Corn-Root Boring White Grub and its Management, the Case of Ethiopia

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Abstract: Maize is among the world’s three most important cereal crops, the other two being wheat and rice. Because of its great genetic diversity, it is grown in more diverse regions than any other crop. Maize is an important staple food in developing countries, in particular in Latin America and Africa and a basic ingredient for local drinks and food products. It is also an outstanding feed for livestock, high in energy, low in fiber and easily digestible. The factors that limit maize production are also diverse, some of the most important being insects and closely related organisms such as mites. These pests can infest maize at any stage of crop development and in storage and attack any part of the plant, often causing severe damage. The moth group (which includes cutworms, armyworms, earworms, borers and grain moths) is the most damaging to maize worldwide, followed by the beetles (rootworms, wireworms, grubs, grain borers and weevils). Next in importance is the group of insects that serve as carriers (vectors) for disease agents (viruses, micoplasms, bacteria and fungi), among which the sap-sucking bugs (leafhoppers and aphids) are the greatest problem. This paper specifically deals with white grubs which have become a challenging subject for our farmers and scientists in various parts of the country. No crop is completely free from or resistant to the attack of these grubs. The loose soils with moderate to low rainfall provide favorable conditions for the survival and multiplication of these insects and they have become destructive particularly in tropical regions of the world. Hence, this review aims to help farmers recognize these pests and thereby take effective protection of the crop against them.

Key words: Ethiopia • Food security • Maize • Pest • White grubs

INTRODUCTION

Food security is a pressing concern for Africa in general and Ethiopia in particular. Even though crops are being produced in most parts of the country, people living in 50% of the country are not able to assure the minimum food energy requirement for their family. Several millions of people in the country are food insecure, several million school children are malnourished and many others suffer from disease, hunger and malnourishment [1].

Cereals and pulses are important food and cash crops for farmers and rural households in Ethiopia. Wheat, sorghum and maize supply over 50% of average daily caloric intake. Cereal production accounts for roughly 60% of rural employment and 80% of total cultivated land. Households spend an average of 40% of their total food budget on cereals. Pulses occupy 13% of cropland in Ethiopia and are the second most important element in the national diet after cereals [2]. Maize exceeds all other cereal crops in terms of annual production and productivity. It is, however, teff (Eragrostis tef (Zucc)) that leads in terms of area of production and importance as the basic staple [3].

Maize (zea mays) is a cereal grain domesticated in Mesoamerica and spread all over the world gaining an important position because of its higher yield potential and short growth duration. It was introduced into Africa mainly by Portuguese and Arab explorer during the trade route in the early 1500s. The practice of cultivating maize then expanded to most of African countries due to: its ease to harvest, its wide climatic adaptability, its taste accepted by local communities, its importance when food

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stuff had to be transported to feed labor and populations which were not self-sufficient. Similarly it stores well if properly dried; and can be harvested over a long period. These conditions contributed to its rapid adoption and expansion [4]. Maize was introduced into Ethiopia during the 16 and 17 century [5].

Maize can be grown in the wide range of environmental conditions ranging between 50° latitude, North and South of the equator and up to 3000 meters above sea level. In Ethiopia, it grows from low rainfall areas to high rainfall areas. And because of its great genetic diversity, it can also be grown across varied agro-ecological zones of the country such as western, southern, southwestern and northeastern. It is produced during the main long season from May to September. In some areas, short amount is produced in short rainy period from February to May. Farmers in the western regions of Ethiopia also produce maize on bottom lands using residual moisture in January and harvest in June which in turn solves the food shortage in main seasons [6, 5].

Maize is one of the high priority crops to feed the increasing human population of the country due to its adaptation and total yield [7]. It is the primary staple food in Ethiopia, averaging slightly more than 20% of daily caloric intake. The Ethiopian Commodity Exchange reports that three-quarters of maize produced is used for household consumption, only about ten percent is marketed and the remainder is used for seed, in-kind payments for labor and animal feed [2]. Millions of people in the country depend on maize for their daily food especially where maize is the major crop. In the highland areas, maize is the first crop grown and is a popular “hunger breaking” crop when harvested and consumed green [6]. Maize is a rich source of food and fodder and widely used in industries for manufacturing of corn oil; flakes, corn syrup, ogi, etc. [8]. It is used as a raw material for local drink, boiled grain, green cobs and bread making [9]. Moreover, it plays a significant role in the social and economic development of the country, especially in food security with the lowest cost source of calories [10].

Despite its vital importance, the yield and production potential of this crop is under pressure due to different constraints, especially insect pests. As it is stated in Ferdu et al. [7], maize suffers from the attack of insect pests from seedling to maturity and these include: Lepidopterous pests (such as cutworms, armyworms, earworms, borers and grain moths) are the most damaging to maize worldwide, followed by the Coleoptera (root worms, wireworms, grubs, grain borers and weevils). Next in importance is the group of insects that serve as carriers (vectors) for disease agents or pathogens, among which the sap-sucking bugs (leafhoppers and aphids) are the greatest problems.

More than 40 species of insects are identified as pests in Ethiopia. Among them maize stalk borer (buseola fusca), spotted stalk borer (chillo partellus) and various termite species are considered to be the major pests. Insects such asfall army worm, cutworm, chaffer grubs, grass hoppers, pink stalk borers and maize aphids are recognized to occur sporadically [7].

Among Coleopterans, over 250 species of scarab forms are considered to be corn root and grass boring insects. Those commonly available are the masked chafers, Cyclocephala spp (annual grubs); May/June beetles, Phyllophaga spp (three-year grubs) and most recently the Japanese beetle, Popillia japonica. True white grubs are the larvae of May beetles (also called June Beetles) found in the genus Phyllophaga, of which there are over 100 different species. White grubs in the genus Phyllophaga are also known as "perennial" white grubs or "true" white grubs. Phyllophaga larvae and other larvae of the family Scarabaeidae are often referred to as "white grubs", including larvae of the Japanese beetle (P. japonica), annual white grubs (Cyclocephala spp.) and the green June beetle (Cotinis nitida) [11]. Adults of Annual white grubs (Cyclocephala spp.) are known as masked chafers (Iowa State University of Science and Technology and Iowa Soybean Association, [12].

White grubs are the C-shaped larvae of scarab beetles. Several species of scarab beetles occur in Africa. They eat a wide range of materials and all developmental stages occur in the soil. White grubs are especially abundant in soil with high content of organic matter. The larvae live for several months and eat decomposing plant material while adults live up to a year and gnaw roots [13].

White grub problem arise from the fields where maize follows soybean, fields previously in hay, fields which have seasonal weed problems and the grazing pasture [14, 15]. White grubs are also problematic in home lawns and in corn planted into an old grass sod; particularly in bluegrass sod fields. In heavily infested sod fields, grubs can be found feeding on the roots of grasses about 1 to 4 inches deep in the soil. If the soil is dry, the insects migrate deeper into the soil profile. When corn is planted into a grass sod, the food source (grass roots) is eliminated, leaving only the corn roots as food. Injury symptoms include small stunted plants, dead
plants and plants with a purple coloration (caused by the roots' inability to acquire phosphorus in the soil). Grubs are dirty white, soft bodied and robust, with a brown head and six well developed legs [16, 17].

Hence, it is important to know the distribution, life cycle and damage caused by this pest in order to choose appropriate control measure and increase the productivity of the crop thereby contributes to the food security of the country. This review, therefore, covers research highlights of corn root boring white grubs and its management from studies conducted at various research centers and higher institutions.

Biology of the White Grubs

Description: White grubs are insects that show complete metamorphosis. Each stage of development and its life cycle is indicated below as referenced from [17, 18] and Iowa State University of Science and Technology and Iowa Soybean Association, [12].

Adult: May beetles are about 12 to 25 mm long. The adults often are yellow to dark reddish-brown to black, robust, oblong, shining beetles. Some, such as the green June beetle, are more brightly colored.

Larva: Length varies from 20 to 45 mm. Larvae are white with a C-shape body, brown head and three pairs of legs. The hind portion of the abdomen is slightly enlarged and appears darker due to the soil particles showing through the body wall. Two parallel rows of spines seen on the underside of the last abdominal segment distinguish true white grubs from similar-looking larvae.

Pupa: Length varies from 20 to 24 mm long. The pupa is colored white, faint yellow or dark brown.

Egg: Eggs are usually 1.5 to 3 mm in diameter and found encased in soil aggregates. They are small, spherical, pearly white eggs that darken just before hatching.

Life Cycle: The Phyllophaga life cycles vary somewhat because some species complete their growth in one year, while others require as much as four years. The common life cycle of the more destructive and abundant of these beetles extends over three years.

Japanese beetle adults emerge from the soil in late June and move to a wide variety of plants, including field crops to feed and mate. Mated females move back to grass in August and September to lay egg masses in soil. Eggs hatch into small, white grubs that feed on plant roots (including soybean and corn) until late September when temperatures cool. Almost fully-grown grubs burrow deeper in the soil and are inactive all winter. In early spring, grubs become active and feed until pupation. Adults emerge from soil after development is complete. There is one generation per year (Iowa State University of Science and Technology and Iowa Soybean Association, [12]).

True white grubs have a three or four year life cycle. The grub overwinters deep in the soil for the first several years. Before its last winter, it will pupate and then overwinter as an adult underground. Adults will emerge in May or June. Mated females deposit eggs in grass or soybean and corn fields and young larvae feed on roots until the winter. True white grubs will feed and develop for at least two more summers before pupating and becoming adults (Iowa State University of Science and Technology and Iowa Soybean Association, [12, 17]).

Identification: If you can identify correctly the type of white grub causing the problem, it will help with subsequent monitoring and in making control decisions. Masked chafer grubs have a chestnut-colored (reddish-brown) head and Japanese beetle grubs have a tan-colored (yellowish-brown) head. Grubs can also be identified by examining the rasters, the arrangement of small spines on the underside of the last body segment. A 10X hand lens is adequate for seeing these diagnostic features. The adult stages of white grubs are easily distinguished from one another. Japanese beetles are 3/8 to 7/16 inch long and metallic green with coppery brown wing covers. A row of white tufts (spots) of hair project from under the wing covers on each side of the body. May beetles are solid brown and 3/4 to 1 inch long. Masked chafers are similar in shape but are only about 1/2 inch long. Green June beetles are 3/4 to 1 inch long and are emerald green except for a tan border on the sides of their wing covers [19].

Distribution: White grubs are widely distributed worldwide; however, the maximum number occurs in the tropical areas of the world, particularly in African and Oriental regions [11]. Similarly, Selman, [18] indicated that phyllophaga spp are distributed throughout the world, but distribution of individual species may be restricted. Moreover, Sapkota, [17] explained that populations of most grub species tend to be highest in older plantings of sod or in soils high in decomposing organic matter.
Host Plants: White grubs affect almost all field crops growing during the rainy season. They feed on the roots of corn, sorghum, soybean, strawberry, potato, barley, oat, wheat, rye, bean, turnip and to a lesser degree, other cultivated crops [11]. They also infest various pasture grasses, lawns and nursery plantings. The adults, which are strongly attracted to fragrant flowers and ripe fruits, feed on the foliage of forest, shade and fruit trees [17]. Virginia Cooperative Extension Publication 444 -106 have indicated that Japanese beetle adults are known to feed on the foliage, flowers and fruits of more than 400 different ornamental and agricultural plant species. Some of the preferred host plants are apple, apricot, asparagus, birch, blackberry, blueberry, cherry, corn, elm, grape, maple, peach, plum, raspberry, rose, soybean, walnut and zinnia. The immature or grub stage of the Japanese beetle is a serious pest of turf grass, field crops, ornamental trees and shrubs and vegetable crops. Annual white grubs (Cyclocephala spp.) are early-season pests attacking corn seeds and seedlings. Heavy infestations can cause stand and yield losses of up to 20%. Because grubs occur in the soil, their presence in fields and subsequent damage to corn may go unnoticed until too late [20].

Damage: White grubs are among the most destructive and troublesome of soil insects, threatening the entire crop production. No crop is completely free from or resistant to the attack of these grubs. The loose soils with moderate to low rainfall provide favorable conditions for the survival and multiplication of these insects and they have become destructive particularly in tropical regions of the world. The rainy season provides favorable conditions for grub attack. White grubs feed underground on the roots of host plants, while the adult beetles are observed feeding on the foliage of certain other choice plants in the vicinity during the night. The damage done by grubs to Kharif crops is sometimes more than Imagination. The losses inflicted to the various crops by this pest range between 40 and 80 per cent in endemic pockets [21]. The infested plants show stunted growth, wilting appearance and finally dry up. Such plants can be easily pulled out from the soil. The severely infested fields show patchy appearance due to withering or drying up of the plants. A good indication of grub infestation is the presence of skunks, crows, mynas and moles feeding on fields following the plough [11].

Scouting/Sampling: Field monitoring, or scouting, is the backbone of all pest management programs. Before appropriate pest control decisions can be made, a detailed assessment of pest populations must be obtained. Efficient pest scouting requires a thorough knowledge of pest and crop biology, pest identification and habits, correct sampling methods and economic thresholds (when available). The goal of scouting is to give a complete, accurate and unbiased assessment of pest populations.

Routine scouting is not suggested. However, damage may be observed during seedling stand counts or cutworm surveys. If signs of white grub damage are found, make counts on 25 plants in 5 areas of the field to determine percentage of damaged plants. Dig up suspect plants and examine the roots for signs of pruning; search for grubs in the soil immediately surrounding the root zone. Record the percent of damaged plants and number of grubs found.

Stand counts should be made the second week after emergence. Count the number of plants in 20 linear feet of row from five randomly selected areas of a field. Measure the distance between rows in several locations within the field. Multiply the total number of plants counted in the 100 feet of row by the appropriate conversion factor (Table 1) to determine plant population.

Soil insects like grubs are counted from a fixed area and depth of soil; by cutting out cylinders of soil four inches in dia and 12 inches deep. A sample of 20 quadrates (i.e. 20 cylinders of soil four inches in dia) is taken from one acre and it can be multiplied by 498,960 (the number of quadrates that could be taken from one acre) to estimate the population in one acre [23].

White Grubs Management/control: White grub is a polyphagous and harmful pest of specific significance as it adversely affects the economic status of the farmers. It is rather difficult to eradicate this polyphagous and noxious pest because of its peculiar behavior and nature of damage to the various crops. The pest can be managed effectively only by integration of several methods [21]. Combined approaches including microbial pesticides, cultural methods, mechanical and physical are well accepted methods.

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<th>Table 1: Conversion factors to determine corn populations [22].</th>
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<td>Row Width</td>
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For example, if you have counted a total of 145 plants and the row width was 30 inches, multiply 145 (plants) * 174 (conversion factor) = 25,230 plants per acre.
Cultural Control: Cultural techniques are useful in reducing the number of larvae as well as of adult populations. Different cultural practices, such as ploughing, harrowing, hoeing, flooding and fallowing of fields, trap cropping and crop rotation, have been suggested by various workers [11]. Although white grubs can be a problem every year, the most serious damage occurs in regular three year cycles. The greatest damage to crops occurs the year after the appearance of the adults. During the years of heavy May beetle infestation, deep-rooted legumes, such as alfalfa or clovers, should be planted. If corn or small grains are present, every effort should be made to keep the field free of grass and weed growth, as this will reduce the number of eggs laid. The year following heavy flights of May beetles, planting corn or potatoes should be avoided in fields that were previously under sod or grass. Late spring or early autumn plowing destroys many larvae, pupae and adults in the soil and also exposes the insects to predators, such as birds and skunks. For this cultural practice to be effective, plowing must occur before the grubs migrate below the plow depth. No-tillage or reduced tillage crop management enhances grub populations [17, 18].

Moreover, to reduce white grub damage the following cultural control methods are recommended: the use of insect-resistant cultivars, encouraging natural enemies by planting a variety of flowering plants that produce pollen and nectar, monitoring for grubs in the early spring by taking a few soil samples and scout for adults in the summer by inspecting ornamental plants and removing the beetles by hand and drop into a jar of soapy water. If adult feeding damage on ornamental plants becomes noticeable [24].

Mechanical Control: Pal [21] has recommended the following mechanical control methods. The use of Light Trap during beetle flight period offers an excellent mode of preventing the buildup of a large scale incidence. Light Traps are effective only if employed on community basis. If an individual farmer employs the light trap, it may in fact accentuate the white grub damage in his field. The collected beetles may be killed by dipping them in Kerosinized water. The insecticidal treated green twigs of bushes of Neem or Bordi etc. may be put in the field at several places in the evening where ever feasible so as to attract emerging adult beetles which would die on feeding the foliage. The peak period of adult catch in the light during June -July gives clue for time of insecticide application in the soil. If the insecticides are applied in the top 5 cm to 10 cm soil depth at the time of peak emergence of beetle, there is likelihood of the young grub being killed.

Biological Control: Parasitic wasps, flies and birds are effective biological control agents for white grubs. Using broad spectrum insecticides for low densities of white grubs is unnecessary and will reduce biological control. Using natural enemies and other integrated pest management (IPM) strategies can reduce adults and grubs to tolerable levels in most cases [24]. Parasitic nematodes, fungus and bacteria are also reported to control white grubs with partial or moderate successes in different parts of the world [11].

Chemical Control: White grubs are subterranean and hence difficult to control. The grubs are very hardy and move to a great depth in the soil. Effective chemical control is possible only if chemical is applied, when the grubs are tiny or young [21]. O’Day et al., [25] recommended the use of insecticide treatment if corn is planted over pasture or grassy ground. Moreover, works of David and Kalra [26], Veeresh [27] and Bhatnagar [28] have shown that application of insecticides such as phorate, quinalphos or gamma-HCH dust before sowing summer crops gave highly significant control of grubs. Chemical control should be considered when cultural methods are not effective. Consider using “reduced risk” insecticides as an alternative to broad spectrum products because they preserve natural enemies and are less toxic to other animals. For annual grubs, soil insecticides are not recommended [24].

Summary/Conclusion: White grubs are subterranean insect pests that can cause significant damage to seedling corn. The most common white grubs found infesting cornfields consist of May beetles, June beetles and the masked chafer. Of these, the annual white grub (masked chafer) is not known to cause damage to seedling corn stands. The true white grubs, larvae of May and June beetles, can cause significant damage to developing corn plants if present in high numbers. The adult beetles rarely cause economic damage.

Successful and economical control of corn insect pests requires the use of multiple control measures. Pest control objectives are to reduce pest populations to levels that are compatible with human interests and economics. Soil tillage in April or May may help reduce the population by exposing larvae to natural predators.
and parasites. When practical, rotation of crops less susceptible to injury such as clover may help reduce the population. Insecticides are registered to control white grubs on many crops. Generally, two important factors to be considered when managing early season corn pests involve (1) preserving targeted plant populations and (2) protecting overall health of surviving plants. Rescue treatments are rarely an option or may be only marginally effective against soil pests. As a result, in-season scouting is generally not recommended for many of these pests. However, finding these pests in your fields may help provide a history of what pests may cause problems in the future.

**REFERENCE**


12. Iowa State University of Science and Technology Extension and Outreach and Iowa Soybean Association, 2012. Field Crop Insects.


