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RNA Interference Gene Silencing; Mechanism and Its Applications in Plant Growth & Development

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Abstract

RNA interference, which is part of a complex network of interconnected pathways for cellular defense, RNA surveillance and development. It has evolved into a powerful tool for manipulating gene expression in the laboratory. It is the process through which double-stranded RNA (dsRNA) silences specific gene expression by degrading associated mRNA in a homology-dependent manner. Interfering RNA (RNAi) is a quick and easy method that can be used in a variety of organisms. The potential of RNAi technology is enormous. In this article, we discuss about how does RNAi works and its application in growth and development of plants.

Introduction

Gene silence is accomplished through a mechanism in which gene-specific double-stranded RNA is produced (dsRNA) causes homologous mRNA to be degraded. This RNA interference, or RNAi, is a term used to describe the process. RNA interference (RNA I) is a biological activity in which RNA molecules put a stop to gene expression or translation, by neutralizing targeted mRNA molecule. RNA interference is a homology-dependent gene silencing phenomena that relies on dsRNA for post-transcriptional gene silencing. The proteins encoded by different domains like DCL, AGO, RDR, and dsRNA-binding domain (dsRBP) are the primary components that make up the entire RNAi gene silencing factory (Sabbione *et al*., 2019).

It is the process through which double-stranded RNA (dsRNA) silences specific gene expression by degrading associated mRNA in a homology-dependent manner. The dsRNA is transformed into siRNAs. RNAi includes miRNAs and the following types of siRNAs: natural-antisense siRNA (nat-siRNA), heterochromatic siRNA (hc-siRNA). Double stranded RNA I are 21 nucleotides long and drive a sophisticated ribonuclease system to substrate mRNA targets. The cleavage at a site matching to the centre of the siRNA starts the degradation of the target mRNA. The RISC protein encourages siRNA to splice mRNA into small DNA fragments. These small DNA segments can't be translated since they're too short. As a result, the gene's activity was reduced.

Mechanism

1. During RNA I, lengthy double stranded RNA is cut or "diced "into short fragments ~21 nucleotides long by an enzyme called "Dicer".

2. These short fragments, known as small interfering RNAs (si RNA), attach to the mRNA sequence produced during the transcription process.

3. It utilizes the RISC multiprotein complex to attach to messenger RNA (rib nucleoprotein).

4. The RISC protein promotes in the splicing of mRNA into short DNA pieces by siRNA.

5. These short DNA segments are incapable of being translated. As a result, the gene's expression was suppressed.

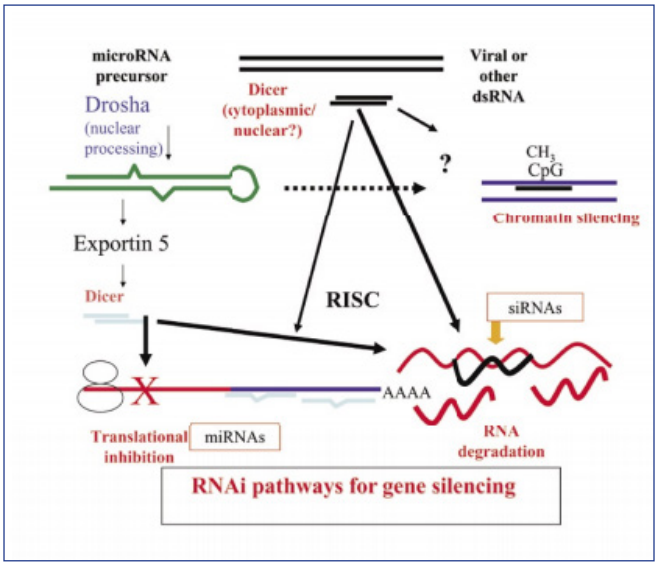

Figure 1: Representative diagram depicting the RNAi pathway for gene silencing explained by Kim *et al*. (2008)

Applications

1. Detoxification of Toxin and Allergens in Plants

All living organisms depend on plants for nutrition, yet some plant species include health-hazardous poisons and allergens that must be detoxified. To detoxify poisons and allergens in rice and soybeans, the PTGS method of gene silencing, such as RNA I, is critical. In rice, an antisense mRNA gene expression method results in the elimination of a 14-16-kDa allergenic protein motif.

For example, knocking down the 7-Nmethylxanthine methyltransferase gene (CaMXMT1) resulted in a 70% reduction in caffeine concentration in transgenic plants (Ogita *et al*., 2003).

2. Improvement of Quality Traits

Gene silencing *via* genetic engineering techniques like RNAi and CRISPR/Cas9 is critical for the regulation of genes involved in quality attributes in many crops (Saurabh *et al*., 2014). Such as miR156 and miR397, which control grain size, quality, and yield miR159, which regulates stem elongation and floral development, in maize, miR164 regulates lateral root growth and miR166 regulates leaf polarity.

3. Immunity against Biotic Stress

Viruses, bacteria, fungus, insects, and nematodes are all biotic stress agents that have significant consequences for plants. Plant immunity is improved through gene silencing, which is important in combating biotic stress. Scabs, leaf spots, and cankers are all diseases caused by bacterial pathogens that can be treated by gene silencing. Crown gall disease caused by *Agro bacterium*, which is managed using targeting silencing and iaaM genes by RNA I (Dunoyer *et al*., 2006).

Conclusion

RNA interference helps in speeding up our study of gene function. It is easier to deploy in the laboratory than transgenic technologies, but it requires careful planning and monitoring. RNA I silencing is a type of epigenetic gene regulation that is commonly employed in agriculture and biotechnology. It is an eco-friendly, biosafety, and evergreen technology as it eliminates some of the risks associated with transgenic development.

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