



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>



HARVARD UNIVERSITY.



LIBRARY

OF THE

MUSEUM OF COMPARATIVE ZOOLOGY.

26237.

GIFT OF

Samuel Henshaw.

October 17, 1905.

OCT 17 1905

26.237

No. 25, 1904.

CAPE OF GOOD HOPE

Department of Agriculture.

GALL WORMS IN ROOTS OF
PLANTS.

^{45.}
Reprinted from the Agricultural Journal of October, 1904.

CAPE TOWN :
TOWNSHEND, TAYLOR AND SNASHALL, PRINTERS.

GALL WORMS IN ROOTS OF PLANTS.

An Important Potato Pest.

BY C. P. LOUNSBURY, Government Entomologist.

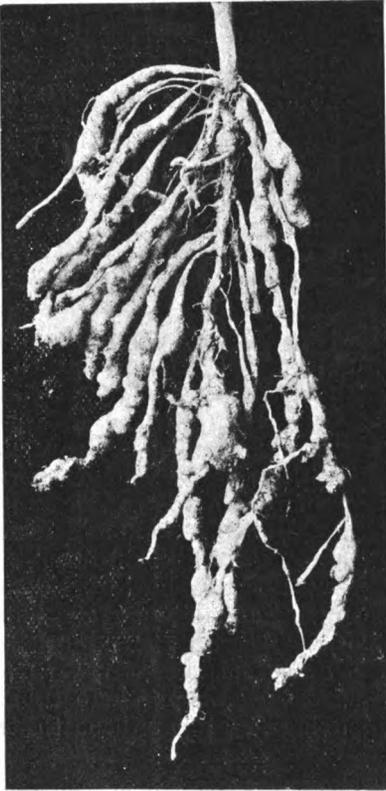
It is only a year since gall worms last formed the subject of notes in the *Journal* but the possible future importance of the pest and the desirability of emphasizing the ease with which it is spread by the planting of infested seed potatoes fully warrants mention of the matter again at this early date. The pest gets its name from the fact that it causes "galls" or swellings on the roots of plants and that it is a species of life classed in the group called "worms." There is very little about the gall worm, however, to call to mind such creatures as we ordinarily associate with the name "worm," since it is almost too small to be clearly seen with the unaided eye and since the fully developed female, the only form a farmer is likely to distinguish, is anything but worm-like in shape.

The gall worm has not been the subject of close scientific study in South Africa. All the specimens that I have examined, however, have seemed to be of one species; and there is little if any reason to doubt that this species is the common gall worm (*Heterodera radicocola*) of Europe, America, and Australia, in all of which countries it has been the subject of careful investigations. The account here given is little more than a compilation, my information being largely derived from the writings of Bos in Germany, Cobb in Australia, and R. E. Smith, Atkinson, and Neale in the United States.

APPEARANCE OF INFESTED PLANTS.

When plants appear sickly and the underground parts are studded with gall-like swellings the presence of gall worm may be suspected. The roots of some plants become greatly swollen and

distended in shape as may be seen by reference to the accompanying illustration of infested tomato roots. The figure is from a photograph of a plant grown at Goudini in the Worcester division.



Infested Tomato Root.

Beans and other legumes get little tubercles of a beneficial nature that might be mistaken for gall worm swellings, but only the very small roots bear them. All such root swellings as these may be ordinarily distinguished from gall worm work by the absence of the female worms.

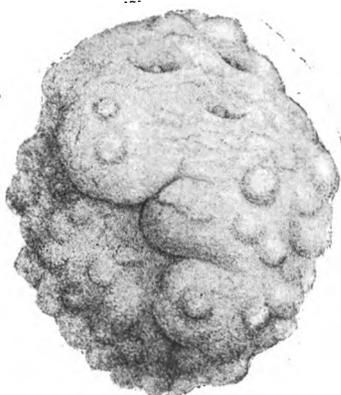
PLANTS INFESTED.

The list of plants subject to attack is a very long one and includes most of the common vegetables and fruit trees, and numerous ornamental plants and weeds. The cultivated plants most severely attacked are included in the cabbage, melon, pea and potato families. Not all varieties of plants of many kinds are equally attacked, and indeed some varieties that are closely related to varieties badly attacked are themselves practically immune. In a mixed vineyard at Goudini that has been infested for many years, the difference of growth between different varieties is very marked owing to this cause; and the Mariana plum was found by MacOwan

and Pillans quite free of the pest in an infested nursery at Wellington, which they had rooted out some years ago, whereas it is well-known that some other plums are very susceptible. Most of the complaints of the pest which have come to my notice at the Cape have been of injuries to potatoes.

APPEARANCE AND LIFE CYCLE OF THE WORM.

If one cuts through one of the gall-like swellings caused by the pest, he is likely to expose a developed female worm; this appears as a soft, rounded, pearl-coloured speck, smaller in size by far than the head of a pin, and located in a cavity from which it may be easily dislodged by a needle. The females lay eggs and die within the galls, and are followed by a multitude of young worms which work their way out into the soil and seek new places to attack. These little worms are slender and about one seventy-fifth of an inch in length. Having pierced a root and come to rest, they gradually swell in diameter. The males behave like the females at first, but later become worm-like in shape again, and, finding embedded females, mate with them. The life period of a female is given as six



Infested Potato.

weeks. It is not at all difficult to find the worms in potato tubers. They lie in discoloured or watery-looking areas just beneath the surface.

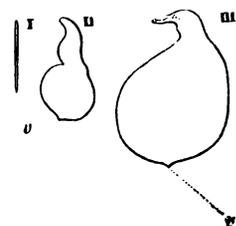
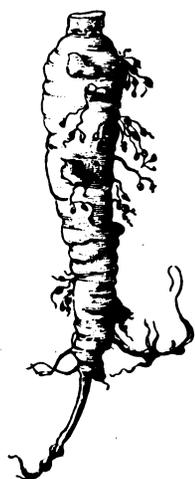
DISTRIBUTION.

The gall worm has probably been at the Cape for a long period of years, and it now occurs, here and there, over much of the Colony. Without consulting notes, I recall complaints of its injuries from Cape, Stellenbosch, Paarl, Worcester, Middelburg, Graaff-Reinet, Maclear, Cathcart, King William's Town, East London, and Uitenhage districts. But although the pest is so widely distributed in the Colony, it probably so far infests only a small proportion of the area of cultivated ground. Loose soils that are well supplied with moisture best suit the gall worm. Moisture is essential for its vigorous development, but it is said that it can withstand long dry spells. Extended periods of intense cold probably destroy it as it is known as a pest only in green houses in the colder sections of Europe and America. It is unlikely that the winters are cold enough anywhere in the Colony to prevent its survival in open ground from year to year.

EXTENT OF DAMAGE.

The working of the worm when it enters a root sets up the abnormal growth; and the damage done is said to be due not nearly

so much to the actual feeding of the worms as to the interference with the flow of sap by this abnormal development of the tissues.



Infested Parsnip. I, II and III are outline figures of the worm magnified twenty-five times; I, is young worm; II, swelling female; and III, full-grown female. (All after Cobb.)

If the infestation is slight the effect on the plant may escape notice, but if the worms are abundant the roots of annual plants are likely to rot off and the plants die long before they can reach maturity. The trees and vines that I have seen infested have been merely stunted in growth; but it is said that in the southern United States large peach, fig, walnut and even willow trees are sometimes killed, and that susceptible young trees and nursery stock in much infested soil

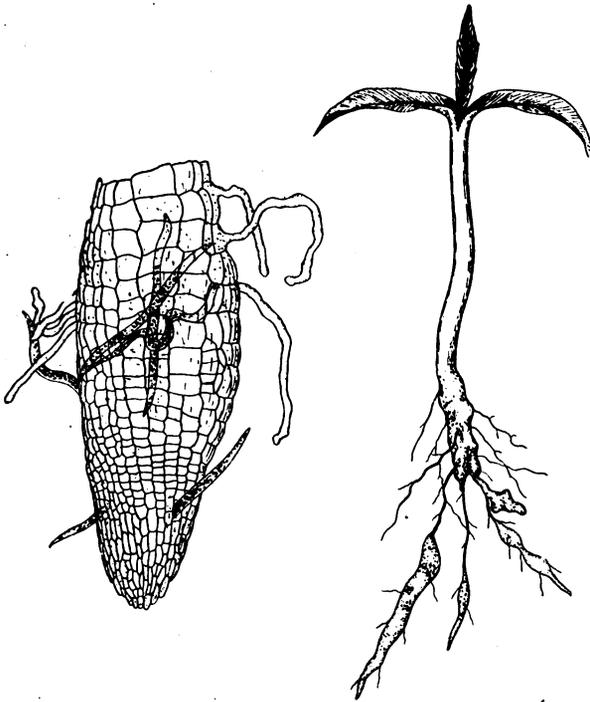
are unlikely to survive the second season. Beans and tomatoes, killed before they had time to bear, I have several times seen at the Cape; though I have more often seen even these particularly susceptible plants manage to exist. But even when the farmer can make plants grow and bear despite an abundance of the pest, the crops he gets must be much smaller than normally, and it is hardly likely that potatoes, beets, radishes, parsnips and such root crops fetch top prices when they are covered with disfiguring knobs, notwithstanding that the buyers are probably all unconscious of the multitude of worms they get with their purchases.

Dr. N. A. Cobb, the Vegetable Pathologist of New South Wales, in writing about the gall worm a few years ago described it as "an insidious and destructive pest, inhabiting the soil, and attacking the roots of a great variety of plants, and causing damage in many respects comparable with that produced by phylloxera." And further on he says: "Much land in Europe has become so badly infested that certain crops—for example, sugar beet—have had to be abandoned altogether. Not a beet-root will mature. The plants break the ground, languish a few weeks, and then die. Since time immemorial crops of various kinds have died suddenly. . . .

The unknown cause in some such cases has probably been the gall worm. Many an agricultural or horticultural failure attributed to the use of improper fertiliser, to poor soil, or wrong cultivation has been due to this insidious foe attacking the very fountain-head of vegetation. Were it possible to sum up in pounds, shillings, and pence the damage done by gall worms, the total would probably amount to a fortune for a nation." I think myself that Dr. Cobb paints the pest rather too black, but it certainly is a trouble, to keep one's land free of which is well worth a good deal of attention.

MEANS BY WHICH THE GALL WORM SPREADS.

Obviously the gall worm can do practically nothing itself to further its distribution. Like scale insects it depends almost entirely upon accidental agencies. A peach tree taken say from an infested Georgia nursery and planted out twelve thousand miles away by the Victoria Falls would almost to a certainty serve to establish the pest at that outpost of civilisation. I suggest this as an illustration as to how and to what great distances the pest may be carried, not as an insinuation against Georgia peach trees, which so far as the Cape Colony is concerned, we won't take at any price for other reasons.



An infested seedling Cucumber Plant; and at left tip of root, magnified seventy-five times, showing worms entering. (After R. E. Smith.)

Similarly, infested seed potatoes from the continent of Europe may be year by year increasing the infested area of the Colony; and it is through infested seed potatoes, I believe, that the pest is chiefly spread with us over considerable distances. The Natal Entomologist has told me that infested potatoes from over-sea have been detected at Durban. Our port inspectors have never reported any, but they are able to examine only a very few of the hundreds of thousands of cases that come through. Very

recently they were furnished with specimens of infested tubers, and now knowing better what to look for, they may find some to report. But there is no need to go abroad to look for infested seed potatoes. The very worst infestation by gall worm I have ever seen was to some potatoes I saw being sold on the East London market a few years ago. There must have been millions of worms in every bag. The moral is obvious. Seed potatoes should always be examined and, as far as possible, purchases should be restricted to the pack of growers and dealers who can be relied on to

sell only a perfectly clean article. Similar care should be exercised in getting fruit trees.

The agencies for spreading the pest locally are many. Irrigation and drainage water is probably one of the most important. Dr. Cobb mentioned above, says: "Almost everything that moves either in or upon the soil may transport the minute eggs and larvæ"; and he demonstrated the existence of the worm in the soil which adhered to farm implements and to the feet of horses, men, and even birds that had just come from infested land. He also states that during dry weather the eggs exposed on the cultivated ground may be caught up by the wind and blown long distances. One is safe in assuming, however, that the spread by the wind and by unavoidable movements of animals is extremely slow and uncertain compared to the spread by the running of water from infested soil on to clean soil, and this latter means still more uncertain than the planting of infested seed potatoes; yet, owing to the scarcity and value of cultivatable land in much of the Colony, such feasible precautions as suggest themselves to minimize the action of the minor agencies that spread the pest should not be ignored.

One correspondent asks if it is safe for him to plant clean land with seeds from plants off infested land. Not having ever seen, heard or read of any plant getting infested, I do not think there is any likelihood of the pest accompanying seeds. The only chance imaginable to me is that eggs adhere to particles of soil mixed with the seed, but this chance is exceedingly improbable and it is hardly conceivable that any such eggs would fail to perish by drying out before the seeds were planted.

REMEDIES.

There is nothing known about remedies based on South African experience so far as I am aware. If any reader has proved any measure practicable, or any of the treatments here mentioned of no avail, he is cordially invited to give others the advantage of his information through the *Agricultural Journal*.

To completely exterminate the pest when once it has become well established in a piece of land may be accepted at once as utterly impossible. But by letting the soil dry out and keeping it bare in the heat of summer, by growing for a few seasons kinds of plants little subject to invasion, and most of all by systematically trapping and destroying the worms in plants particularly liked by them, it has been found in other countries that land may be cleared to such an extent that susceptible crops may be raised for several seasons without their suffering appreciably.

Some writers claim that the gall worm can stand drying out, but others have proved that both it and its eggs perish if the soil dries out completely. A temperature of 140° F. for a short time is also fatal. It is quite possible that the best remedy for our dry districts is to clear the land of all plant growth, and to let it remain without water through a summer.

Lucerne, mealies, barley, and cereals generally are said to be little troubled by the pest, and to be safe plants therefore to grow in infected soil; mealies, in particular, are said to be only slightly attacked. Fruit trees, other than fig, peach, apricot, almond, plum, and citrus trees, may also be planted with little risk of severe injury. If the holes in which they are set are made extra large and filled with soil taken from a depth, or from beyond the infected area, they should get a good start before the worm finds them. In none of the publications that I have examined is there any mention of pears and apples being attacked. The orange and lemon are said to be slightly affected, but the other trees in the above list are said to suffer severely in the southern United States.

There is considerable discussion, in the books, regarding the value of chemicals and chemical fertilizers for destroying the worm; and the general conclusion may be drawn that none are worth trying in the Colony. Lime and potash fertilizers seem to have given the most encouraging results, but not until used in very large quantities; unslaked lime at the rate of two to four tons an acre, and potash fertilizers at the rate of one and a half tons are among the recommendations.

The most practicable remedy advocated is a systematic trapping of the worms in special crops. This remedy is based on a knowledge of the life cycle of the worm, and in Germany, where it was devised by University investigations, it is said to prove very successful. The idea is to get the worms that are in the soil into the roots of an easily-grown plant specially susceptible to attack, and to then root out and destroy this "catch crop" before eggs for a new generation are laid. The sugar beet and a kind of mustard (*Brassica rapa rapifera*) are given as plants used in Germany for the purpose. They are allowed to grow four weeks, and are ploughed out and sun-dried or raked up and burned. Several such catch crops in rapid succession may be required to get the pest well under control in badly-infested soil. Dr. Cobb, above mentioned, suggests the use of mangels, sown thickly, and also cow peas, as catch crops; and there seems to be no reason why such edible plants may not be fed off before the roots are ploughed out.



3 2044 107 334 252



