Efficiency regarding potato production

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Presently there is a rapid increase of demand for agricultural products for the food, feed and fuel markets. At the same time the concern for sustainability issues is on the rise. It is questioned whether the planet can augment the agricultural production for increasing numbers of people consuming more animal products and using a larger share of crops as fuel for transport, electricity and heat, while sustaining the natural resource base. The need is felt for decision support tools at global, field and plant levels and for certification of best practices. At Wageningen University we develop a generic approach on sustainability principles, criteria, indicators and norms to assure optimal efficiency of resources such as land, water, chemicals and energy. We call it the Potato Production Ecology (PPE) approach. It shows us which crop to promote where, how it should be grown to optimize the efficient use of resources, how to certify the best practices and which crop properties need genetic improvements to make best use of scarce resources in adverse conditions. Specifically for potato the approach helps us to calculate how efficient the resources such as water, land, light, chemicals could be used and confront this with the actual efficiencies.

The quantitative approach is best illustrated in the formula: \( Y = R \times RUE \times HI : DMC \). Here \( Y \) is the fresh tuber yield per hectare, \( R \) is the amount of Resources used or taken up by the crop per ha, \( RUE \) is the Resource Use Efficiency meaning how many
grams of dry crop matter (hauls and tubers) are produced per unit of resource intercepted or taken up, HI is the harvest index meaning the percentage of all dry matter produced that ends up in the tubers and DMC, finally is the Dry Matter Concentration of the tubers.

The PPE approach is represented graphically in the figure. Based on numerous experiments under all kinds of potato growing conditions we calculated the most important efficiencies and their relationships. We know potato produces about 3 gram per mega joule intercepted light, 5 grams of dry matter per liter water transpired or 30 g per g of nitrogen taken up. When it is dry the water use efficiency goes up but the other efficiencies go down at known calculated rates. All efficiencies depend on the abundance of resources available.

The PPE approach allows us to assist decision supports at three levels of scale: regional, farm and plant. Policy makers and multinational enterprises operate at global, national or regional scales. When starting a potato development program or planning a factory the approach shows – based on soil and meteorological data – the expected yields and quality and risks of crop failure. Based upon such figures governments may decide to alter restrictions such as on water use, and companies may decide to locate a factory and production area somewhere else. Farmers are assisted in making strategic (which field and variety) and operational (how much water and fertilizers to apply) decisions and obtain yield forecasts using this approach. Sometimes remote sensing images assist further in forecasting. Decision support at the plant level assists geneticists and plant breeders to design potato crops and varieties with desired yield, quality, resistance to pests and diseases, tolerance of abiotic factors and improved resource use efficiencies.

Finally the PPE approach is being employed in assuring sustainable potato production. Most countries have a Food Safety Authority that regulates food safety pre-competitive issues. Of increasing concern, however, is the sustainability of the primary production of food: are they produced such as making best use of scarce resources? The PPE approach yields the efficiencies that are obtainable. If from crop registration data it appears that e.g. water or phosphate were used sub-optimally compared to what was expected, an improvement trajectory can be started. In future Sustainable Agriculture Authorities will be set up in countries to assure durable production. To obtain level playing fields they will use a generic approach transportable over crop types and environments. For potato the PPE is a likely candidate. Sean Ranger (Ranger Consulting), Martin Steyn (University of Pretoria) and Linus Franke and myself (Wageningen University) presently compare data from 14 growers in the Sandveld with calculations with the model. When the data are analyzed we will publish them in a scientific paper and also present them in Chips.