

## Agricultural concepts of roots: from morphogenetic to functional equilibrium between root and shoot growth<sup>1</sup>

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### Abstract

Concepts of the importance of root growth and function for plant production have changed gradually over the past century from a 'morphogenetic equilibrium' between root and shoot growth, which can be summarized as 'the more roots the better shoot growth', to a 'functional equilibrium' which puts emphasis on the water and nutrient uptake by the root system and not on the size of the root system as such. In fact, separate optima for root growth and shoot growth (dependent on root function) can often be distinguished. To obtain maximum crop production, relatively small root systems can be sufficient, provided the supply of water and nutrients is continuously high. Agricultural interventions aimed at increasing rooting depth by lowering the water-table or by deep soil tillage may be counterproductive for plant growth. Larger root systems may, however, reduce risks under rapidly changing environmental conditions and may increase nutrient use efficiency and hence reduce nutrient losses to the environment. Concepts are discussed in a historical perspective and examples are given of the empirical evidence to support or refute them.

### Introduction

Roots link plant and soil. Concepts of root growth and function therefore are important for understanding effects of soil conditions on plant growth. Concepts of the role of roots in plant growth have varied over the past century from the plant-centred view of a 'morphogenetic equilibrium' between root and shoot growth to the soil-centred view of an 'environmental determinism' by which soil factors govern root growth. In the past decades a synthesis of these two views was formulated in the hypothesis of a 'functional equilibrium' between shoot and root growth (Brouwer, 1963, 1983). In this article the various concepts will be formulated and

<sup>1</sup> Dedicated to the memory of Prof. Dr R. Brouwer.