Short Report

A Method to Describe Root Branching*

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根の分枝程度を定量的に把握する方法*：森田茂紀・ハロルド P コリンズ**（東京大学農学部；アメリカ合衆国 農商務省 農業研究部 コロンビア高原保全研究センター）

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Root length density is used commonly as an indicator to describe root systems, but it shows only total root length per unit soil volume regardless of the age distribution of primary or branch roots. There is a need to study not only primary roots but also branch roots to understand the structure and function of a whole root system. Root branching has rarely been studied quantitatively^{1,2,3}), partly because techniques to examine root branching are limited. The authors have developed a quantitative method describing the degree of root branching. This method was used to characterize the developmental process of seminal root branching of both common (*Triticum aestivum* L.) and club wheats (*Triticum compactum* Host.).

Materials and Methods

A common wheat cultivar ‘Stephens’ and a club wheat cultivar ‘Tres’ were selected for study. Pregerminated kernels were planted in plastic tubes (3.8cm in diameter at top, 21.6cm in length and 164cm³ in volume) filled with 300g air-dried Walla Walla silt loam (typical Haploxeroll). All tubes were watered with 5ml fertilizer solution and soil was covered with vermiculite to reduce evaporation. Every 3 days 5ml water was added to each tube. Tubes were placed in an environmental growth chamber at 15°C with a 12h photoperiod at 525μmol · m⁻² · s⁻¹ photosynthetically active radiation. The location of tubes in the growth chamber was randomized every few days.

Samples were taken at intervals for about 1 month. After washing out the root system carefully, shoot development, length of seminal roots and number of first-order branch roots along seminal roots were recorded. Total root length including all branch roots was measured by the line intersection method⁴⁾ after staining⁵⁾.

A quantitative procedure was developed to evaluate characteristics of root branching. Degree of branching was described by “branching index” (BI) which is defined as follows :

$$BI = (TRL - TPL) / TPL$$

where TRL is total root length including all branch roots of any-order and TPL is total primary axis length. This BI describes the total length of branch root per unit length of primary root. BI is the product of two terms :

$$BI = ((TRL - TPL) / TBN) \\ \times (TBN / TPL)$$

where TBN is total number of first-order branch roots along primary axes. The first term (TRL - TPL) / TBN describes the average length of one first-order branch root including branch roots on it (“length factor”). The second term TBN / TPL presents number of first-order branch roots per unit length of primary axis (“density factor”).

Results and Discussion

The relationship between BI and total leaf blade length seemed to be sigmoidal within the experimental period (Fig. 1A). The “density factor” increased rapidly to a maximum value of about 5 (Fig. 1B). The “length factor” increased nearly linearly with shoot development with no indication of change before the

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Fig. 1. Development of branching on seminal roots of wheat. common : common wheat, club : club wheat.

experiment was stopped (Fig. 1C). There was no significant difference in branching characteristics between these two species.

This analysis effectively described the developmental process of seminal root branching. "Branching index" (BI) was developed from the 'coefficient of branching' (CB)²⁾ which was defined as a ratio of total root length including all branch roots of any-order divided by total primary axis length. Therefore, there is a relation of $BI = CB - 1$ between them. However, "branching index" is more useful than 'coefficient of branching' for analysis of root branching, because "branching index" is the product of "density factor" and "length factor" and shows more detailed information on root branching.

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