dissolved slowly in 25% NH₃.) Individual *H. bacteriophora* in the rosettes were alive and could infect *Galleria*. Similar rosettes were not observed in suspensions of *Neoaplectana carpopcapsae* (Weiser) or *N. glaseri* (Steiner), but a single rosette has been seen in a suspension of *N. bibionis* (Bovien).

Such rosettes (‘medusa heads’) have also been observed in free-living Rhabditid nematodes and in microfilaria of *Wuchereria bancrofti* (Croll, 1970). Whether this behaviour is a survival strategy for the dispersal of a cluster in an aquatic environment or is an artifact is unknown.

These observations were made during work supported by the Swedish Council for Forestry and Agricultural Research.


**Croll, N. A., 1970.** *The behaviour of nematodes, their activity, senses and responses.* London, Edward Arnold.

**Alison M. Spaull**: *A simple and reliable method of estimating root length.*

Plant roots often respond to nematode attack by producing many rootlets, which add little to the weight of the system but may increase its total length considerably, and Spaull (1980) found root weight to be a poor measure of size of the root system even in the uninfested plant. Root weight is also a poor measure of physiological activity, which is more closely related to the surface area or total length (Newman, 1966).

There is a need for a simple method of estimating root length and as there may be large amounts of root in small volumes of soil (Dittmer, 1938), the method must be accurate over a wide range of lengths. Newman (1966) derived a formula to convert scores from a line-intersect method to length estimates and Marsh (1971) simplified the method to occupy less time, which was satisfactory with lengths ≤ 10 m (Tennant, 1975); greater lengths were not tested. I tested the modified method using lengths of cotton thread ≤ 50 m, and have found such lengths in mature cereals, even in pots.

**METHOD**

Rectangular dishes of 37 cm x 30 cm and 2 cm deep were made from 3 mm perspex sheet and used superimposed on the required grid. Sheets of black paper, 42 cm x 34 cm, were marked in white to give grid squares of a) 1.27 cm (0.5 inch) or b) 2 cm: the sheets were protected with a transparent, adhesive plastic covering.

White cotton threads 0.3, 0.5, 1.0, 3.0, 5.0, 10.0, 30.0 and 50.0 m long, were each cut into strands of various lengths to mimic root lengths on a plant

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These strands were scattered into the dish and counted by traversing the horizontal and vertical lines systematically. Scores of one were given to: a “root” crossing a line, a “root-end” touching a line, or a curved portion touching a line. A score of two was given to portions lying on, or immediately alongside a line. Concentration on one edge of the intercept line aided interpretation (Tennant, 1975).

Scores were converted to length measurements using the formula

\[
\text{root length} = \frac{11}{14} \times \text{(no. of intercepts)} \times \text{(grid-spacing unit)}; \quad \text{(Marsh, 1971)}.
\]

Scores from the 1.27 cm grid (14/11 cm) required no conversion and gave the length in cm directly.

Cotton lengths of 0.3-5.0 m were counted on the smaller grid and lengths of 3-50 m were counted on the 2 cm grid. Most of the replicate counts were made after moving the dish upon the grid so that a different pattern of intercepts was counted but the sample was redistributed before every fourth count. An illuminated magnifying glass (X 2.5) was useful when counting longer samples.

**RESULTS**

Estimates were within ± 5% of the true length with one exception (Table I) and there was no consistent trend towards either under-estimation or over-estimation, except for under-estimation when counting conditions were poorest; i.e. with the greatest lengths measured on each grid size (5 m on 1.27 cm grid and 50 m on 2 cm grid).

For all estimates, except those from the shortest thread length (0.3 m) coefficients of variation were < 5%; an acceptable degree of precision (Tennant, 1975), (see Table I). Estimates of the 3 m length thread on both grid sizes had significantly greater precision (P < 0.05) on the 2 cm grid; there was no significant difference in tests of the 5 m thread.

Times taken for length estimates up to 10 m were similar to those of Tennant (1975) and greater lengths took proportionately longer (Table I). When both

<table>
<thead>
<tr>
<th>Thread length (m)</th>
<th>Length estimates (m)</th>
<th>% over-/under-estimation Grid size (cm)</th>
<th>Coefficient of variation (%)</th>
<th>Time (mins: secs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>0.31</td>
<td>+3.3</td>
<td>9.0</td>
<td>0:21</td>
</tr>
<tr>
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<td>0.53</td>
<td>+6.0</td>
<td>4.3</td>
<td>0:32</td>
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<td>-2.0</td>
<td>4.7</td>
<td>1:09</td>
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<tr>
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<td>-0.3</td>
<td>+2.3</td>
<td>3.5</td>
</tr>
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<td>-4.8</td>
<td>3.5</td>
</tr>
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</tr>
<tr>
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<td>3.8</td>
<td>14:45</td>
</tr>
<tr>
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<td>48.18</td>
<td>-3.6</td>
<td>3.4</td>
<td>23:38</td>
</tr>
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</table>