Crop improvement and resistance to pathogens benefits from non-coding RNA studies

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With the rise of emerging economies around the world and a concomitant upgrade of health care systems, the global population has been rapidly expanding. As a consequence, worldwide demand for agricultural products is also growing.

Crops now provide food and the other important resources for seven billion humans.

Food supplies are primarily based on such crops as wheat, maize, rice and vegetables. But as the area of arable land and of cultivated land continues to decline, the future ability to meet the world's food security needs has come under a cloud of uncertainty.

Meanwhile, the use of pesticides and fertilizers has triggered long-term adverse effects on the environment, and has presented a serious threat to human health.

These problems and threats have caused scientists across the continents to search for solutions aimed at improving the production of grain to meet the needs of the growing global population and at bolstering the pest resistance of crops while reducing the use of chemical pesticides.

Proponents of new technologies including DNA recombination have promised a new green revolution, with genetically modified crops featuring transgenes achieving targeted traits including improved quality, increased production, and resistance to pests and stress. Unfortunately, safety concerns with respect to food and the environment caused by the expression of exogenous genes in crops have been raised.

Yet now, using non-coding RNA (ncRNA) to improve crops provides a new alternative.

Non-coding RNAs refer to transcripts that do not code for proteins, but play important regulatory roles in the cell, which excludes the possibility of producing exogenous protein products. Non-coding RNAs can be classified into two major groups: small non-coding RNA (siRNAs, miRNAs, and piRNAs) with a length of 20-30 nucleotides and long non-coding RNAs with a length of more than 200 nucleotides.

Advances in honing non-coding RNAs to enhance crops and in gRNA-guided genome editing are outlined in a new study entitled "Non-coding RNAs as potent tools for crop improvement," published in the Beijing-based journal *National Science Review*. Co-authors Renyi Liu, of the Shanghai Institutes for Biological Sciences, part of the Chinese Academy of Sciences, and Jiankang Zhu, concurrently based at SIBS and at Purdue University, state in the study that non-coding RNAs are now understood to play important roles in gene regulation.

"The functional roles of small RNAs in RNA-directed DNA methylation, viral defense, transposon suppression, abiotic and biotic stress responses, DNA double-strand break repair, and plant development have been demonstrated," they state in the article. "These advancements in basic research have greatly increased our knowledge of plant ncRNAs and facilitated the effective design of ncRNA-based strategies for crop improvement. ncRNAs function by repressing the expression of endogenous or exogenous genes at the transcriptional, post-transcriptional, or translational levels in a sequence-specific manner …

[and] can be used to specifically control the expression of target genes."

RNA genetic engineering has contributed significantly to two of the major goals of crop enhancement: resistance to pests and pathogens and improved nutritional value.

"RNA interference (RNAi) evolved as a defense mechanism against invading nucleic acid molecules such as those from viruses," the scholars write in the National Science Review.

Discoveries surrounding RNA have transformed it into a powerful tool of genetic engineering and functional genomics aimed at producing better agronomic traits.

RNA silencing-based technology has enjoyed success in improving the nutritional value of crops. By down-regulating key genes in plant metabolic pathways using RNAi constructs, transgenic crops may accumulate more favorable metabolites or produce less unwanted ingredients. Examples include corn with increased essential amino acids, soybean, canola and cotton with improved fatty acid composition, wheat with increased fiber content, alfalfa and poplar with reduced lignin, and soybean, rice, peanut, and apple with reduced allergens.

"A recent and exciting ncRNA-based technology is the clustered regularly interspaced short palindromic repeat (CRISPR)/CRISPR-associated (Cas) technology for gene editing in plants," they point out in the review.

CRISPR/Cas is a bacterial defense strategy against invading DNA such as phages or plasmids.

In this strategy, the CRISPR ncRNA guides a Cas endonuclease to cleave invading homologous DNA. Engineered CRISPR single guide

RNAs (sgRNAs) and the Cas9 endonuclease can be expressed in transgenic plants, so that the Cas9 generates double-stranded DNA breaks at target genes that are complementary to the sgRNA sequences.

"Through cellular DNA repair, mutations or corrections of the target genes can be achieved," the scholars state. "This CRISPR/Cas-based gene editing or genome engineering technology is a very powerful tool for plant functional genomics and crop improvement."

RNAi-based technologies have proven to be potent tools for crop improvement.

"As genomic resources for major crops and pests and pathogens are accumulated at a fast pace, additional target genes will be exploited for crop improvement," predict Renyi Liu and Jiankang Zhu. "RNAi-based technologies also have the potential to play a major role in achieving other goals for crop improvement such as increased yield and enhanced resistance to abiotic stresses once the relevant pathways are better understood."

More information: Renyi Liu and Jiankang Zhu. Non-coding RNAs as potent tools for crop improvement. *National Science Review*, 2014 Vol.1 (2): 186-189 nsr.oxfordjournals.org/content/1/2/186.full

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