

ROOT KNOT OF TEPHROSIA.*

C. H. GADD.

Tephrosia vogelii has on many estates proved to be a particularly valuable green manure plant, but the increasing prevalence of a particular disease of its roots is now causing concern to many superintendents. I refer to that disease known as the "Eelworm disease", (or if we conform with general nomenclature, "Root knot"), which is characterised by the presence of swellings (galls or knots) of greater or smaller size on the roots. Within each swelling there are one or more minute eelworms, technically known as nematodes, which are the cause of them. Before discussing whether such swellings or root knots are of any real importance it may be advisable first to explain a little more precisely what is meant by the term eelworm, and give a short account of what is known of this one in particular.

There are various forms of worms such as earthworms, wireworms, tapeworms, threadworms, hookworms, and so on, but they are not necessarily closely related zoologically although they are all called worms. The nematodes or eelworms are more closely related to the hookworms and tapeworms than to earthworms or wireworms. In structure they are relatively simple. For instance, they have no distinct vascular system or network of blood vessels such as an earthworm has. They have acquired their common name "eelworm" mainly because of their shape and movement which somewhat resemble the eel. Some species attain a length of several feet whereas others, such as the one found in *Tephrosia* roots, are minute.

As a group of animals, nematodes are remarkable for their parasitic mode of life. Some occur as parasites of animals, including man, and of plants; others are free living.

The eelworm which causes the root knots on *Tephrosia* is known by the scientific name *Heterodera marioni* (Cornu) Goodey. It occurs in temperate as well as sub-tropical and tropical countries and can attack a great variety of plants. In 1933 a list of plants attacked by this nematode, published in America, contained the names of 855 species. So you will realise that it is not very particular as regards its climatic and host requirements. Amongst the plants seriously attacked in Ceylon are included *Tephrosia*, Dadap, and Tea seedlings.

* Address given before the Nuwara Eliya District Planters' Association on 11th Dec., 1937.

Within a few days of the egg being laid, under favourable conditions a larva emerges. This is eel-like in shape, and measures slightly less than half-a-millimetre in length. It can remain viable in moist soil for some months, but where *Tephrosia* is grown the larva soon finds a suitable root for entry. It makes its way into the root in the vicinity of the root tip and rarely, if ever, enters an older part of the root. The large galls which one sees at the base of the tap roots were started when that region was the growing root tip, and consequently are the oldest. The larva enters the root tip in about 6-12 hours and takes up a position in the cortex with the body lying parallel to the longitudinal axis and with the head close to the central bundle of woody tissue. At this stage it is impossible to distinguish the sexes and this cannot be done until the larvae are about 15 days old. During that time they steadily become larger and thicker, but afterwards their course of development is different according to sex.

The males when full grown still retain an eel-like shape and may measure up to $1\frac{1}{2}$ mm. in length. The female, however, becomes pear shaped, the head being at the narrow end of the pear and is usually rather less than 1 mm. long and about $\frac{1}{2}$ mm. broad. Both males and females become fully mature in about a month.

The presence of eelworms within the root causes an enlargement and multiplication of cells in the region of the eelworm and results in a swelling or root knot. The size of the root knot will to a large extent depend upon the number of eelworms within. The formation of the gall begins after the parasite has been within the root about a week and the swelling becomes easily recognisable by the time the eelworm is mature. There is an accumulation of nutrients in the vicinity of the worms and the other organs of the plant must in consequence be deprived of some of their normal nutrients.

The majority of larvae develop into females, and fertilization is not essential for reproductive purposes. Parthenogenetic reproduction is quite normal and regular; males are produced mainly in heavily parasitised roots or under other conditions adverse to the parasite.

Each female lays from 300 to 600 eggs in a gelatinous mass. Frequently the gall ruptures and so allows the extrusion of these eggmasses. The larvae from the extruded eggs find themselves in the soil, but many remain within the gall. The latter go deeper into the tissues and set up new centres of infection. In this way the large galls are formed, and these old galls or root knots in which the 2nd and 3rd and later generations occur usually contain eelworms at all stages of growth.

The point I would like to emphasise here is the alarming rate at which the eelworm population can increase. Starting with a small number, if we multiply that population by 300 each month somewhat alarming figures are arrived at within a year. There can be no doubt that in those fields in which eelworms occur the continuous growth of *Tephrosia* has materially increased the nematode population, and the severity of attack on *Tephrosia* has increased accordingly. The infected area also is increasing rapidly. That will be readily understood if you bear in mind the minute size of these eelworms and the fact that small quantities of soil from heavily infected fields adhering to the foot or to agricultural implements may contain appreciable numbers of the parasites.

So far no mention has been made of the effect of the parasite on the plant other than the formation of galls on the roots. *Tephrosia* plants which have heavily infected roots appear to grow normally and there is no very striking evidence that such plants yield less heavily than healthy plants. The leaves may be slightly paler in colour, but that is of no great importance. In my opinion the trouble really starts when the plants are lopped. The number of enquiries concerning the death of *Tephrosia* plants after lopping has steadily increased, and in the majority of cases I have examined, such plants have had heavily infested roots. Given that climatic conditions are suitable and the plants lopped at a suitable height, the healthy plants are more likely to survive that operation than are those with root knot. Hence deaths after lopping result more from eelworm attack than from the lopping operation itself.

We must also expect that a large increase in the nematode population will probably be accompanied by increased numbers of deaths among the seedlings. I have grown *Tephrosia* seed in heavily infected soil taken direct from the field. At the end of a month the root systems were very small and in most cases consisted of little more than what appeared to be one continuous root knot along the short tap root. At that time eggmasses were being extruded from the older part of the galls so there would be no shortage of larvae to attack any new growth that may be produced later. A comparison of such roots with others of the same age from eelworm free soil can leave no doubt that plants heavily infected in the seedling stage have very small chance of becoming productive and that under such conditions the mortality of seedlings must be high.

You may have noticed certain resemblances between the life history of the root knot nematode and that which causes anchylostomiasis of humans. In both cases the larvae occur in the soil; they enter into and live within their hosts from which they extract their

nutriment; the worms reach maturity and the eggs are passed, only too frequently, back to the soil whence they infect other individuals. The effect of hookworm infection in a labour force is well known. It can be summarised briefly as loss of efficiency and vitality. That also summarises the effect of root knot of plants.

Tephrosia, however, is not our main crop, and whenever a disease occurs amongst the intergrown plants the question usually arises "What about the Tea?" The effect of this eelworm in a tea nursery can well be described as disastrous. There is no question whatever about the effect of this parasite on tea seedlings. But for some reason or other old tea becomes immune to a large extent. I have frequently examined the roots of tea bushes from nematode infested soil without finding any trace of a root knot. Recently, however, on examining the fine feeding roots microscopically I have come across nematode larvae within the roots. Whether such larvae ever reach maturity I am at present unable to say. So far as we know at present this eelworm does no material damage to adult tea bushes.

I think it will be agreed without argument that an increase in the nematode population in the fields increases the risk of its introduction into nurseries, unless precautions are taken against such introduction. If the disease on Tephrosia is regarded as of minor importance, especial care should be taken of tea nursery soils which are not exactly plentiful in Ceylon.

It is a simple matter to increase the parasitic nematode population of soil but an extremely difficult job to reduce it, especially where the ground is occupied permanently by plants. Where the soil can be cleared of living plants soil sterilisation with steam has proved an efficient method of destroying the nematodes, but obviously such methods are inapplicable to tea fields.

There is, however, one method which I think is worthy of consideration, that is by starving out the nematode, by keeping the land free of susceptible plants for a few years. In practice this means a rotation of green manure plants in which the use of nematode resistant plants would play an important part. If there are suitable nematode-free green manure plants you may ask "Why bother with Tephrosia at all?" If rotations can be devised without the use of root knot susceptible plants well and good. But I would like you to consider the question of rotation apart from this particular disease. All plants have their own enemies and diseases and the continuous cropping of any one plant tends to increase the number of its enemies and the amount of disease. One of the reasons for rotation of crops

in temperate regions is its value as a disease prevention measure. That is not the only reason of course, but to me it is an important one. Admittedly I am looking at the subject mainly from a pathological point of view which at times is apt to be overlooked. I can, however, leave the subject of rotation for your further consideration.

There is one other point I should like to mention and that is in connection with selective weeding. Before deciding whether a particular weed should be left or not it is advisable to examine its roots. Weeds which are susceptible to this root knot disease are best avoided, otherwise the nematode population of the soil will be increased in the same way as though *Tephrosia* were grown continuously.

Whether root knot of *Tephrosia* is a disease of any really serious importance will be largely a matter of opinion. It must be recognised that the disease materially reduces the life of the plant and, to some extent, its efficiency. At the same time if *Tephrosia* is grown continuously the nematode population of the soil is being very materially increased. Whether we are storing up for the future a further spot of trouble time alone will prove, but we should not close our eyes entirely to that side of the problem. As a precaution I have suggested the rotation of green manures but I recognise that that subject will have to be considered from other aspects than the pathological one alone.
