

## **Combining agronomic and breeding approaches for improved nutrient use efficiency**

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Many studies are made on genes, genotypes and breeding approaches aimed at improved nutrient use efficiency (NUE). However, crops are grown in cropping systems interacting with their environment and the agricultural management they are subjected to. What farmers and society need is improved NUE of cropping systems, not of single crops. It is important to keep in mind, that NUE is not a trait of a genotype, but a “trait” of the crop or cropping system, determined by the interaction between Genotype, Environment and agricultural Management (GxExM).

Better NUE can be achieved by a range of approaches, by improved fertilizer management, growing catch crops or by improved crop rotations. When trying to optimize NUE in a specific field, these other methods typically have much larger potential for improving NUE than the choice of improved genotypes. However, the smaller effect of genotypes is more easily achieved on larger areas, by choosing the efficient genotypes over other less efficient ones, while most of other approaches require special attention from the farmer each year. The choice is not between genotypes or agronomic measures, both are needed. Both because they interact, and because they can solve different aspects of the NUE problems. Improved NUE of genotypes must be directed at the farming system they are going to be grown in, e.g. the plant traits needed for high NUE are quite different in a low input organic system compared to a high input conventional system.

Crop root growth is a key factor in improving nutrient use efficiency of crops and cropping systems. It is important, as extensive root growth is needed to bring the crop into contact with the spatially distributed soil resources. Deep rooting is important for crop productivity as well as for environmental effects, as it brings the crop into contact with deep resources of water and nitrogen, otherwise left unexplored. However, deep rooting or other aspects of rooting are not included in breeding programmes.

We have been working on many aspects of crop root growth, differences among crop species and how they can be utilized for improved crop rotations as well as root growth of catch crops and their significance for improved nitrogen management. Currently we are working on genotypic variation in root growth and function, mainly in wheat. By drawing from the results from this root research, the combination of agronomic and breeding approaches for improved nutrient use efficiency will be discussed.

Also the term nutrient use efficiency (NUE) itself will be discussed. It is far from well defined, and sometimes it is used with directly contradictory meanings. There is a need to clear up this concept and define more precisely we are trying to achieve.