Applications of RNA interference for plant disease resistance

Javad Abkhoo
Institute of Plant Biotechnology,University of Zabol, 98616, Iran
Email: javad.abkhoo@yahoo.com

Abstract

Research to alter crops for their better performance involving modern technology is underway in numerous plants, and achievements in transgenic plants are impacting crop improvements in unparalleled ways. Striking progress has been made using genetic engineering technology over the past two decades in manipulating genes from diverse and exotic sources, and inserting them into crop plants for inducing desirable characteristics. Gene silencing, often referred to as RNA silencing or RNA interference, is an evolutionarily conserved mechanism that protects the host genome against invasive nucleic acids, such as viruses, transposons, and transgenes. The RNAi gene silencing techniques are utilized for induction of resistance to *Helicoverpa armigera* in tobacco, crown gall disease in tomato and *Arabidopsis*, *cassava mosaic virus* in cassava, improving carotenoid and flavonoid content in tomato and for attractive flower colour in rose. RNA silencing is an area of intense studies leading to exciting new discoveries in plant improvement programmes.

Keywords: Disease resistance, Plant, RNA silencing

Introduction

Gene silencing, often referred to as RNA silencing or RNA interference, is an evolutionarily conserved mechanism that protects the host genome against invasive nucleic acids, such as viruses, transposons, and transgenes (Hannon, 2002). RNA silencing-based resistance has been a powerful tool that has been used to engineer resistant crops during the last two decades. Based on this mechanism, diverse approaches were developed. In this review, we focus on the application of RNA silencing to produce plants that are resistant to plant viruses such as RNA and DNA viruses, nematodes, insects, and the recent expansion to fungal pathogens.

Bacterial disease resistance

Crown gall disease, caused by the bacterium *Agrobacterium tumefaciens*, results in significant economic losses in perennial crops worldwide. The iaaM and ipt oncogenes which show 90% DNA sequence identity across studied *A. tumefaciens* strains are required for tumor formation. By expressing two self-complementary RNA constructions designed to initiate RNA interference of *iaaM* and *ipt*. They generated transgenic *Arabidopsis thaliana* and *Lycopersicon esculentum* plants that are highly resistant to crown gall disease development (Escobar et al, 2001).

Viral disease resistance

Currently, most of the successful resistance mediated by RNA silencing has been reported against RNA viruses as most being described on the above 'approaches to induce RNAi' section.
inoculation of blackgram (*Vigna mungo*) leaves, via bombardment with a hpRNA construct containing the promoter sequence of geminivirus Vigna mungo yellow mosaic virus (VMYMV) under the control of the 35 S promoter, showed that most of the plants completely recovered from the VMYMV infection (Pooggin et al, 2003), suggesting that the RNA silencing strategy is also effective in engineering resistance to DNA viruses. Interestingly, a recent report showed that the geminivirus Bean golden mosaic virus (BGMV) can also be suppressed by the expression of a hpRNA transgene derived from a replicase coding sequence (AC1) (Aragao and Faria, 2009), suggesting that a geminivirus can be targeted by both PTGS and TGS mechanisms (Buchmann et al, 2009; Rodriguez-Negrete et al, 2009; Zhang et al, 2011).

Insect and nematode resistance

Previous studies report several trials of directly injecting or orally administering exogenous dsRNA into insects to reduce target genes expression (Eleftherianos et al, 2006; Ohnishi et al, 2006) and the reduced development of rootknot nematodes, as well as Lepidoptera and Coleoptera insects, feeding on transgenic plants that carry RNAi constructs against target genes in these pests (Huang et al, 2006; Baum et al, 2007).
However, recent advances have brought high expectations for the future role of RNA-mediated resistance in crops. Once the novel resistance performances are in line with these expectations, this technology will create a new era in plant disease management, and its application will be extended to the commercial product in agriculture crops, at the same time further feasibility studies are needed for its wider application in future.

References

Aragao, Francisco and Faria, Josias. (2009). First transgenic geminivirus-resistant plant in the field. Nature Biotechnology. 27. 1. 1086–1088.
Baum, James. Bogaert, Thierry. Clinton, William. Heck, Gregory. Feldmann, Pascale. Ilagan, Oliver. Johnson, Scott. Plaetinck, Geert. Munyikwa, Tichafa. Pleau, Michael. Vaughn, Ty and Roberts, James. (2007). Control of coleopteran insect pests through RNA interference. Nature Biotechnology. 25. 1. 1322–1326.

Buchmann, Robert. Asad, Sofd. Wolf , John. Mohannath, Gesi and Bisaro, Martyn. (2009). Geminivirus AL2 and L2 proteins suppress transcriptional gene silencing and cause genome-wide reductions in cytosine methylation. Journal of Virology. 83. 1. 5005–5013.

Eleftherianos, Isaar. Marokhazi, Jonata. Millichap, Jessi. Hodgkinson Jozef. Sriboonlert, Advard. Ffrench-Constant, Robert and Reynolds, Esar. (2006). Prior infection of Manduca sexta with non-pathogenic Escherichia coli elicits immunity to pathogenic Photorhabdus luminescens: roles of immune-related proteins shown by RNA interference. Insect biochemistry & insect molecular biology. 36. 2. 517–525.

Escobar, Mrseh. Civerolo, Elmin. Summerfelt, Kodsa and Dandekar, Afvet. (2001). RNAi-mediated oncogene silencing confers resistance to crown gall tumorigenesis. Proceedings of the National Academy of Sciences of the United States of America. 98. 1. 13437-13442.

Hannon, Gregory. (2002). RNA interference. Nature. 418. 1. 244-251.

Huang, Gregory. Allen, Robert. Davis, Eleka. Baum, Taylor and Hussey Rsver. (2006). Engineering broad rootknot resistance in transgenic plants by RNAi silencing of a conserved and essential root-knot nematode parasitism gene. Proceedings of the National Academy of Sciences of the United States of America. 103. 1 . 14302–14306.

Ohnishi, Ader. Hull, Jobyli and Matsumoto, Susuki. (2006). Targeted disruption of genes in the Bombyx mori sex pheromone biosynthetic pathway. Proceedings of the National Academy of Sciences of the United States of America. 103. 1. 4398–4403.

Pooggin, Mogery. Shivaprasad, Posrt. Veluthambi, Kober and Hohn Todera. (2003). RNAi targeting of DNA virus in plants. Nature Biotechnology. 21. 1. 131-132.

Rodriguez-Negrete, Edvard. Carrillo-Tripp, Johan and Rivera-Bustamante Foder. (2009). RNA silencing against geminivirus: complementary action of posttranscriptional gene silencing and transcriptional gene silencing in host recovery. Journal of Virology. 83.1. 1332–1340.

Zhang, Zho. Chen, Hu. Huang, Xhi. Xia, Ri. Zhao, Qi. Lai, Ji. Teng Kubi. Lee, Yhi. Liang Lee. Du, Qi. Zhou Xhn. Guo, Hi and Xie Qhi. (2011). BSCTV C2 attenuates the degradation of SAMDC1 to suppress DNA methylation-mediated gene silencing in Arabidopsis. Plant Cell. 23. 1. 273–288.