THE FEEDING HABITS OF PLANT PARASITIC NEMATODES

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The Yearbook of the U. S. Department of Agriculture for 1915 contains an article by the late Dr. N. A. Cobb, in which he chides biologists about their ignorance of the organisms that inhabit the soil. "We depend on the soil for our very existence," he wrote, "and it may seem that this fact should have caused us long ago to have made ourselves thoroughly acquainted with it and all its inhabitants; yet the truth is otherwise." "Relatively speaking, in a biological sense, this soil we daily tread under foot is almost a veritable terra incognita."

Cobb's accusations contain considerably more than a grain of truth and although this was written almost forty years ago the passage of time has not brought about a very substantial improvement. There is scarcely an experiment station or any other institution engaged in agricultural research that does not have a department of soil chemistry or employ on its staff one or more soil chemists. No group of scientists merits the gratitude of farmers more than the soil chemists; the results of their work have been of inestimable value to agriculture. But institutions that support departments of soil biology are indeed few and far between. Yet, I do not think anyone will contradict me when I say that soil biology is just as important as soil chemistry. As a matter of fact, soil biology and soil chemistry are inseparably joined together; they are the Siamese twins of soil science.

Of the myriads of organisms that inhabit the soil no animals of comparable size are as numerous as nematodes. Their number varies, of course, with different soils and with different conditions. A pint of soil may contain only a few specimens or it may contain thousands. All of these, you can be assured, feed on something. A very large number, often more than half the total population, are saprophagous and derive their food, in one way or another, from decaying organic matter. Such species, in most instances, are not likely to be injurious to crops; they may even be beneficial. A considerable number are predaceous and feed on small animal organisms, including other nematodes. To the extent that these predators destroy noxious organisms they too are beneficial. Some kinds of nematodes, though I do not think their number is large, feed on fungi. After the species in these various categories have been accounted for there still remains a great many that, undoubtedly, derive their food directly from living plants and in so doing interfere with plant growth.

Most of the work on plant parasitic nematodes has been done in a few central laboratories and the investigators have depended, to a large extent on material collected elsewhere and brought or sent to the laboratory for examination. As a result almost the entire literature on the subject deals with species that, in feeding, either penetrate into the tissues or occur in the buds, under the leaf sheaths, or in some location where, when the plant is examined, the parasites will be found associated with the injury they cause. But by no means do all the plant parasitic nematodes enter the tissues; many feed on the roots from the outside. Some of these external parasites cause just as severe damage to crops as do any of the other type and I am not excluding the well known root-knot nematodes. When an affected plant is taken to the laboratory for examination these parasites are not found associated with the injury they cause, they are left in the soil. This is one of the reasons why their importance has been overlooked.

The nematodes that feed on plants are sucking organisms and their manner of feeding is not essentially different from that of many sucking insects. Their mouth is provided with a long, slended, tube-like structure called the stylet, with which they penetrate the tissues and through which they suck out the content of cells. This, of course, results in a certain amount of mechanical injury to the plant. Those species that enter their hosts cause additional mechanical injury by their migration through the tissues. If nematodes had no effect on plants other than that caused by injury of this kind, their importance in crop production would, in all probability, be relatively trivial. Unfortunately this is not the whole story.

When a mosquito alights on the back of your neck it begins its feeding operation by injecting into your tissues a salivary secretion. The purpose of this, so we are told, is to prevent the coagulation of blood. The reaction of the surrounding tissues to this secretion is what causes the swelling and the itching. When a nematode feeds on a plant it does precisely the same thing for esentially the same purpose. First it injects into the tissues of the plant a secretion, the active ingredient of which, without much doubt, is a digestive enzyme. The purpose of this secretion, apparently, is to partially digest the protoplasm of the plant's cells and render it more fluid. The reaction of the surrounding tissues to the stimulus provided by this secretion is responsible for much of the damage that nematodes inflict on plants.

The manner in which the tissues react to this stimulus varies a great deal, depending on the kind of nematode, the kind of plant, and the location in the plant where the feeding takes place. In the case of the root-knot nematodes, this reaction, as you know, is pronounced and complicated and includes hypertrophy, proliferation, and coalescence of cells, and various other abnormal changes, both morphological and physiological. The result, in addition to the formation of a swelling or gall, is a general derangement in the normal functioning of the part affected.

The effect of the secretion produced by some nematodes is to kill the surrounding plant tissues and cause a small necrotic lesion. If the species of nematode is one where large numbers of individuals have the habit of congregating within the plant, these small lesions may coalesce to form a large one and the size of this may gradually increase as adjacent tissue is invaded. Many of the meadow nematodes (*Pratylenchus* spp.) have this effect, which is the reason why they are sometimes called the lesion nematodes.

The stubby-root nematode (*Trichodorus* sp.), which is causing so much damage to certain vegetable crops in the Sanford area, is an external parasite and feeds at the root tips. It causes very little necrosis, sometimes none at all, but it stops growth. In other words, the secretion injected into the root tips by this nematode has a devitalizing effect on meristematic tissue. The plant, in an attempt to overcome the injury, forms new roots but the tips of these may be promptly attacked and their growth stopped. If the plant becomes severely affected while small it may stand in the field for months without increasing appreciably in size. If its roots are examined one may see no lesions, little or no discoloration, in fact none of the symptoms ordinarily associated with a root disease. This is another reason why nematodes of this kind are so elusive and why their importance has escaped detection for so long.

The sting nematode (*Belonolaimus gracilis*), which has been found injuring strawberries in the Plant City area and certain vegetable crops in the Sanford area, is another external root parasite. It feeds at the root tips and along the sides of the small rootlets and in so doing may cause at least a moderate amount of necrosis. When the roots of an affected plant are examined they may have a yellowish discoloration and brown tips.

Thus we see that part of the injury which nematodes inflict on plants, probably the greater part of it, is caused by a secretion injected by these animals while feeding. This feeding operation may cause at least three distinct types of injury: galls, lesions, and devitalized root tips. While such classifications are useful in helping to visualize a situation, they have one fault, that of over-simplifying. Some nematodes may cause a condition that involves, in varying degrees, two or even all three of these types of injury.

This habit of injecting a secretion at the time of feeding is shared by some of the sucking insects. Mosquitoes do it, as already mentioned, and, I might add, they may at the same time inject the organisms that cause malaria. Some aphids inject a secretion into the plants on which they feed and nothing I have learned by reading or inquiry seems to preclude the possibility that this is true for most or all of them. Surely the fact that these insects feed in this manner and at the same time are so important in the transmission of viruses is no mere coincidence. No one has demonstrated that nematodes transmit viruses though some of the investigators in this field are keenly interested in the possibility. It has occurred to me that, in investigating this possibility we may have been working with the wrong nematodes. Some of these external root parasites seem able to migrate through the soil quite extensively and, in feeding, undoubtedly go from plant to plant. The similarity between their feeding habits and that of aphids excites the imagination.

I would like to say in closing that these external root parasites, about which we know so little, and of which the sting nematode and the stubby root nematode are examples, constitute a vast and almost wholly unexplored field in plant pathology and a field that is of enormous importance to the agriculture of the South.

THE VEGETABLE DEAL IN THE MUCK LANDS OF PALM BEACH COUNTY

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Belle Glade

My subject, "The Vegetable Deal in the Muck Lands of Palm Beach County" is rather large, so in order to cover it in a comprehensive way without over-running my allotted time, I have decided to divide my comments into three different sections.

1. *Early Days*:

First, in order that the subject may be better understood, I want to discuss the conditions that existed in the early days of development of Custard Apple lands on the islands and around the South East side of Lake Okeechobee.

When the first settlers, who were primarily fishermen, trappers, and plume hunters, started planting garden plots around their camp sites, and vegetables grew so luxuriantly that they could hardly believe what they were seeing, the phenomenal success obtained encouraged some of them to clear plots large enough to try small commercial plantings.

String beans, peppers and egg plant, english peas, tomatoes, and lima beans all did well and could be packed and carried out to market along the East Coast. The first vegetables grown were carried down the North New River Canal to Fort Lauderdale by boat and a few years later the Palm Beach Canal was opened up and could be used for water transportation. These early growers produced their small plots of vegetables only during mid-winter and as a rule obtained high prices, which encouraged them to clear larger plots. Only Custard Apple land, close to the lake was used and the cost of clearing was as much as $100.00 per acre at around $1.50 per day for labor, so fields necessarily remained small.

The farmers had no water control and frequently planted strips that were long and narrow along the lake shore as the water went down enough to leave the soil in farming condition. They had only light weight and very inadequate equipment for preparing land and most of their crops were planted with hand planters a few days after the moonvines, which covered every foot of cleared land, were cut and rolled up like rolling up a carpet.

In the early twenties a few Fordson tractors, No. 3 Oliver plows, and light weight discs were brought in and by staying on the job it was possible to turn an acre and a half a day with such an outfit.

The Florida East Coast Railroad was completed into the area in 1925 and this of course started rapid expansion of farm sizes and resulted in many more farms being opened up.

High water continued to prevent fall crops but Refugee beans and Little Marvel peas were planted during the mid-winter months and tomatoes and lima beans were added as major crops in the spring.

High prices, ($5.00 average for beans in the winter of 1926-27), low costs, and good yields made small farms profitable. Incomes of $1000.00 per acre were not too unusual and many families made a good living on less than ten acres of land. After the railroad came in a large part of the vegetables grown went out as express shipments. Several buyers confined their entire business to express orders, many of these orders for no more than five hampers, others running as high as fifty. Frequently the Canal Point Express Agent handled from 2500 to 3000 packages a day.

During the winter of 1927 the Everglades Experiment Station discovered the value of copper sulphate in getting crops to grow on saw grass muck, which up to this time had not been used at all. The use of copper sulphate made saw grass lands quite productive for certain crops including Irish potatoes and