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AGGREGATION AND REPULSION OF NEMATODES AT pH GRADIENTS

by

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Nematodes show a tendency to aggregate. This may be a result of their migration in response to a source of stimulation or it may occur purely as a chance phenomenon, i.e., the nematodes may get trapped at a particular spot. Wallace (1963) regarded this phenomenon to be of fundamental importance in the survival of nematodes. Bergman and Van Duuren (1959) working with *Heterodera schachtii*, Bird (1959) with *Meloidogyne javanica*, *M. hapla*, *H. schachtii* and *Ditylenchus dipsaci*, and Klingler (1961) with *D. dipsaci*, concluded that these nematodes do not aggregate at any particular pH. However, Bird (1959) showed that *M. javanica* and *M. hapla* were repelled at extreme levels of pH 3 and 10.6. Townshend (1964) reported that *Aphelenchus avenae* was repelled by *Sclerotium rolfsii* and attributed this repulsion to low pH conditions brought about by the fungus. Edmunds (1967) working with *A. avenae* concluded that aggregation was more evident at higher pH gradients.

MATERIALS AND METHODS

The following experiment was done to study the aggregation of certain species of nematodes in different pH gradients. The nematodes used were *Hoplolaimus indicus* Sher, *Helicotylenchus indicus* Siddiqi, *Hemicriconemoides mangiferae* Siddiqi and other tylenchs, dorylaims and saprophagous nematodes which were extracted from soil around roots of citrus from Jawahar Park, Aligarh, where they

occur in a mixed population. Citrate-phosphate buffer was added to petri-dishes (7 cm diam.) containing 1.5% water-agar to provide a series of pH ranging from 2 to 8. In each dish a 5 ml mixed nematode suspension, containing approximately 500 nematodes was spread uniformly over the agar surface. After the water had evaporated 2 cm diam. discs were cut with a cork borer from the agar plates. Discs of different pH were then fitted at random to other petri-dishes within the pits formed by the removal of discs. In this way 10 sets of dishes were prepared each having three agar discs and two sets with two discs (Fig. 1) of different pH combinations; in each dish at least one of the replacement discs was the same pH as the original water-agar to provide the means of comparing nematode densities of the dish with that of the disc at the time of counting. The petri-dishes were then kept at 28 ± 2 °C for 24 hours, during which time the nematodes in the dishes and on the discs migrated under the influence of pH. The numbers of nematodes in each of the six categories (viz., *Hop. indicus*, *Hel. indicus*, *H. mangiferae*, other tylenchs, dorylaims and saprophagous nematodes) were counted in each of the discs, providing an indication of movement between different pH regimes. The experiment was replicated ten times and the results obtained are summarized below.

RESULTS

Fig. 1 shows percentage of nematodes which aggregate in the discs at pH gradients in the sets mentioned below:

Dish pH 7, disc pH 2, 4.3 and 7: All categories of nematodes were repulsed at the extreme acidic pH 2 and 4.3. *H. mangiferae* and dorylaims were more repulsed by pH 2, whereas only *H. mangiferae* was more repulsed by pH 4.3 than other categories. The maximum aggregation of all categories of nematodes was observed at neutral pH (7), but *H. mangiferae* and dorylaims showed comparatively more aggregation than others.

Dish pH 4.3, disc pH 2, 4.3 and 7: All nematodes were repulsed at pH 2 and 4.3 and aggregated at pH 7 as above. The maximum repulsion was shown by the dorylaims at pH 2 and minimum by *Hel. indicus*, *H. mangiferae* and other tylenchs. At pH 4.3 *Hop. indicus* showed more repulsion than all the others. The maximum aggre-

gation at pH 7 was observed in *Hop. indicus* and minimum in saprophagous nematodes.

Dish pH 3, disc pH 3, 4.3 and 7: The maximum repulsion was shown by *H. mangiferae*, *Hel. indicus*, other tylenchs and saprophagous nematodes and minimum by *Hop. indicus* and the dorylaims at pH 3. At pH 4.3 maximum repulsion was shown by *Hel. indicus* and dorylaims and minimum by others. The maximum aggregation was observed at pH 7 by *Hel. indicus*, dorylaims, other tylenchs and minimum by *Hop. indicus* and saprophagous nematodes.

Dish pH 3, disc pH 3, 5.2 and 8: All nematodes were repulsed at pH 3, and aggregated in the discs at pH 5.2 and 8. The saprophagous nematodes and *H. mangiferae* showed extreme repulsion at pH 3, while *Hop. indicus* showed minimum. In comparison the saprophagous nematodes showed maximum aggregation at pH 5.2, and *Hel. indicus*, *H. mangiferae*, other tylenchs, and dorylaims at pH 8.

Dish pH 6.4, disc pH 3, 6.4 and 6.7: All nematode categories were repulsed at pH 3 and aggregated at pH 6.4 and 6.7.

Dish pH 7, disc pH 5.8, 6.4 and 7: The maximum aggregation of *Hop. indicus* and *H. mangiferae* was observed at 6.4 and 7, and *Hel. indicus* at pH 7. The tylenchs aggregated at pH 6.4 and 7 whereas dorylaims showed maximum aggregation at pH 6.4 and the saprophagous nematodes at pH 7.

Dish pH 5.8, disc pH 3, 5.8 and 6.4: All nematode categories were repulsed at pH 3 and aggregated at pH 5.8 and 6.4. The maximum repulsion at pH 3 was seen in *Hel. indicus*, *H. mangiferae*, other tylenchs and saprophagous nematodes, and minimum in *Hop. indicus* and dorylaims. The saprophagous nematodes showed maximum aggregation at pH 5.8, whereas others at pH 6.4.

Dish pH 2, disc pH 2, 4 and 7: All nematode categories were repulsed at pH 2 and 4 and aggregated at pH 7. The maximum repulsion was observed at pH 2 and 4 in saprophagous nematodes and minimum in *Hel. indicus*. The maximum aggregation was observed at pH 7 in *Hop. indicus* and saprophagous nematodes and minimum in *Hel. indicus*.

Dish pH 4, disc pH 4, 6 and 7: All nematode categories were repulsed at pH 4 and aggregated at pH 6 and 7. The maximum aggre-

gation was observed at pH 7 in *Hel. indicus* and *H. mangiferae*, and at pH 6 in dorylaims and saprophagous nematodes. *Hop. indicus* and other tylenchs showed no distinctive preference between these two pH gradients (pH 6 and 7).

Dish pH 6, disc pH 4, 6 and 7: All nematode categories were repulsed at pH 4. The maximum repulsion was observed with saprophagous nematodes and minimum in *Hop. indicus* and *H. mangiferae*. The maximum aggregation was observed at pH 6 in saprophagous nematodes and minimum in dorylaims. At pH 7 maximum aggregation was observed in dorylaims and minimum in *Hop. indicus* and *Hel. indicus*.

Dish pH 4.3, disc pH 4.3 and 8: The aggregation of all nematode categories occurred at pH 8, maximum in *Hel. indicus* and dorylaims and minimum in *Hop. indicus*.

Dish pH 8, disc pH 4.3 and 8: All nematode categories were repulsed at pH 4.3 with little difference between them, but the minimum repulsion was in *Hop. indicus*. Maximum aggregations at pH 8 were similar for all the nematode categories.

DISCUSSION

The observations suggest that all six categories of nematodes are repulsed at pH 2-4.3, but tend to aggregate at pH ranging from 5.8-8. The maximum aggregation occurred at 6.4-6.7, when available, otherwise at pH close to this optimum. *H. mangiferae* is more sensitive to pH fluctuations than *Hop. indicus* or *Hel. indicus*. In general, the dorylaims and saprophagous nematodes are more sensitive to pH gradients than the tylenchs. In combinations of highly acidic pH (2-4.3) with neutral pH (7) all categories of nematodes aggregated at the latter. When the choice was between an acidic (4.2) and an alkaline (8) pH, the nematodes aggregated at pH 8. In pH combinations of 5.2, 6.4, 6.7 and 7 the preferences were not significant because of the narrow range.

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SUMMARY

The influence of pH on the aggregation and repulsion patterns of certain species of plant-parasitic and soil-inhabiting nematodes was studied. In general, the nematodes aggregated at pH ranging from 5-8 and were repulsed to a varying degree at high acidic pH. Maximum aggregation occurred at 6.4-6.7 or, if not available, at pH close to this optimum.

RIASSUNTO

Aggregazione e repulsione di nematodi a gradienti di pH.

È stata studiata l'influenza del pH sull'aggregazione o repulsione di nematodi del suolo, alcuni dei quali fitoparassiti. In generale, i nematodi si sono aggregati a pH tra 5 ed 8 e si sono respinti a pH più acidi. Il maggior grado di aggregazione è stato osservato a pH 6,4-6,7.

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