Proteins called membrane transporters will be key to sustainable food production

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Of the present global population of seven billion people, almost one billion are undernourished. At the same time, we are close to the sustainable limit of 15 percent of Earth's surface that can be exploited for food production. Key proteins will be key to the future production of nutritious foods.

To grow more food more sustainably we need to make plants better at recruiting nutrients and water from soil to seed, according to 12 leading plant scientists writing in *Nature*.

Essential to this are proteins called membrane transporters. Transporters also effectively carry high-energy molecules to where they are needed, help plants resist pathogens and make plants more tolerant to adverse conditions. One challenge is to make crops do these things simultaneously.

"Just as our mobile phones will need more advanced technology to carry more information, plants will need better or new transporters to do the extra work we're going to require of them," said corresponding co-author Professor Dale Sanders, director of the John Innes Centre.

"We want plants to load up with more of what they need from the soil, making the most of what it offers."

"Or where the soil harbours salt or toxins, we want the plant to offload them or exclude them from essential cells where they could do harm."

Transporters can carry important molecules from outside to inside cells or vice versa. Recent advances in understanding how plants control these processes will help scientists create new tools to hand over to breeders.

Of the present global population of seven billion people, almost one billion are undernourished and lack sufficient protein, fats and carbohydrates in their diets. At the same time, we are close to the sustainable limit of 15% of Earth's surface that can be exploited for food production.

"We need to make the crops growing on existing agricultural land work harder," said Professor Sanders.

"Agro-chemicals are the current solution, but we can make plants better at finding and carrying their own chemical elements."

A long term goal at the John Innes Centre is to engineer cereals able to acquire their own nitrogen with the help of symbiotic bacteria. In the shorter term, nitrate transporters can be recruited in crops to make better use of applied fertilisers. Plants currently use only 30 to 50% of nitrogen applied in fertiliser and the rest contributes to water pollution and producing the greenhouse gas nitrous oxide.

Professor Sanders' own research is on improving the accumulation of zinc in cereal grains. Around two billion people suffer from iron and zinc deficiencies worldwide. Enhanced nutrient content is a crucial goal in the context of the growing world population and the central roles of staple crops in human diets. More research on transporters will improve uptake from the soil to the plant, and then redistribution within the seed.

Corresponding co-author, Professor Julian Schroeder, from the University of California San Diego, identified transporter HKT1 that protects plants from saline soils. In research and field experiments by

author Professor Rana Munns, from Australia's CSIRO, grain yields in pasta wheat improved by 25% on saline soil.

The HKT1 membrane transporter is from one of the earliest domesticated wheat varieties. It keeps salt out of leaf cells that are essential for photosynthesis.

"Saline soils are causing increasing losses in agricultural yields globally," said Schroeder.

"Research is showing that HKT1 transporters protect very different types of plant species, suggesting they could help produce more food in many locations."

A major challenge will be to combine, or "pyramid", such traits without diverting energy from yield. Insights into transporters are showing that they operate in specific parts of the plant or specific cell types. This means that traits bestowed by transporters may be particularly suitable for "pyramiding". More research will be needed to check they are compatible.

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