PERONOSPORA INFESTANS. *MONT.*

Potato Peronospora.

By R. A. Bastow, F.L.S.

Read May 18, 1886.

Natural order VIII.—Fungi.

Sub-order IV.—Hyphomycetes.

Tribe XVII.—Mucedines. *Hooker's Handbook.*

Peronospora infestans. Threads of mycelium slender, always destitute of suckers; fertile thread thin gradually attenuated upwards, with one to five branches; branches either simple or with short branchlets; acrospores ellipsoid or ovoid, apex furnished with a prominent papilla. *Cooke's Handbook of British Fungi*, p. 593. *Cooke Micro. Fungi*, t. 14; f. 264; p. 155. *Pop. Sc. Review*, vol. iii; t. 8; f. 3; p. 193. vol. xiii; p. 151. *Botrytis infestans, B. and Br. Ann. N. H. No.* 521. *Journ. Hort. Soc.* vol. 1; t. 4; p. 11. *De Bary. Ann. Sc. Nat.*, (1863), xx. t. 5; vol. 6. *Monthly Mic. Journ.*, 1874, 1875, 1876. *Science Gossip*, vols, xii., xiii. *Gard. Chron.*, 1875, 1876.

On potato stems, leaves, and tubers.

Many theories have been advanced with regard to the origin of the destructive *Peronospora infestans* or potato disease. Meteorological and electrical states of the atmosphere, saturation of the plant by water, degeneration by various methods of cultivation, the ravages of insect life, these and others have each in their time been brought forward as the cause of all the mischief with our potato crops. But the last twenty years of scientific inquiry by Messrs. Cooke, Berkley, De Bary, and more especially the researches of Mr. W. G. Smith, of Mildway Grove, London (to whom was awarded the Royal Horticultural Society's Gold Medal for his discoveries), has done much towards the completion of the life history of this withering blight, many proofs have been obtained of its fungoid origin, and its growth and method of reproduction has been most assiduously traced in its several forms as far as modern appliances will allow of investigations being made.

For much information concerning *P. infestans* given in this paper, I am indebted to Mr. W. G. Smith, who, in reply to my numerous queries in 1879 took the greatest pains to make points clear of which I was doubtful, and could not without assistance come to any definite conclusion, and who also liberally supplied me with slides for comparison.

When the potato plant has been attacked by the disease, the leaves assume a pale tint, and discolored spots appear thereon; if, in this stage of the disease, the underside of the leaf is examined it will be found to be covered with whitish patches, these patches are stems with fruit, and arise from the

abundant septate and branched *mycelium*, or opalescent thread-like roots which grow in the midst of the cells of the leaf, and eventually appear through the stomata as fertile stems; these patches are seldom seen on the upper side of the leaf, on account of the scarcity of the stomata on that side, and because the cuticle is too thick and too strong for the delicate threads easily to penetrate. The mycelium quickly proceeds towards the stem; the stem then becomes spotted with dark brown patches and very soon the tuber is reached and affected. In a day or two, and sometimes in a few hours, the disease which has attacked the leaf proceeds from within, outwards, to bear fruit in conspicuous white tufts. Almost as soon as the white tufts appear on the leaves, brown specks become visible in the tissue of the tuber, the starch grains are affected and discolored by them, the specks become darker and eventually flow together, the cell construction becomes dissolved and the potato is speedily converted into a dark brown semi-liquid mass.

If a section of a diseased leaf is made and observed with an eighth of an inch objective, the hyaline or opalescent *mycelium* or root threads will then be observed creeping amongst the enclosed cells of the leaf, and making their way towards the stem of the plant, branching, increasing, and bearing fruit as they extend.

The fertile stem, *i.e.*, that part of the plant which appears externally through the *stomata* may also be observed growing from the *mycelium*, and eventually through the *stomata*. This fertile stem is very thin, transparent, and is gradually attenuated upwards, it is supplied with from one to five branches, either simple or with short branchlets, not bifid, nor trifid. There are singular nodose swellings on the branches. The tips of the branches are furnished with acrospores or sheaths, and these contain zoospores furnished with cilia apparently for locomotion.

The *P. infestans* appears to be propagated by at least two different processes, each of them being productive in a high degree; these are, by *acrospores* on the fertile stems, and by resting spores on the *mycelium*; they have thus a slight but curious illustration in the potato plant itself, *i.e.*, the potato apple, the fruit; and the potato itself, the tuber.

The acrospores just mentioned as growing on the tips of the branches of the fertile stem are ellipsoid or ovoid in form, papillate at the apex, and slightly pedicellate at the base, one square line will contain 3,270 of them. These acrospores are sometimes called privileged spores or swarm spores.

It would appear that the acrospores are themselves capable of germinating under certain conditions, but more frequently important changes take place in the granulous matter with which they are filled. The granulous matter appears to differentiate,

forming minute separate bodies in the acrospore; these are zoospores, resembling small infusoria. When the acrospore is fully ripe it bursts with some force and scatters the contained minute bodies to some distance; thus liberated they move about very freely by means of their cilia: and then, eventually finding a resting-place favourable to their development, their cilia drop off, and after a little rest, strange as it may appear, a transparent tube or mucedinous thread proceeds from them, and entering by the stomata, they draw their sustenance from the plant on which they rest, producing more mycelium, and therefrom eventually fertile stems with acrospores containing another generation of zoospores.

The branchlets of the fertile stems also produce conidia or secondary spores, sometimes called dust spores; it is assumed that both the acrospores and the conidia are assexual. De Bary states that one square line will contain 19,620 zoospores, under favourable conditions sufficient to destroy an immense number of potato plants; they are thus fraught with much importance to the producers of such an extensively used article of food as the potato.

The second method of propagation is by resting spores, and we find these in and on the mycelium in the midst of the leaf and in the heart of the tuber, they are the production of oginia with antheridia. The antheridia are very small semi-opaque or very faint grey brown bodies attached to the mycelium by fine threads, these are attracted too and are absorbed by the oginia or ovarian sacs which afterwards produce resting spores. The oginia are larger than the antheridia and are of a pale grey brown colour before fertilization, but they become dark brown when the spores are ripe.

When Mr. W. G. Smith first stated that the resting spores under consideration produced *P. infestans*, some eminent Continental scientists were sceptical on that point; and it led to some interesting experiments being made. Some of the turbid fluid which flowed from an infected tuber, and which was almost one mass of mycelium, antheridia, and oginia, was set aside and carefully protected for examination. For three or four days the parts of the fungus floated and grew, the antheridia and oginia conjugated and were present in abundance at the bottom of the liquid, and a photograph of these minute bodies in conjugation was secured. The fertilized oginia, the future resting spores, were then preserved in sealed bottles and placed aside until the month of April in the following year. At that time some of the spores were taken out of the bottle and placed in pure water, some in potato liquor, some in saccharine fluid, some in nitrogen, some between glasses constantly moist, some on broken tiles, and some on the potato leaf as it was growing. These were under

darkened bell-glasses and were carefully examined daily. In nine months the oginia had doubled their size, and from being smooth round bodies they changed into semi-transparent brown rough bodies. The resting spores could then be seen within the oginium or sac, and in some cases two resting spores were within one sac.

In the beginning of May a number of these burst and broke into atoms, discharging a small bladder which also perished in dust; these were supposed to be effete spores. Others became darker, and through their structure the formation of zoospores could be distinctly observed. The zoospores were hyaline, and were eventually expelled, but after laying quiescent for a little time, two curved filaments appeared, they became straight, quivered a little, and swam out of the field of view, similarly to the zoospores from the acrospores on the fertile stem.

The cilia or filaments eventually perishing, the zoospores rested, they then threw out mycelium threads from which a fertile stem with acrospores was propagated; but the conditions being unfavourable, the growth was abnormal. The resting spores did not all produce zoospores, some of them produced a long jointed thread only.

The slides now under the microscope were made eight or ten days ago from dried specimens brought from Lancashire, England. The fertile stem, acrospores, mycelium, and resting spores are distinctly visible in one of the slides; the zoospores may also be observed, but very minute and without cilia. The filamentous white tuft of fertile stems is shown on another slide as an opaque object under a two-thirds of an inch objective. A glance at this object will enable the observer at once to identify the fungus on the potato plant if perchance it should appear in his kitchen garden; it is a beautiful object; it has the appearance of a minute crystal forest; the stems, the branches, and the fruit, all transparent and glittering; its beauty is however but short-lived, for when it touches it destroys, and as its victim falls its own beauty passes away, its power to destroy still remaining.

The *P. infestans* is nearly always in company with the *Fusisporium solani*, and it requires not a little practice to distinguish between the two kinds of spores. The Fusisporium spores are much smaller, 1/2500″ in diameter, and finely muriculated. They are equally destructive.

The *P. infestans* seem to vegetate most luxuriantly on plants that are grown on undrained ground, or on ground that has been dressed with rich hot manure; the plant, being saturated with moisture and forced with the manure, is delicate and appears unable to resist the attack, especially in warm rainy weather.

The crops on sandy soils appear to suffer the least from this

disease, as the air penetrates more freely into the earth, and the moisture passes off more freely. No one seems to know exactly where the disease came from when it so suddenly appeared in the Isle of Wight in 1844, all we know is that it there appeared and that it spread very rapidly.

It may be that the *P. infestans* is a descendant of a fossil species *Peronosporites antiquarius* found amongst the vascular bundles of a Lepidodendron from the coal measures, figured and described in Science Gossip, Vol. XIII., p. 270. It appears that the ovarian sacs visible in that fossil plant contain zoospores as well defined as any to be obtained on living plants, the septate mycelium being equally distinct. The only difference appears to be that the host was not a potato plant; the genus *Peronospora* is not however confined to solanacious plants. The eighteen at present known species of Peronospora attack parsnips, peas, onions, spinach, lettuce, clover, nettles, anemones, poppies, roses, docks, etc., but apparently not in such a destructive manner as *P. infestans* does with potatoes.

THE OCCULTATION OF JUPITER.

By A. B. Biggs.

Read 16th April, 1886.

As the visibility of an occultation, like that of a solar eclipse, depends upon the position of the observer, the chance of such an event being visible in any particular locality is rather scanty. On looking down the list of southern occultations of Jupiter for the current year, I saw there were three that came temptingly near us. On working these out, I found that one, that of 16th of April, was in a most favourable position for observation, being near the meridian; but, to my disappointment, that those for March 20th, and May 13th, would be just missed by us; the former being over just before the moon would rise, and the latter commencing just after setting. On 20th March, I had both bodies in the same field of the telescope at rising, the moon having passed the planet.

With regard to the occultation of 16th April, I regret much that, through my not having taken the precaution of obtaining assistance to record notes, and being flurried by the clatter caused by a boisterous wind upon my iron roof, I was not able