Grids in ground cover measurements

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Summary

Two methods for measuring the proportion of crop ground cover were compared. Both employed a rectangular grid of cords fitted in a frame at regular distances. One was based on the proportion of rectangles in which green area occupied more than half, and the other was based on the proportion of intersects coinciding with green area. The second method was accurate under all circumstances, whereas the first method was found to give biased records when the smallest details in the canopy were small compared to the grid cell size. A theoretical estimate of the standard error of the intersect method was derived for homogeneous canopies and confirmed by experimental data.

Introduction

Relative ground cover is the proportion of ground covered by green foliage, given as percentage (Burstall & Harris, 1983) or fraction ($P_{gc}$ as abbreviated by Haverkort et al., 1991). It is a most important variable for crop growth models based on intercepted solar radiation (Spitters, 1987) because of its close relationship with the fraction of radiation intercepted (Burstall & Harris, 1983).

A frequently used device for measuring $P_{gc}$ is a rectangular grid made of cords fitted in a frame at regular distances and held above the canopy to aid in the assessment of the covered area. Two distinct ways of using the grid are described in the literature: one is based on the proportion of rectangles that are more than half filled by green area (Burstall & Harris, 1983), and another based on the proportion of intersects directly above the green area, the so-called point intersect method (Nicholson, 1991). The terms “rectangle method” and “intersect method” respectively will be used hereafter in this paper. Korva & Forbes (1995) described a perforated double table for measuring leaf area. The $P_{gc}$ estimate from their table method as a by-product is virtually the same as that from the intersect method.

In grassland ecology, a somewhat similar controversy exists between the use of rectangular quadrats and dimensionless, point quadrats. In measurement of the botanical composition of a sward, the rectangular quadrat method is biased because the quadrat size affects the results (Greig-Smith, 1983; Neuteboom et al., 1992). In 1933, Levy & Madden published a point quadrat method that does not suffer from quadrat size problems. It was meant for (1) percentage of ground covered by each species and (2) percentage cover each species is contributing to the total area. In the special case of a crop consisting of one species, these signify $P_{gc}$ and leaf area index.
(LAI). Essentially, the table method of Korva & Forbes (1995) is a point quadrat method. While Levy & Madden (1933) used sharpened metal rods as probes, Korva and Forbes used human sight guided by aligned holes in a double table.

The objective of this paper is to assess the accuracy and precision of the rectangle and intersect methods, to provide practical recommendations for field work.

Materials and methods

Although it would be possible to arrive at conclusions of this paper with a theoretical study, a small experimental dataset is presented for illustration.

The two methods were applied on four images shown in Fig. 1, produced with a personal computer drawing programme and originating from a photograph taken from above a potato (*Solanum tuberosum* L.) crop. The scale of the working copies of the images was unknown, but was probably between 1:3 and 1:2. Two of the images consisted of one individual plant, the other two represented a closed canopy. In each of the two pairs of images there was one image with thinner foliage and another more fully covered, with approximately double the LAI of the thin one.

The grid used with both methods consisted of square cells with side length of 28 mm, printed on a transparency. Its size compared to the images is shown in Fig. 1. To assure free movement of the grid, only 8 columns and 4 rows were utilized with the

![Fig. 1. The four images used as material in the study. Left: individual plants; right: canopies; upper: thin; lower: double LAI.](image-url)