The logic of root shapes

A lot of scientists have pondered the question of what the logic is behind all those different shapes that plant roots can take. Why are some roots thicker and others thinner, for instance? Liesje Mommer was one of the scientists who cracked the code. 'It is as though you've discovered buried treasure.'

TEXT ROELOF KLEIS **PHOTOS** ISTOCK

Plants weigh up the economic pros and cons of their investments in their roots. We're talking here about investments of carbon and nutrients, explains Liesje Mommer, personal professor of Plant Ecology and Nature Management at Wageningen. 'Thin, fast-growing leaves that don't need big investments of much carbon soon die. Thick leaves that need a lot of carbon last longer.'

So plants choose between 'grow fast, live for a short time' strategies, adopted by *Lathyrus* flower species for example, and 'grow slowly, live long' strategies, as used by oak trees. Plants can be categorized by these differences. For a long time, it was assumed that roots obey the same principles, and that 'fast leaves' call for 'fast roots'. 'Lots of studies have tried to demonstrate that,' says Mommer, 'but they didn't manage. The surface per gram of leaf, for instance, did not really correlate with the length per gram of root. No one understood it.'

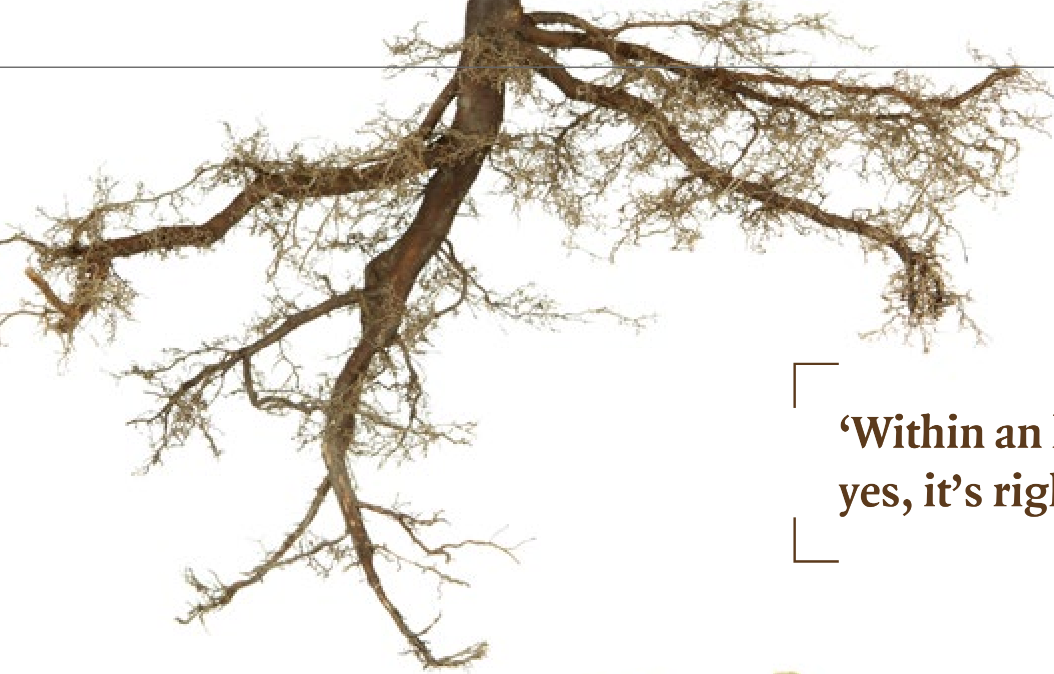
1800 SPECIES

So there had to be another logic at work than that of the division into fast and slow growers. An international research team of 20 scientists, led by Wageningen and the German Centre for Integrative Biodiversity Research, met in three workshops in Leipzig to get to the root of this mystery. The scientists used data on the roots of 1800 different species, which between them represented the large variety of climates and soil types on Earth, to figure out the relationships between root characteristics such as diameter, length per gram, tissue density and nitrogen levels.

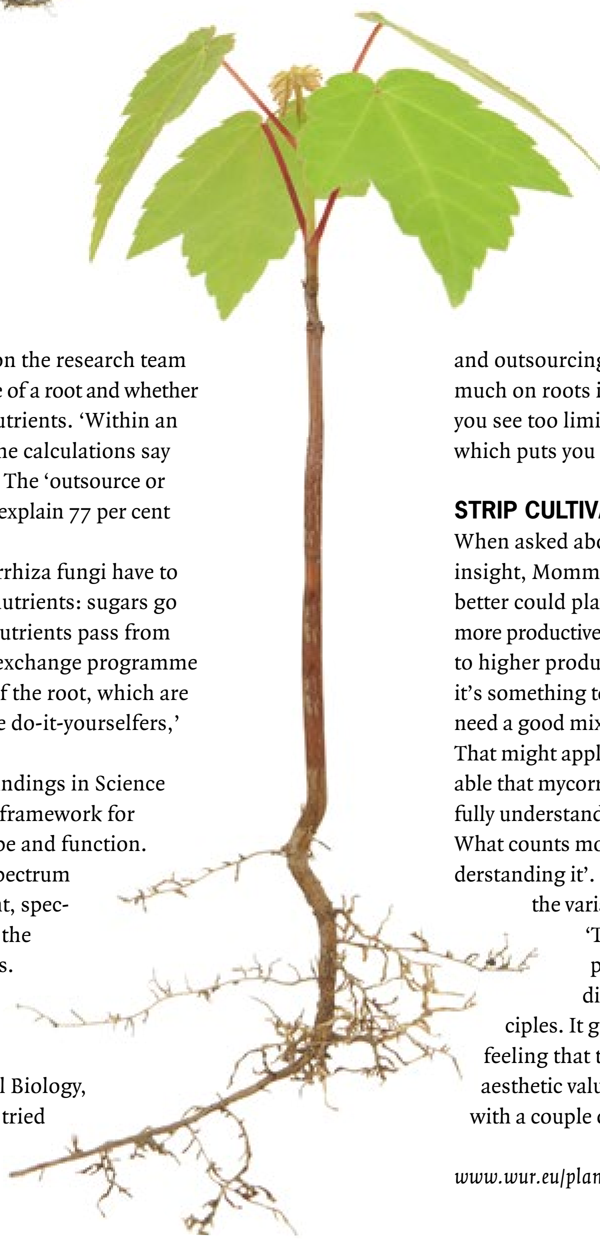
The scientists also looked at the functions of the roots. 'You see, all leaves have to do is capture CO_2 and light,' says Mommer. 'But there are more functions in play underground. A root has to store not just easily absorbable nitrogen, but also strongly soil-bound phosphorus, 12 other essential nutrients and water.' A root also has to contend with the density of the soil. Thin roots cannot easily penetrate dense soils. And roots form a habitat for many micro-organisms, which can have their own interactions with the plant. There are roots, for example, that do not absorb nutrients directly from the soil, but via symbiotic fungi, mycorrhiza, in the soil around the root. The onion, for example, with its short and relatively thick roots, cooperates intensively with soil fungi, 'outsourcing' its absorption of nutrients in the soil to them.

EXCHANGE PROGRAMME

All the possible relations were examined. 'That was the strength of this research group,' says Mommer. 'We sat down and thought about it first. We hardly ever take the time for that because we're all busy, busy, busy. And when the term 'outsourcing' was introduced during the workshop as the driving principle, everything suddenly



‘Within an hour we heard: yes, it’s right’



fell into place. The data analysts on the research team looked for a link between the shape of a root and whether it outsourced the absorption of nutrients. ‘Within an hour we heard the people doing the calculations say “Yes, it’s right”,’ Mommer recalls. The ‘outsource or do-it-yourself’ principle seems to explain 77 per cent of the variation in root shapes.

Roots that collaborate with mycorrhiza fungi have to create space for the exchange of nutrients: sugars go from the plant to the fungi, and nutrients pass from the fungi to the plant root. ‘That exchange programme takes up space in the outer cells of the root, which are therefore thicker than those in the do-it-yourselfers,’ says Mommer.

The researchers published their findings in Science Advances, and the result is a new framework for explaining such variations in shape and function. Alongside the existing fast-slow spectrum there is now a second, independent, spectrum that is key to understanding the shape and functions of plant roots. ‘It’s as though you’ve dug up buried treasure,’ says Mommer.

Mommer’s colleague Thom Kuyper, personal professor of Soil Biology, was on the research team too. He tried some years ago to demonstrate the link between root shape and outsourcing – in vain. ‘At that time I focused too much on roots in temperate zones,’ he recalls. ‘Then you see too limited a range of root variation in nature, which puts you on the wrong track.’

STRIP CULTIVATION

When asked about possible applications of this new insight, Mommer speculates: ‘Understanding roots better could play a role in making farming systems more productive. We know that more biodiversity leads to higher production. Why is that? One idea is that it’s something to do with the root strategy. Maybe you need a good mix of do-it-yourselfers and outsourcers. That might apply to strip cultivation too. It is indisputable that mycorrhiza play a very big role, and we don’t fully understand that role yet.’

What counts most for Kuyper is ‘the pleasure of understanding it’. ‘To be able to explain 77 per cent of the variation is a lot in biology,’ says Kuyper. ‘There are about 300,000 species of plants. It is pleasing that nearly all the diversity can be explained with two principles. It gives you a kind of deep philosophical feeling that there is order in the world. There is aesthetic value to being able to understand nature with a couple of simple principles.’ ■

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