVTSB-I 2021-7	3.75 (11.15)	4.83 (12.68)	3.75 (11.15)
16	HOVTSB-I 2021-8	3.56 (10.82)	4.75 (12.58)	3.30 (10.43)
17	HOVTSB-I 2021-9	5.20 (13.16)	4.15 (11.74)	5.23 (13.12)
18	HOVTSB-I 2021-10	3.90 (11.17)	3.29 (10.31)	3.16 (9.91)
19	HOVTSB-I 2021-11	2.68 (9.41)	2.90 (9.58)	2.49 (9.04)
20	HOVTSB-I 2021-13	3.57 (10.83)	4.31 (11.95)	3.56 (10.54)
21	HOVTSB-I 2021-14	3.26 (10.36)	3.98 (11.49)	3.91 (11.35)
22	HOVTSB-I 2021-15	2.47 (9.01)	3.34 (10.49)	2.57 (9.17)

23	HOVTSB-I 2021-16	3.46 (10.70)	3.66 (10.89)	3.06 (9.91)
24	HOVTSB-I 2021-17	3.45 (10.70)	3.41 (10.57)	3.21 (10.30)
25	HOVTSB-I 2021-18	4.85 (12.72)	4.89 (12.75)	4.55 (12.31)
26	HOVTSB-I 2021-19	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
27	AHOVTSB2021-1	3.41 (10.63)	3.86 (11.21)	3.27 (10.19)
28	AHOVTSB2021-2	3.88 (11.34)	3.96 (11.38)	5.07 (12.92)
29	AHOVTSB2021-3	2.24 (8.54)	2.96 (9.81)	2.44 (8.98)
30	AHOVTSB2021-4	2.09 (8.24)	2.24 (8.39)	1.71 (7.34)
31	AHOVTSB2021-5	2.47 (8.97)	2.23 (8.50)	2.24 (8.45)
32	AHOVTSB2021-6	2.87 (9.74)	2.92 (9.78)	2.84 (9.69)
33	AHOVTSB2021-7	4.53 (12.20)	3.34 (10.43)	3.74 (11.13)
34	LSVT-I 2021-1	7.94 (16.28)	6.70 (14.93)	7.61 (16.00)
35	LSVT-I 2021-2	0.91 (3.87)	0.00 (0.00)	1.37 (4.75)
36	LSVT-I 2021-3	5.70 (13.80)	4.06 (11.62)	6.79 (15.08)
37	LSVT-I 2021-4	6.75 (15.03)	7.49 (15.84)	9.63 (18.03)
38	LSVT-I 2021-5	4.64 (12.43)	5.28 (13.28)	5.07 (12.89)
39	LSVT-I 2021-6	7.31	6.44	8.96

		(14.98)	(14.69)	(17.34)
40	LSVT-I 2021-7	2.24 (8.61)	0.40 (2.54)	1.85 (7.79)
41	LSVT-I 2021-8	4.58 (12.19)	4.68 (12.49)	4.50 (12.19)
42	LSVT-I 2021-9	5.01 (12.83)	5.73 (13.80)	5.36 (13.23)
43	AVK-2021-1	5.65 (13.72)	7.69 (16.07)	6.93 (15.24)
44	AVK-2021-2	11.64 (19.91)	18.07 (25.15)	10.99 (19.34)
45	AVK-2021-3	12.24 (20.46)	11.20 (19.31)	10.91 (19.23)
46	AVK-2021-4	4.78 (12.62)	5.83 (13.97)	3.73 (11.12)
47	AVK-2021-5	8.60 (17.00)	11.47 (19.39)	6.32 (14.55)
48	IVK-I 2021-1	3.33 (10.37)	3.06 (10.07)	3.71 (11.09)
49	IVK-I 2021-2	4.24 (11.83)	3.84 (11.24)	5.24 (13.21)
50	IVK-I 2021-4	4.52 (12.27)	4.64 (12.40)	3.57 (10.85)
51	IVK-I 2021-5	5.66 (13.73)	5.17 (13.05)	6.26 (14.37)
52	IVK-I 2021-6	1.38 (6.37)	1.65 (7.34)	0.89 (5.40)
53	IVK-I 2021-7	4.02 (11.56)	4.57 (12.23)	5.95 (14.01)
54	IVK-I 2021-9	0.00 (0.00)	2.00 (7.58)	0.56 (3.02)
55	IVK-I 2021-10	5.72 (13.80)	4.84 (12.68)	5.82 (13.62)

56	IVK-I 2021-11	4.76 (12.53)	4.80 (12.63)	5.98 (13.92)
57	IVK-I 2021-12	5.77 (13.82)	5.73 (13.83)	6.68 (14.97)
58	IVK-I 2021-13	0.51 (2.89)	5.00 (9.21)	5.39 (9.57)
59	IVK-I 2021-14	2.87 (9.70)	4.67 (11.98)	4.46 (11.99)
60	IVK-I 2021-15	4.03 (11.47)	7.11 (15.02)	6.17 (13.69)
61	IVK-I 2021-16	2.29 (8.70)	4.50 (12.22)	3.32 (10.31)
62	IVK-I 2021-17	6.35 (14.53)	4.81 (12.63)	5.69 (13.65)
63	IVK-I 2021-18	4.58 (12.24)	5.00 (12.73)	5.50 (13.54)
64	ISK-I-2021-1	4.13 (11.70)	5.14 (13.04)	3.70 (11.05)
65	ISK-I-2021-2	3.28 (10.41)	3.44 (10.68)	2.74 (9.53)
66	ISK-I-2021-3	12.84 (20.85)	7.08 (15.29)	5.12 (13.02)
67	ISK-I-2021-4	13.88 (21.84)	15.68 (23.31)	10.37 (18.78)
68	ISK-I-2021-6	2.96 (9.84)	5.47 (13.51)	3.89 (11.34)
69	ISK-I-2021-7	3.85 (11.24)	4.95 (12.81)	4.03 (11.48)
70	ISK-I-2021-8	6.62 (14.87)	8.53 (16.87)	6.69 (14.54)
71	ISK-I-2021-9	3.19 (10.27)	3.45 (10.67)	3.20 (10.11)
72	ISK-I-2021-10	6.12	6.65	11.17

		(14.00)	(14.36)	(19.35)
73	ISK-I-2021-11	7.15 (15.48)	8.47 (16.91)	7.61 (15.80)
74	ISK-I-2021-12	6.07 (14.18)	7.32 (15.54)	5.40 (13.41)
75	ISK-I-2021-13	3.23 (10.35)	3.54 (10.78)	3.14 (10.10)
76	ISK-I-2021-14	4.52 (12.28)	4.35 (11.99)	3.02 (9.98)
77	ISK-I-2021-15	3.73 (11.12)	4.95 (12.73)	3.24 (10.32)
78	ISK-I-2021-16	4.65 (12.43)	4.12 (11.61)	2.75 (9.30)
79	ISK-I-2021-18	3.96 (11.35)	4.00 (11.51)	3.36 (10.49)
80	ISK-I-2021-19	4.88 (12.75)	6.68 (14.94)	4.30 (11.95)
81	ISK-I-2021-20	3.24 (10.37)	3.43 (10.63)	3.39 (10.60)
82	ISK-I-2021-21	5.11 (13.04)	5.63 (13.72)	4.67 (12.27)
83	ISK-I-2021-22	4.01 (11.55)	3.94 (11.39)	3.01 (9.96)
84	ISK-I-2021-24	3.35 (10.44)	2.59 (8.88)	2.54 (8.95)
85	ISK-I-2021-26	5.47 (12.82)	4.84 (12.43)	12.26 (20.40)
86	ISK-I-2021-27	1.01 (4.08)	4.93 (12.78)	5.62 (13.69)
87	LGN-1 (Susceptible check)	10.99 (19.34)	11.64 (19.91)	10.91 (19.23)
	C.D.	4.55	5.19	5.49
	SE(m)	1.64	1.87	1.98

	C.V.	20.32	22.07	23.92
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Note: Figure in parenthesis are angular transformed value.

4.1.1 Screening of groundnut genotypes against earwig

The eighty six genotypes along with check of groundnut were also grouped in to scale (1-9) depends on % pod damage.

The data presented in the table 4.1 and 4.2 revealed that the pod damage due to Earwig ranged was between 0 to 13.88 per cent. Out of eighty six genotypes screened for earwig pod damage along with susceptible check. Both the entries HOVTSB-I 2021-19 (0.00%) and IVK-I 2021-9 (0.00%) recorded 0 per cent pod damage. However, HOVTVG-I 2021-3 (2.01%), HOVTVG-I 2021-1 (2.61%), HOVTVG- I 2021-4 (2.84%), recorded of scale 2 having pod damage between 1 to 10. Whereas the genotype ISK-I 2021-4 (13.88%), ISK-I 2021-3 (12.84%), AVK-2021-3 (12.24%), AVK-2021-2 (11.64%) and check LGN-1(10.99%) recorded in the scale 3 having pod damage between 11 to 20 per cent. Out of eighty six genotypes two genotypes having pod damage 0 per cent, eighty genotypes have pod damage between 1 to 10 per cent and the four genotypes having damage between 11 to 20. The genotypes HOVTSB-I 2021-19 and IVK-I 2021-9 recorded No pod damage and formed promising genotype for earwigs.

Similar result are observed by Chillar *et al.* (2004) observed less incidence of earwig on genotypes JL-24, JL-1 and CO1.

Our findings are also in agreement with Pawar (2021) who screened 92 genotypes against earwig pod damage. The earwig damage ranged between 0 to 16.25 per cent. Lowest earwig damage were recorded on STVT-I-2020-01 (0.00%), STVT-I-2020-07 (0.00%), HOVTSTB-I-2020-07 (0.00%), and HOVTVG-I-2020-07 (0.00%). Highest number of pods damage by earwig were recorded on TSB-I-2020-09 (16.25%), followed by ISK-I-2020-06 (15%) and ISK-I-2020-29 (15%).

Table 4.2: Grouping of scale depending upon the % pod damage to earwig

Sr. No	Scale (1-9)	% pod damage	Name of genotypes
1	1	0	HOVTSB-I 2021-19, IVK-I 2021-9
2	2	1 to 10	HOVTVG-I 2021-1, HOVTVG- I 2021-2, HOVTVG-I 2021-3, HOVTVG-I 2021-4, HOVTVG-I 2021-5 , HOVTVG-I 2021-7, HOVTVG-I 2021-8, HOVTVG-I 2021-9, HOVTVG-I 2021-10, HOVTSB-I 2021-1, HOVTSB-I 2021-2, HOVTSB-I 2021-3, HOVTSB-I 2021-4, HOVTSB-I 2021-5, HOVTSB-I 2021-7, HOVTSB-I 2021-8, HOVTSB-I 2021-9, HOVTSB-I 2021-10, HOVTSB-I 2021-11, HOVTSB-I 2021-13, HOVTSB-I 2021-14, HOVTSB-I 2021-15, HOVTSB-I 2021-16, HOVTSB-I 2021-17, HOVTSB-I 2021-18, AHOVTSB2021-1, AHOVTSB2021-2. AHOVTSB2021-3, AHOVTSB2021-4, AHOVTSB2021-5, AHOVTSB2021-6, AHOVTSB2021-7, LSVT-I 2021-1, LSVT-I 2021-2, LSVT-I 2021-3, LSVT-I 2021-4, LSVT-I 2021-5, LSVT-I 2021-6, LSVT-I 2021-7, LSVT-I 2021-8, LSVT-I 2021-9, AVK-2021-1, AVK-2021-4, AVK-2021-5, IVK-I 2021-1, IVK-I 2021-2, IVK-I 2021-3, IVK-I 2021-4, IVK-I 2021-5, IVK-I 2021-6, IVK-I 2021-7, IVK-I 2021-10, IVK-I 2021-11, IVK-I 2021-12, IVK-I 2021-13, IVK-I 2021-14, IVK-I 2021-15, IVK-I 2021-16, IVK-I 2021-17, IVK-I 2021-18, ISK-I-2021-1, ISK-I-2021-2, ISK-I-2021-6, ISK-I-2021-7, ISK-I-2021-8, ISK-I-2021-9, ISK-I-2021-10, ISK-I-2021-11, ISK-I-2021-12, ISK-I-2021-13, ISK-I-2021-14, ISK-I-2021-15, ISK-I-2021-16, ISK-I-2021-18, ISK-I-2021-19, ISK-I-2021-20, ISK-I-2021-21, ISK-I-2021-22, ISK-I-2021-24, ISK-I-2021-26, ISK-I-2021-27
3	3	11 to 20	ISK-I 2021-4, ISK-I 2021-3, AVK-2021-3,

			AVK-2021-2, LGN-1
4	4	21 to 30	-
5	5	31 to 40	-
6	6	41 to 50	-
7	7	51 to 60	-
8	8	61 to 75	-
9	9	76 to 100	-

4.1.2 Screening of groundnut genotypes against wireworm

The eighty six genotypes along with check of groundnut were also grouped in to scale (1-9) depends on % pod damage. The data presented in the table 4.1 and 4.3 revealed that the pod damage due to wireworms ranged between 0 to 18.07 per cent. Out of eighty six genotypes screened for wireworm pod damage HOVTSB-I 2021-19 (0.00%), LSVT-I 2021-2 (0.00%) recorded of scale 1 having pod damage 0 per cent. However, genotypes HOVTVG-I 2021-10 (4.24%), HOVTSB-I 2021-1 (3.34%) recorded of scale 2 having pod damage between 1 to 10 per cent. whereas, genotypes ISK-I 2021-4 (15.68%), AVK-2021-3(11.20%), AVK-2021-2(18.07), AVK-2021-5(11.47%) and check LGN-1(11.47%) recorded in the scale 3 having 11 to 20 per cent pod damage. Out of eighty six genotypes two genotypes having pod damage 0 per cent, eighty genotypes have pod damage between 1 to 10 per cent, and the four genotypes having damage between 11 to 20. The genotypes HOVTSB-I 2021-19 and LSVT-I 2021-2 recorded No pod damage and formed promising for wireworms.

Similar results are reported by Chillar *et al.* (2004) which showed JL-1 and CO1 varieties were reported less damage due to wireworm.

Our findings are also in agreed with Pawar (2021) who screened 92 genotypes against wireworm pod damage. The wireworm damage ranged between 0 to 17.75 per cent. Lowest wireworm damage were recorded on STVT-I-2020-01 (0.00%), STVT-I-2020-07 (0.00%), HOVTSTB-I-2020-07 (0.00%), and HOVTVG-I-

2020-07 (0.00%). Highest number of pods damage by wireworm were recorded on TSB-I-2020-09 (17.75%), followed by ISK-I-2020-29 (16.05%), ISK-I-2020-6 (16.25%). Our observations are also found similar with these results.

Table 4.3: Grouping of scale depending upon the % pod damage to wireworm

Sr. No	Scale (1-9)	% pod damage	Name of genotypes
1	1	0	HOVTSB-I 2021-19, LSVT-I 2021-2
2	2	1 to 10	HOVTVG-I 2021-1, HOVTVG- I 2021-2, HOVTVG-I 2021-3, HOVTVG-I 2021-4, HOVTVG-I 2021-5 , HOVTVG-I 2021-7, HOVTVG-I 2021-8, HOVTVG-I 2021-9, HOVTVG-I 2021-10, HOVTSB-I 2021-1, HOVTSB-I 2021-2, HOVTSB-I 2021-3, HOVTSB-I 2021-4, HOVTSB-I 2021-5, HOVTSB-I 2021-7, HOVTSB-I 2021-8, HOVTSB-I 2021-9, HOVTSB-I 2021-10, HOVTSB-I 2021-11, HOVTSB-I 2021-13, HOVTSB-I 2021-14, HOVTSB-I 2021-15, HOVTSB-I 2021-16, HOVTSB-I 2021-17, HOVTSB-I 2021-18, AHOVTSB2021-1, AHOVTSB2021-2. AHOVTSB2021-3, AHOVTSB2021-4, AHOVTSB2021-5, AHOVTSB2021-6, AHOVTSB2021-7, LSVT-I 2021-1, LSVT-I 2021-3, LSVT-I 2021-4, LSVT-I 2021-5, LSVT-I 2021-6, LSVT-I 2021-7, LSVT-I 2021-8, LSVT-I 2021-9, AVK-2021-1, AVK-2021-4, IVK-I 2021-1, IVK-I 2021-2, IVK-I 2021-3, IVK-I 2021-4, IVK-I 2021-5, IVK-I 2021-6, IVK-I 2021-7, IVK-I 2021-10, IVK-I 2021-11, IVK-I 2021-12, IVK-I 2021-13, IVK-I 2021-14, IVK-I 2021-15, IVK-I 2021-16, IVK-I 2021-17, IVK-I 2021-18, ISK-I-2021-1, ISK-I-2021-2, ISK-I-2021-3, ISK-I-2021-6, ISK-I-2021-7, ISK-I-2021-8, ISK-I-2021-9, ISK-I-2021-10, ISK-I-2021-11, ISK-I-2021-12, ISK-I-2021-13, ISK-I-2021-14, ISK-I-2021-15, ISK-I-2021-16, ISK-I-2021-18, ISK-I-

			2021-19, ISK-I-2021-20, ISK-I-2021-21, ISK-I-2021-22, ISK-I-2021-24, ISK-I-2021-26, ISK-I-2021-27
3	3	11 to 20	ISK-I 2021-4, AVK-2021-3, AVK-2021-2, AVK-2021-5, LGN-1
4	4	21 to 30	-
5	5	31 to 40	-
6	6	41 to 50	-
7	7	51 to 60	-
8	8	61 to 75	-
9	9	76 to 100	-

4.1.3 Screening of groundnut genotypes against subterranean ants

The eighty six genotypes along with check of groundnut were also grouped in to scale (1-9) depends on % pod damage. The data presented in the table 4.1 and 4.4 revealed that the pod damage due to subterranean ants ranged between 0 to 12.26 per cent. Out of eighty six genotypes screened for subterranean ant pod damage, the genotype HOVTSB-I 2021-19 recorded of scale 1 having pod damage 0 per cent and also IVK-I-2021-9 & IVK-I 2021-6 recorded very less per cent pod damage i.e. 0.56 & 0.89 respectively. However, genotypes AHOVTSB2021-3(2.44%), AHOVTSB2021-2 (5.07%), LSVT-I 2021-1(7.61%) recorded of scale 2 having pod damage between 1 to 10 per cent. whereas, genotypes ISK-2021-10 (11.17%), AVK-2021-3(10.91%), AVK-2021-2 (10.99%), check LGN-1(10.91%) & highest was recorded in ISK-I-2021-26 i.e. 12.26 per cent recorded in the scale 3 having 11 to 20 per cent pod damage. Out of eighty six genotypes only one genotype having pod damage 0 per cent, eighty one genotypes have pod damage between 1 to 10 per cent, and the four genotypes having damage between 11 to 20. The genotype HOVTSB-I 2021-19 recorded No pod damage & formed promising for subterranean ants.

Similarly, Chillar *et al.* (2004) reported four varieties JL-24, JL-1, TMV 2 and CO1 from India have been found less susceptible to subterranean ant in the field.

Our findings are also in agreement with Pawar (2021) who screened 92 genotypes against subterranean ant pod damage indicated that the pod damage range between 0 to 16.75% per cent. Lowest subterranean ant pod damage were recorded on STVT-I-2020-01 (0.00%), STVT-I-2020-07 (0.00%), HOVTSTB-I-2020-07 (0.00%), and HOVTVG-I-2020-07 (0.00%) and reported as highly promising genotype. Highest number of pods damage by subterranean ants were recorded on IVK-I-2020-05 (16.75%) followed by ISK-I-2020-12(16.5%).

Table 4.4: Grouping of scale depending upon the % pod damage to subterranean ants

Sr. No	Scale (1-9)	% pod damage	Name of genotypes
1	1	0	HOVTSB-I 2021-19
2	2	1 to 10	HOVTVG-I 2021-1, HOVTVG-I 2021-2, HOVTVG-I 2021-3, HOVTVG-I 2021-4, HOVTVG-I 2021-5, HOVTVG-I 2021-7, HOVTVG-I 2021-8, HOVTVG-I 2021-9, HOVTVG-I 2021-10, HOVTSB-I 2021-1, HOVTSB-I 2021-2, HOVTSB-I 2021-3, HOVTSB-I 2021-4, HOVTSB-I 2021-5, HOVTSB-I 2021-7, HOVTSB-I 2021-8, HOVTSB-I 2021-9, HOVTSB-I 2021-10, HOVTSB-I 2021-11, HOVTSB-I 2021-13, HOVTSB-I 2021-14, HOVTSB-I 2021-15, HOVTSB-I 2021-16, HOVTSB-I 2021-17, HOVTSB-I 2021-18, AHOVTSB2021-1, AHOVTSB2021-2, AHOVTSB2021-3, AHOVTSB2021-4, AHOVTSB2021-5, AHOVTSB2021-6, AHOVTSB2021-7, LSVT-I 2021-1, LSVT-I 2021-3, LSVT-I 2021-4, LSVT-I 2021-5, LSVT-I 2021-6, LSVT-I 2021-7, LSVT-I 2021-8, LSVT-I 2021-9, AVK-2021-1, AVK-2021-4, IVK-I

			2021-1, IVK-I 2021-2, IVK-I 2021-3, IVK-I 2021-4, IVK-I 2021-5, IVK-I 2021-6, IVK-I 2021-7, IVK-I 2021-10, IVK-I 2021-11, IVK-I 2021-12, IVK-I 2021-13, IVK-I 2021-14, IVK-I 2021-15, IVK-I 2021-16, IVK-I 2021-17, IVK-I 2021-18, ISK-I-2021-1, ISK-I-2021-2, ISK-I-2021-3, ISK-I-2021-6, ISK-I-2021-7, ISK-I-2021-8, ISK-I-2021-9, , ISK-I-2021-11, ISK-I-2021-12, ISK-I-2021-13, ISK-I-2021-14, ISK-I-2021-15, ISK-I-2021-16, ISK-I-2021-18, ISK-I-2021-19, ISK-I-2021-20, ISK-I-2021-21, ISK-I-2021-22, ISK-I-2021-24, ISK-I-2021-27, ISK-I-2021-4
3	3	11 to 20	ISK-I 2021-26, ISK-2021-10, AVK-2021-3, AVK-2021-2 , LGN-1
4	4	21 to 30	-
5	5	31 to 40	-
6	6	41 to 50	-
7	7	51 to 60	-
8	8	61 to 75	-
9	9	76 to 100	-

Other scientist Chand *et al.* (2019) also screened 10 varieties against termite. Out of the ten varieties, lowest 10.91 per cent termite damaged observed in variety RSG-807 followed by RSG-991(12.31%) and CNG-663 (13.32%). The highest termite damage were observed in CNG-1488 (34.09%) followed by CNG-1581 (29.09%) and RSG-973 (28.97%). Based on per cent termite damaged plants, he categorized varieties.

Similar report are found by scientist Amin *et al.* (1985) had screened 530 genotypes against pod scarifying termite (*Odontotermes* sp) for three years field screening trials. The most resistant genotype were NC Ac 2243 (T and DP), NC Ac

2240 (T and DP), and NC 343. Other genotypes NC Ac 10033, FESR 386, NC Ac 2142, NC Ac 17888, NC Ac 2242 and NC Ac 2230, NC Ac 1705 and M13 also showed substantially lower damage than standards. These result are collaborated with our results.

Our findings are also in agreement with Shukla (2008) they screened four varieties of wheat against termite and found that the lowest infestation was found in variety LOK-I where as the variety Raj-3077 were moderately susceptible to termites showed higher infestation of termite. While G.W-173 and Raj-3765 were found moderate susceptible to termite infestation.

However, Gadhiya & Board (2017) observed less termite population on Raj-1555, whereas it was higher in the Lok-1.

Similaraly, Naresh *et al.* (2017) reported per cent infestation of groundnut pod borers was less in K-9, ICGV-86368, TCGS-1426, CS-19 genotypes and more in K-6, Dharani, Narayani and TCGV-1543.



HOVTSB-I 2021-19
Free from pod damage



IVK-I-2021-13
Lowest pod damage



LSVT-I 2021-1
Lowest pod damage

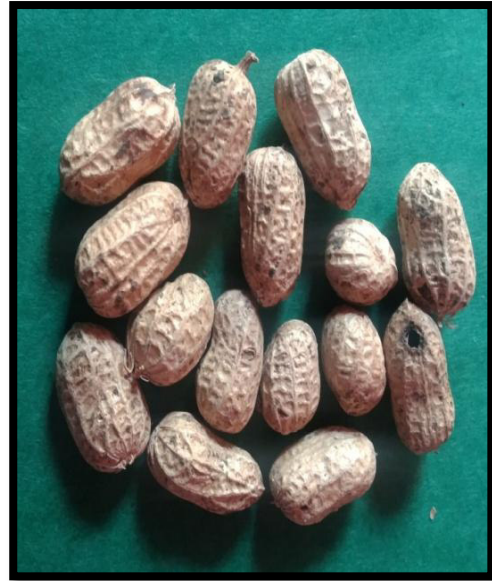


ISK-I 2021-4
Highest pod damage

Plate 4.1: Groundnut genotypes based on their pod damage to Earwig



HOVTSB-I 2021-19
Free from pod damage



LSVT-I 2021-7
Lowest pod damage



ISK-I-2021-8
Lowest pod damage



AVK-2021-2
Highest pod damage

Plate 4.2: Groundnut genotypes based on their pod damage to wireworm



HOVTSB-I 2021-19
Free from pod damage



IVK-I-2021-9
Lowest pod damage



IVK-I 2021-15
Lowest pod damage



ISK-I 2021-26
Highest pod damage

Plate 4.3: Groundnut genotypes based on their pod damage to subterranean ants

4.1.4 Pod yield of groundnut genotypes during *kharif* 2021-2022

The data presented in table 4.5 revealed that the groundnut pod yield ranged from 743 kg/ha to 3627 kg/ha. The significantly highest pod yield was recorded by the HOVTVG-I 2021-7 (3627 kg/ha) which was found significantly superior for yield than other all genotypes, which was followed by HOVTSB-I-2021-19 (3523kg/ha). The next genotypes which recorded maximum yield were IVK-I 2021-9 (3373kg/ha), LSVT-I-2021-2 (3367kg/ha). However lowest was recorded in ISK-I 2021-4 i.e. 743 kg/ha.

The genotypes HOVTVG-I-2021-7, HOVTVG-I-2021-8, AHOVTSB2021-6, AHOVTSB2021-4, HOVTVG-I2021-3, ISK-I-2021-13 were good yielders and had a moderate level of resistance to earwig, wireworm and subterranean ants. The genotype HOVTSB-I-2021-19 is unique in being resistant to earwig, wireworm and subterranean ant & also having good yield.

Table 4.5: Pod yield of groundnut genotypes during *kharif* 2021-2022

Sr. No.	Genotypes	Yield Mean Kg/ha
1	HOVTVG-I 2021-1	1963
2	HOVTVG-I 2021-2	2037
3	HOVTVG-I 2021-3	3130
4	HOVTVG-I 2021-4	2660
5	HOVTVG-I 2021-5	897
6	HOVTVG-I 2021-7	3627
7	HOVTVG-I 2021-8	3260
8	HOVTVG-I 2021-9	2110
9	HOVTVG-I 2021-10	2363
10	HOVTSB-I 2021-1	2250
11	HOVTSB-I 2021-2	2277
12	HOVTSB-I 2021-3	2073
13	HOVTSB-I 2021-4	1540
14	HOVTSB-I 2021-5	2040
15	HOVTSB-I 2021-7	1727
16	HOVTSB-I 2021-8	1527

17	HOVTSB-I 2021-9	1207
18	HOVTSB-I 2021-10	2607
19	HOVTSB-I 2021-11	1983
20	HOVTSB-I 2021-13	2630
21	HOVTSB-I 2021-14	2370
22	HOVTSB-I 2021-15	2810
23	HOVTSB-I 2021-16	2957
24	HOVTSB-I 2021-17	2983
25	HOVTSB-I 2021-18	2733
26	HOVTSB-I 2021-19	3523
27	AHOVTSB2021-1	2177
28	AHOVTSB2021-2	1750
29	AHOVTSB2021-3	3083
30	AHOVTSB2021-4	3167
31	AHOVTSB2021-5	3033
32	AHOVTSB2021-6	3233
33	AHOVTSB2021-7	2747
34	LSVT-I 2021-1	1400
35	LSVT-I 2021-2	3367
36	LSVT-I 2021-3	1947
37	LSVT-I 2021-4	867
38	LSVT-I 2021-5	1793
39	LSVT-I 2021-6	1287
40	LSVT-I 2021-7	2590
41	LSVT-I 2021-8	1807
42	LSVT-I 2021-9	1367
43	AVK-2021-1	1987
44	AVK-2021-2	947
45	AVK-2021-3	807
46	AVK-2021-4	1083
47	AVK-2021-5	833
48	IVK-I 2021-1	2003

49	IVK-I 2021-2	2170
50	IVK-I 2021-4	1747
51	IVK-I 2021-5	2500
52	IVK-I 2021-6	2840
53	IVK-I 2021-7	2217
54	IVK-I 2021-9	3373
55	IVK-I 2021-10	1117
56	IVK-I 2021-11	1477
57	IVK-I 2021-12	920
58	IVK-I 2021-13	3300
59	IVK-I 2021-14	1950
60	IVK-I 2021-15	1373
61	IVK-I 2021-16	2057
62	IVK-I 2021-17	1150
63	IVK-I 2021-18	1757
64	ISK-I-2021-1	2957
65	ISK-I-2021-2	2573
66	ISK-I-2021-3	1077
67	ISK-I-2021-4	743
68	ISK-I-2021-6	2167
69	ISK-I-2021-7	2753
70	ISK-I-2021-8	1330
71	ISK-I-2021-9	2357
72	ISK-I-2021-10	1143
73	ISK-I-2021-11	1850
74	ISK-I-2021-12	1583
75	ISK-I-2021-13	3110
76	ISK-I-2021-14	2193
77	ISK-I-2021-15	2933
78	ISK-I-2021-16	2253
79	ISK-I-2021-18	2833
80	ISK-I-2021-19	1447

81	ISK-I-2021-20	2217
82	ISK-I-2021-21	1467
83	ISK-I-2021-22	2580
84	ISK-I-2021-24	2560
85	ISK-I-2021-26	2160
86	ISK-I-2021-27	2807
87	LGN-1 (Susceptible check)	2283
	C.D.	71.8
	SE(m)	25.9
	C.V.	17.17

4.2 To study the abundance of groundnut pod borers

During study, the pod borers associated with groundnut at different growth stages of the crop at Oilseed Research Station, Latur indicated as earwigs, wireworms and subterranean ants. Earwig and wireworm were found to be dominant pests in research field. Subterranean ants also recorded from research plot. Pod borers associated with groundnut were given in Table 4.6.

Table 4.6: Pod borers associated with groundnut during *kharif* 2021-2022

Sr. No.	Common name	Scientific name	Family	Order
1	Earwig	<i>Euborellia annulipes</i>	Labiduridae	Dermaptera
2	Wireworms	<i>Melanotus communis</i>	Elateridae	Coleoptera
3	False wireworm	<i>Gonocephalum spp.</i>	Tenebrionidae	Coleoptera
4	Subterranean ants	<i>Dorylus labiatus</i>	Formicidae	Hymenoptera
5	Termites	<i>Odontotermes spp.</i>	Termitidae	Isoptera
6	White grub	<i>Holotrichia consanguinea</i> Blanchard	Scarabeidae	Coleoptera

4.2.1 EXTENT OF DAMAGE

Groundnut pod borer was recorded at Oilseed Research Station, Latur during the *kharif* seasons of 2021-2022 and the data on per cent damaged pods and the insects associated groundnut pod damage are presented in Table 4.7, 4.8, 4.9. In general the incidence of pod borers was high and ranged between 0 to 40 per cent. Earwigs, wireworms were predominant pod borers fauna associated with this damage. Earwigs and wireworms contributed more damage compared to subterranean ants. It was also observed that the damage due to borers was more or less consistent irrespective of age of crop and did not indicate clear cut trend in the progress of damage. In vertisols the number of pod borers were relatively higher during rainy season compared to alfisols. High moisture required for multiplication of earwigs. Earwigs are commonest in the black soil.

The abundance of groundnut pod borer, earwig were dominant species. Earwig recorded in terms of per cent pod damage (The per cent pod damage was calculated by using the formula suggested by Naresh & Singh (1984) on groundnut are presented in table 4.7. The activity of earwig commenced from 37 SMW to till harvesting of crop but highest pod damage was observed during 39 SMW. Initially less pod damage was observed which is then followed increasing and reached maximum up to 40 per cent during 39 SMW and then gradually decreased. Highest earwig mean pod damage observed at 39 SMW and 40 SMW. Earwig feeding on kernel by boring in to the pods. They mostly preferred immature tender pod. Earwig damage recorded in between 0 to 40 per cent in research plot in *kharif* season. These observations are in agreement with studies by Cherian & Basheer (1940).

High infestation of earwig to the extent of about 40 per cent of bored pods has been observed. The present finding were in conformity with the results of ICRISAT, 1986.

Das & Ray (1988) recorded pod borer incidence as high as 30 per cent and in some samples the average was 9 per cent in Tripura.

In vertisols the number of pod borers were relatively higher during rainy season compared to alfisols. Earwigs are commonest in the vertisols. (Wightman *et al.* 1990). Our observations are similar with these statement. Barwal

and Gupta (1991) also indicated that high moisture is necessary for multiplication of earwigs.

The wireworm was recorded damaging pest in this region. Wireworm also was predominant in *kharif* season. Wireworm recorded in terms of per cent pod damage on groundnut are presented in table 4.8. The wireworm damage activity started on groundnut from 37 SMW to till harvesting of groundnut crop but highest pod damage was observed 45 SMW i.e. 36.36 Per cent. Initially damage was less in research plot followed by increasing up to harvesting of the crop. Highest mean damage of wireworms recorded at 45 SMW and at the time of harvesting. Wireworm damage recorded in between 0 to 36.36 per cent in research plot in *kharif* season.

Similar report observed Arant as high as 35 per cent of the pods injured, by wireworm *Heteroderes sp.* (Bass and Arant, 1973), these result are found similar with our result.

Wireworm were damaging groundnut pods and newly sown seed. (Wightman and Amin (1988). Our findings are also collaborated with result.

The subterranean ant recorded in terms of per cent pod damage on groundnut are presented in table 4.9. The subterranean ant made pin tip size hole on groundnut pods feed on inner content of the pods. The activity of subterranean ant *Dorylus labiatus* commenced from 37 SMW to till harvesting of the crop but maximum pod damage was observed at the 46 SMW. Subterranean ant damage recorded in between 0 to 33.33 per cent in research plot in *kharif* season. Initially damage observed less which is followed increasing trend and reached to maximum (33.33%) during harvesting of the crop.

The present findings were in conformity with the results of Keeratikasikon & Singha (1986) were pod damage due to subterranean ants was found to range from 15-48 per cent, with average of 31.6 per cent.

Roonwal *et al.* (1975) identified another species of subterranean ant, *Dorylus orientalis* Westwood. This species was found to penetrate or perforates groundnut pod and consume the internal content.

In case of damage caused by the subterranean ant reported 3 mm holes on the pod made by *Dorylus* spp. which also removed the seeds from the pod. Wightman (1989). Our findings are also similar with these result.

It was also observed that the damage due to borers was more or less consistent irrespective of age of crop and did not indicate clear cut trend in the progress of damage. The abundance of groundnut pod borers, number of bored pods were relatively higher during rainy season. Earwig and wireworm was dominant species followed by subterranean ant.

The observations on incidence of pod borers are recorded at 37 SMW, 38 SMW, 39 SMW, 40 SMW, 41 SMW, 42 SMW, 43 SMW, 44 SMW, 45 SMW and 46 SMW showed severe infestation of pod borers.

4.2.2. NATURE OF DAMAGE

The damage was usually detected until the crop was harvested, it was not always easy to determine which insect caused the damage, especially when the pods were rotting. Nevertheless an attempt were made to characterize the symptoms of damage associated with each pod borer pest.

Table 4.7: Incidence of per cent pod damage due to earwig

Standard Meteorological week										
Plant Number	37	38	39	40	41	42	43	44	45	46
1	12.50	9.09	0.00	8.33	13.33	11.11	0.00	10.00	5.56	8.00
2	12.50	0.00	14.29	25.00	8.33	9.09	8.33	0.00	4.55	9.09
3	0.00	7.14	15.00	11.76	0.00	17.65	0.00	0.00	0.00	4.00
4	9.09	6.67	27.78	11.11	0.00	0.00	10.00	16.67	5.26	0.00
5	9.09	21.43	8.33	33.33	12.50	11.11	6.67	0.00	0.00	5.56
6	0.00	5.56	0.00	0.00	17.65	0.00	7.69	5.88	10.00	4.55
7	10.00	0.00	11.76	0.00	0.00	11.76	5.00	9.09	0.00	0.00
8	5.88	12.50	9.09	27.27	0.00	5.56	0.00	5.88	9.09	5.00
9	0.00	0.00	0.00	0.00	6.25	6.67	0.00	0.00	6.67	0.00
10	0.00	5.56	9.52	7.69	10.00	18.18	6.67	9.09	0.00	0.00
11	10.00	0.00	0.00	10.53	0.00	0.00	0.00	0.00	5.00	16.67
12	6.67	7.69	9.09	0.00	10.00	0.00	0.00	0.00	0.00	3.70
13	6.25	7.14	15.38	6.67	0.00	0.00	15.38	6.25	9.09	4.00
14	0.00	9.09	0.00	7.14	7.14	0.00	5.56	8.33	0.00	5.00
15	10.53	0.00	0.00	0.00	16.67	9.09	9.09	4.55	0.00	0.00
16	0.00	10.00	9.52	18.75	11.76	0.00	0.00	0.00	13.33	4.55
17	6.67	37.50	0.00	0.00	5.88	7.69	0.00	0.00	0.00	10.00
18	6.25	6.67	10.34	11.11	16.67	5.88	10.00	4.55	11.76	7.69
19	5.88	0.00	40.00	0.00	0.00	22.22	12.50	0.00	7.69	7.14
20	0.00	14.29	7.14	12.50	7.69	0.00	7.14	5.56	9.09	0.00
21	10.00	0.00	0.00	14.29	0.00	9.09	8.33	0.00	8.33	5.56
22	0.00	0.00	36.36	10.00	6.25	11.11	12.50	0.00	11.11	4.76
23	0.00	7.69	9.52	9.09	5.88	5.88	0.00	5.88	10.00	3.70
24	11.11	0.00	9.09	14.29	16.67	9.09	7.14	9.09	0.00	4.76
25	5.56	7.14	15.00	20.00	5.88	6.25	4.35	5.00	9.09	3.85
Mean	5.52	7.01	10.29	10.35	7.14	7.10	5.45	4.23	5.43	4.70

Table 4.8: Incidence of per cent pod damage due to wireworm

Plant Number	Standard Meteorological week									
	37	38	39	40	41	42	43	44	45	46
1	6.25	0.00	7.69	16.67	0.00	11.11	5.56	5.00	11.11	12.00
2	0.00	6.25	0.00	25.00	8.33	9.09	8.33	9.09	9.09	18.18
3	0.00	7.14	5.00	5.88	11.11	11.76	8.33	9.52	36.36	12.00
4	0.00	0.00	0.00	5.56	0.00	15.38	10.00	8.33	5.26	9.09
5	4.55	0.00	8.33	11.11	12.50	33.33	13.33	5.56	4.00	11.11
6	0.00	5.56	0.00	20.00	0.00	12.50	7.69	11.76	5.00	9.09
7	0.00	0.00	0.00	18.18	8.70	0.00	10.00	9.09	11.76	5.88
8	0.00	0.00	9.09	9.09	18.18	11.11	10.53	11.76	0.00	10.00
9	0.00	10.00	0.00	0.00	0.00	6.67	16.67	20.00	6.67	18.18
10	5.88	0.00	4.76	15.38	20.00	9.09	6.67	18.18	18.18	8.33
11	0.00	14.29	7.14	5.26	22.22	16.67	11.11	30.00	15.00	16.67
12	6.67	0.00	0.00	6.25	10.00	16.67	0.00	11.11	13.33	3.70
13	6.25	0.00	0.00	6.67	0.00	0.00	15.38	6.25	27.27	8.00
14	10.00	0.00	0.00	7.14	7.14	5.88	16.67	8.33	18.18	10.00
15	0.00	5.88	4.76	15.38	16.67	9.09	18.18	0.00	18.18	6.25
16	10.00	0.00	0.00	6.25	5.88	0.00	0.00	8.70	0.00	9.09
17	0.00	12.50	8.33	0.00	0.00	15.38	22.22	9.09	5.56	10.00
18	6.25	0.00	3.45	5.56	11.11	11.76	10.00	4.55	11.76	15.38
19	5.88	5.88	0.00	11.11	0.00	0.00	6.25	5.88	0.00	14.29
20	0.00	0.00	0.00	0.00	15.38	0.00	7.14	5.56	9.09	9.09
21	10.00	10.53	0.00	0.00	0.00	18.18	16.67	0.00	8.33	16.67
22	0.00	0.00	18.18	0.00	12.50	0.00	18.75	9.09	11.11	9.52
23	0.00	0.00	0.00	9.09	5.88	11.76	5.88	11.76	10.00	3.70
24	5.56	0.00	0.00	0.00	8.33	9.09	0.00	36.36	6.67	9.52
25	0.00	7.14	10.00	0.00	5.88	18.75	8.70	10.00	9.09	11.54
Mean	3.09	3.41	3.47	7.98	7.99	10.13	10.16	10.60	10.84	10.69

Table 4.9: Incidence of per cent pod damage due to subterranean ants

Standard Meteorological week										
Plant Number	37	38	39	40	41	42	43	44	45	46
1	0.00	0.00	0.00	8.33	6.67	0.00	0.00	0.00	5.56	4.00
2	0.00	0.00	0.00	12.50	0.00	0.00	8.33	18.18	4.55	18.18
3	0.00	0.00	5.00	0.00	0.00	5.88	8.33	4.76	9.09	8.00
4	0.00	0.00	5.56	5.56	15.38	0.00	0.00	8.33	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	6.67	5.56	4.00	5.56
6	5.88	5.56	0.00	10.00	5.88	12.50	0.00	11.76	0.00	4.55
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.88	11.76
8	0.00	0.00	9.09	0.00	9.09	5.56	10.53	5.88	18.18	5.00
9	0.00	0.00	5.00	14.29	12.50	0.00	0.00	10.00	6.67	18.18
10	5.88	0.00	0.00	7.69	0.00	9.09	0.00	0.00	27.27	33.33
11	0.00	0.00	3.57	10.53	0.00	0.00	22.22	10.00	5.00	0.00
12	0.00	0.00	9.09	6.25	10.00	16.67	14.29	5.56	0.00	7.41
13	0.00	0.00	0.00	0.00	0.00	10.00	0.00	6.25	9.09	0.00
14	0.00	0.00	0.00	7.14	7.14	5.88	5.56	0.00	0.00	5.00
15	5.26	0.00	9.52	7.69	0.00	0.00	9.09	0.00	9.09	25.00
16	0.00	10.00	0.00	0.00	11.76	20.00	0.00	4.35	0.00	9.09
17	0.00	0.00	0.00	6.25	5.88	7.69	11.11	9.09	5.56	0.00
18	0.00	0.00	0.00	0.00	5.56	0.00	0.00	0.00	5.88	15.38
19	0.00	5.88	0.00	0.00	0.00	0.00	6.25	5.88	7.69	14.29
20	0.00	0.00	0.00	0.00	15.38	12.50	0.00	0.00	0.00	9.09
21	0.00	5.26	8.33	0.00	0.00	0.00	8.33	10.00	16.67	5.56
22	16.67	7.14	0.00	10.00	0.00	22.22	6.25	27.27	22.22	4.76
23	0.00	0.00	0.00	0.00	5.88	0.00	5.88	0.00	10.00	7.41
24	5.56	9.09	9.09	0.00	0.00	0.00	14.29	9.09	6.67	4.76
25	0.00	0.00	0.00	10.00	0.00	6.25	0.00	5.00	9.09	7.69
Mean	1.57	1.72	2.57	4.65	4.45	5.37	5.49	6.28	7.53	8.96

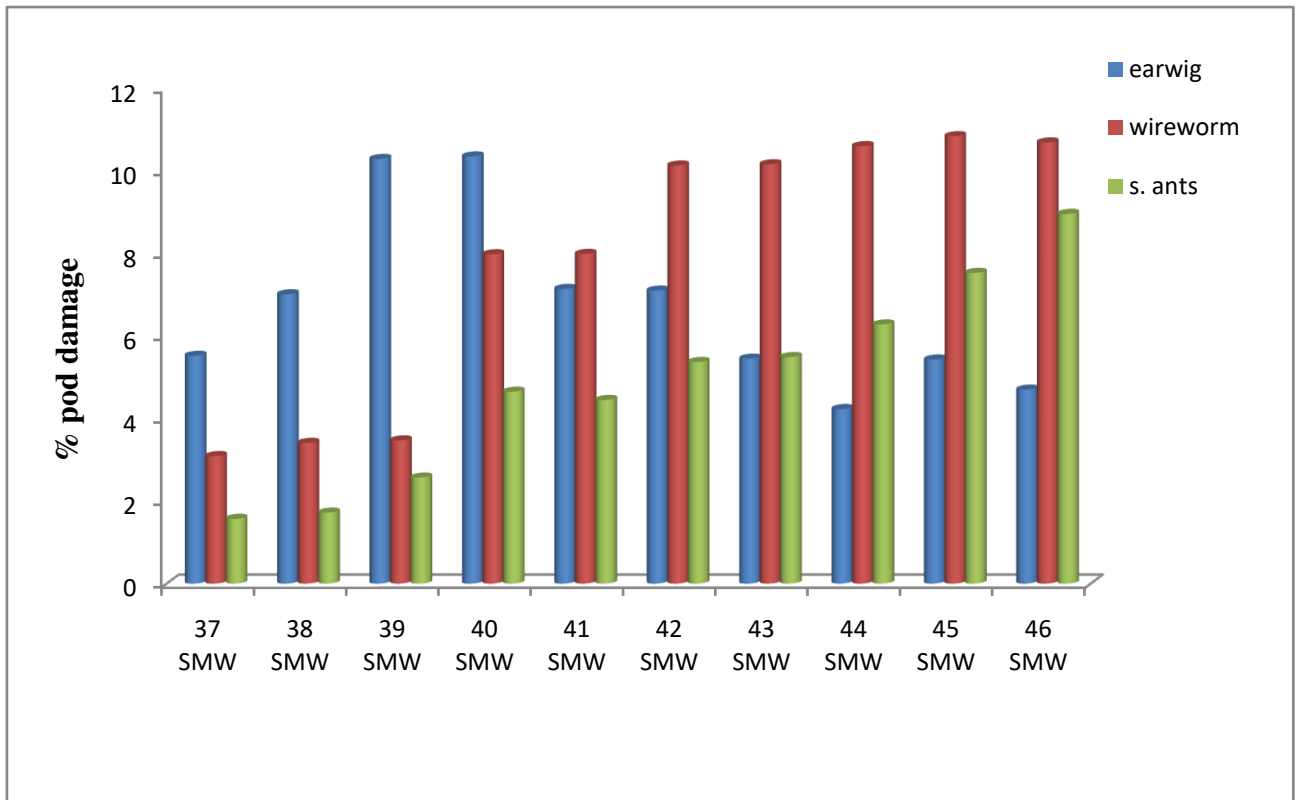


Fig. 4.1: Per cent pod damage by groundnut pod borers during *kharif* 2021-2022

4.2.3 Earwig

Earwig damage was observed at Oilseed Research Station, Latur. Based on the field as well as laboratory observations the type of pods preferred, position of damage, size, shape, number of holes and nature of damage to kernel made by the earwig have been described in detail.

4.2.4 Pod preference

Earwig made hole in tender developing pods. Maximum damage was seen in the tender developing pods rather than in the mature pods. The kernel in such pods are whitish pink and soft, surrounded by white juicy pod flesh. It was found that bored pods obtained from both the red and black soils showed similar symptoms of damage.

4.2.5 Shape of the holes

Hole made by earwig looks regularly round or oval. On close examination under a microscope, the edges of the hole appear irregular and oval or triangular. In most observation the holes bored by earwigs were clear without any plugging with soil, frass or excreta. Very few holes were found plugged with soil.

4.2.6 Size of holes

Size of holes generally measured 1-3 mm. Sometimes bigger holes of 4-5mm were observed. Both nymphs and adults of earwig were found to bore the pod. Size of the hole depends upon the stage of the earwig boring into the pod.

4.2.7 Nature of pod Damage

Nature of pod damage by earwig observed that it first makes a hole through the shell of the pod followed by scraping through the pod flesh, making a pathway towards the kernel. When freshly done the pathway appears yellowish orange due to the feeding against the white succulent flesh in young tender pods. The pathway is not straight, but often wavy and erratic. The pathways generally start at the boundaries of the split pod and proceed towards the centre. The pathways in the pod were mostly found to lead to the kernel, but occasionally 2-3 pathways were also seen in the endocarp with 1-3 holes reaching up to shell.

4.2.8 Damage to Kernel

The earwig seems to prefer very young and tender kernels, when the coat or testa color is whitish or whitish pink. The earwig prefers first kernels then prefers slightly harder kernel. Both nymph and adults bore into tender developing pods and feed on the seeds. Infested pods are prone to fungal infestation.

4.2.9 Number of holes on the Kernel

As per the feeding habit of the earwigs, earwig were found to bore into the kernel at 2 or 3 places. Wherever two holes were observed, one was the entry hole and other was exit hole. Mostly the seed was totally consumed, leaving only the testa and many times a thin kernel tissue left underneath the testa. This is a definite character of identification of the earwig damage. Regarding the typical feeding behaviour of the earwig, the ultimate destination appeared to be the embryo. Rarely the earwigs were found to have devoured the kernels voraciously with no signs of regular holes, leaving only a remnant of the kernel. Depending on the position of the entry into the pod, the hole on the kernel varied. Sometimes the hole in the kernel was seen at the tip of the kernel facing the hole on the pod. In some instances the earwig made a pathway from the entrance hole on the pod from underneath the kernel and bored into the kernel from the side. The entrance hole in all cases was usually roundly triangular and is always smaller than the exit hole. The entry hole measures 1-3 mm, but the exit hole is about 5-6 mm.

4.2.10 Excreta

To identify the earwig damage through differences in the structure of faecal matter, an attempt was made to observe the excreta content in bored pods. It was observed that the pod flesh as well as the kernel were littered with pellets of brown or black excreta. When freshly excreted, the pellets were cream coloured, which turn to reddish brown and later black. When the bored pods were opened, a long time after the actual boring, the black pellets may not be as clear and distinct. They may appear as soil particles. These pellets were woven together by fungal or webs made by mites. The excreta can take other irregular forms, but most often the pellet was the most common. The pellets have been found all over the feeding or bored area of the kernel and pod.

4.2.11 Time of Feeding

When it enters the pod, it stayed inside the pod until it was disturbed. It can be said that the feeding process was more or less continuous though the possibility of the earwig.

4.2.12 Wireworm

Wireworm damage were recorded during at Oilseed Research Station, Latur from the pods damaged by these insects. The wireworms have caused damage to both developing and almost mature pods. Among the 2 species, the brown coloured one showed preference to the pods nearing maturity. The wireworms also preferred the area around the beak to enter the pod. The holes were 3-4 mm in diameter depending upon the size of the wireworm. The edges of the hole were irregular and sometimes one end of the hole was thickened. But generally holes are oval to round shape. This species seemed to prefer wide pods as compared to narrow ones. Wireworm damage both kernel as well as the endocarp. When the kernels were very tender, the wireworms relished the endocarp more than the kernels. The kernels showed signs of nibbling reflected by the yellowish orange markings on the kernel. When freshly eaten the inner side of the pod appeared yellowish. As time passed the same appeared as blackened frass.

4.2.13 Subterranean Ant

At the time of harvest in the Oilseed Research Station fields, pods with very minute holes (Pin tip size) were found associated with red ants. The holes measured 0.5-1.0 mm. It was observed that in most cases these holes (tunnelling) did not run deep and were limited to the shell and its tissue. Internally, in most cases, no injury could be seen in the kernel, but occasionally the kernel and its flesh was found to be irregularly eaten.

4.2.14 Identification of groundnut pod borers

Based on the pod injury, nature and position of hole, type of kernel damage and external structure, a key has been formulated for identification of pod borers involved. The earwig, wireworms and subterranean ants were recorded in the present investigations.

Table 4.10: Key for identification of groundnut pod borers

Sr. No.	Pod borers associated with groundnut	Key for identification
1	Earwig	Earwig attack immature pods with 1-3 mm holes on all sides of pods. The kernel showed 1-2 mm entry and exit holes littered with 3 segmented cylindrical excreta.
2	Wireworms	Wireworms made 3-4 mm oblong or oval holes on ventral sides of pod surface close to the beak end.
3	Subterranean ants	0.5-1mm pin tip holes on matured pods along with irregular feeding on kernel leaving some frass.

Insects pests of groundnut pod borers



Adult of earwig



Earwig attack on immature tender pods.



1-3mm holes on dorsal and ventral side of the pod at beak end construction on tender pods of due to Earwig



Earwig feed on inner content of pods.

Plate 4.4: Earwig damage on groundnut pod



Adult of Wireworm (Click beetles)



Larvae of wireworm



Wireworm larvae enter into pod and feed on kernel of pod



Wireworm damage inside the pods

Plate 4.5: Wireworm damage on groundnut pod



Plate 4.6: 3-4mm oblong or oval shaped holes on the ventral side of the pod at the beak with blackened internal wall.....Wireworm



Plate 4.7: Pin tip holes made by subterranean ant

CHAPTER - V
SUMMARY AND CONCLUSIONS

CHAPTER - V

SUMMARY AND CONCLUSION

The studies on screening of groundnut genotypes against pod borers in *kharif* season were undertaken at the Oilseed Research Station, Department of Agricultural Entomology, College of Agriculture (Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani), Campus Latur Dist: Latur (MS)-India during *kharif* season 2021-2022. The result obtained during the course of experimentation are summarized below.

5.1 To Screen different groundnut genotypes against groundnut pod borers

5.1.1. Screening of groundnut genotypes against Earwig

Total eighty six genotypes along with one check LGN-1 have screened against pod damage due to earwig. The pod damage due to earwig infestation ranged from 0 to 13.88 per cent. The No pod damage was recorded in two genotypes *viz.*, HOVTSB-I 2021-19 (0.00%), IVK-I-2021-9 (0.00%) and can be categorized under 1 scale. The four genotypes and check recorded in the 3 scale having pod damage between (11 to 20 per cent.) *viz.*, ISK-I 2021-4 (13.88%), ISK-I 2021-3 (12.84%), AVK-2021-3(12.24%), AVK-2021-2 (11.64%) and LGN-1 (10.99%).

5.1.2. Screening of groundnut genotypes against wireworms

Eighty six genotypes along with one check LGN-1 have screened against pod damage due to wireworm. The pod damage due to wireworm infestation ranged from 0 to 18.07 per cent. The No pod damage was recorded in two genotypes *viz.*, HOVTSB-I 2021-19 (0.00%), LSVT-I 2021-2 (0.00%) and can be categorized under scale 1. The four genotypes and check recorded in the 3 scale having pod damage between (11 to 20 per cent.) *viz.*, AVK-2021-2 (18.07%) followed by ISK-I-2021-4 (15.65%), AVK-2021-5 (11.47%), AVK-2021-3 (11.20%) and LGN-1(11.64%).

5.1.3. Screening of groundnut genotypes against subterranean ants

Total eighty six genotypes along with one check LGN-1 have screened against pod damage due to subterranean ants. The pod damage due to subterranean ants infestation ranged from 0 to 12.26 per cent. The No pod damage due to subterranean

ants was recorded in only one genotypes viz., HOVTSB-I 2021-19 (0.00%) and can be categorized under scale 1. The five genotypes and check was recorded in the scale 3 having pod damage between (11 to 20 per cent.) viz., ISK-I 2021-26 (12.26%), ISK-2021-10 (11.17%), AVK-2021-2 (10.99%), AVK-2021-3 (10.91%), ISK-I-2021-4 (10.37%) and LGN-1 (10.91%).

5.2 To study the abundance of groundnut pod borers

The intensive research at Oilseed Research Station, Latur indicated that earwig, wireworms and subterranean ant were the important groundnut pod feeding and pod damaging insects. The Earwig are predominant in Oilseed Research Station, Latur. Generally, the incidence and their pod damage maximum and noted range from 0 to 40 per cent in research plot. Earwig damage observed in range between 0 to 40 per cent in *kharif* season, wireworm damage observed in between 0 to 36 per cent in *kharif* season and 0 to 33.33 per cent pod damage was recorded due to subterranean ant in *kharif* season 2021-2022. The activity of earwig commenced from 37 SMW to till harvesting of crop but highest pod damage was observed during 39 SMW. Initially less pod damage was observed which is then followed increasing and reached maximum up to 40 per cent during 39 SMW and then gradually decreased.

Wireworm also predominant in *kharif* season. The wireworm damage activity started on groundnut from 37 SMW to till harvesting of groundnut crop but highest pod damage was observed from 45 SMW i.e. 36.36 Per cent. Initially damage was less in research plot followed by increasing up to harvesting of the crop. The subterranean damage also started from 37 SMW to till harvesting of the crop but maximum pod damage was observed at 46 SMW i.e. 33.33 Per cent.

However, tender developing pods were preferred by earwigs. Earwig preferred first immature pod first than mature pods. 1-3 mm round or oval holes on dorsal side of the beak and pod littered with three segmented faecal pellets with plugging of the hole were the characteristic symptoms. It was also observed that earwig infestation are prone to fungal infection.

Among two wireworm species, the brown coloured species made 3-4mm oval holes on ventral sides of pods with beak region. The wireworm damaged pods normally developed blackened internal pod wall. The subterranean ant damaged

pod possessed several 0.5 -1mm holes (pin tip holes) all over pod specially lateral sides of pods.

In conclusion it was concluded that in the present investigation, the genotypes HOVTSB-I 2021-19(0.00%) and IVK-I-2021-9(0.00%) recorded No pod damage (0 per cent) & formed promising for earwigs. No wireworm damage also recorded on HOVTSB-2021-19 (0.00%) followed by LSVT-I 2021-2 (0.00%) and formed promising for wireworm pod damage. The genotype HOVTSB-I 2021-19 recorded 0 per cent pod damage & formed promising for subterranean ants. The genotype HOVTSB-I 2021-19 (0.00%) was one of unique genotype resistant to earwig, wireworm and subterranean ants & relatively good yielder can be used as resistant source in breeding for resistance programme against pod borers of groundnut.

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APPENDIX

APPENDIX – I

Meteorological data recorded at Meteorological Observatory, Oilseeds Research Station, Latur (MS)

Year	:	2021	Latitude	:	18° 24' N
State	:	Maharashtra	Longitude	:	76° 36'
District	:	Latur	Altitude	:	633.85 m.
Zone	:	Deccan plateau zone	Soil Type	:	Vertisol

Sr. No.	S.M.W.	Period	Rainfall (mm)	Number of rainy days	Temperature (°C)		Humidity (%)	
					Max.	Min.	AM	PM
1	31	30-05Jul	00	0	29.4	19.9	78	78
2	32	06-12Aug	00	0	28.3	20.4	80	80
3	33	13-19Aug	40	4	27.1	19.8	82	78
4	34	20-21Aug	43	4	27.2	20.3	81	81
5	35	27-02Aug	57	3	27.3	20.1	78	83
6	36	03-09Sep	124	4	26.2	20.1	63	78
7	37	10-16Sep	07	1	28.8	20.8	70	85
8	38	17-23Sep	25	2	27.5	19.9	74	81
9	39	24-30 Sep	132	4	27.6	20.4	77	93
10	40	01-07Oct	17	2	27.7	18.6	53	84
11	41	08-14Oct	79	2	27.4	20.1	64	89
12	42	15-21Oct	20	1	28.2	19.8	60	85
13	43	22-28Oct	00	0	27.6	20.4	90	60

CURRICULUM VITAE

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Academic qualifications

Course/ Degree	Name of college/ institute	University/ Board	Year of passing	Percentage (%)/ CGPA	Class/ Grade
SSC	CVMV, Asegaon	MSBS&HSE, Pune	2014	87.20	First with Distinction
HSC	Shree. Nrusinh junior college, Tadkalas	MSBS&HSE, Pune	2016	69.85	First
B.Sc. (Agriculture)	Rajiv Gandhi Agriculture college, Parbhani	VNMKV, Parbhani	2020	7.69	First

Place: Latur

Date : 30/11/2022


(MAGAR S. M.)