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Research progress in Nitrogen interaction between plants and pathogenic microorganisms

Hua Zhuang[1,2,3,4,5], Yang Zhang [1,2,3,4,5]

[1] Shaanxi Provincial Land Engineering Construction Group Co., Ltd., China

[2] Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd., China

[3] Key Laboratory of Degraded and Unused Land Consolidation Engineering, Ministry of Natural Resources., China

[4] Shaanxi Engineering Research Center of Land Consolidation., China

[5] Land Engineering Technology Innovation Center, Ministry of Natural Resources., China

Abstract

Nitrogen is one of the most basic elements of organisms, and the absorption and utilization of nitrogen is the main limiting factor for plant growth and crop yield. Higher plants can absorb and use various forms of nitrogen components from the soil. It is very important to study the relationship between plants and pathogenic microorganisms. In this paper, we reviewed the interaction between nitrogen and pathogenic microorganisms from three aspects, including the effect of nitrogen on the virulence of pathogens, in order to provide ideas for further application in plant health management in agricultural systems.

Keywords

Nitrogen , microorganisms , plants.

1. Introduction

Nitrogen usually enters the soil through the application of fertilizers, which are classified into four types: ammonium, nitrate, amide, and ammonium/nitrate. The application of nitrogen fertilizer affects the content of crude protein in agricultural products and the quality of agricultural products. However, we should pay attention to the content of nitrate in agricultural products. Excessive application of nitrogen fertilizer can lead to high nitrate content in leafy vegetables, which threatens human health. In addition, nitrogen also affects the stress resistance of crops. Excessive nitrogen leads to the increase of protoplasm synthesis, the increase of cell number, the thinning of cell wall, and the increase of plant water content and gravy, which is not conducive to the synthesis of cellulose and leads to the decline of disease resistance and lodging resistance. Nitrogen nutrition is a large number of essential elements for plant growth, which is closely related to the occurrence of plant diseases and has a complex relationship. Nitrogen not only directly provides nutrients for the growth of plants and plant disease pathogens, but also affects the growth and development stage and nutritional status of plants and improves the defense ability of plants against diseases. However, it also provides the available nitrogen source for the pathogen to increase its sensitivity, thus facilitating the growth of the pathogen. A large number of studies have shown that trace elements or mineral elements are closely related to plant diseases, and the deficiency or imbalance of elements directly or indirectly affects the occurrence of diseases.

2. Organization of the Text

2.1. Plant N absorption and fixation

Nitrogen uptake and fixation by plants is one of the most basic elements of organisms. Nitrogen uptake and utilization are the main limiting factors for plant growth and crop yield[1-3]. Nitrogen is not only a key component of cellular molecules such as amino acids, nucleic acids, chlorophyll, ATP, and plant hormones, but also a key regulator of many biological processes [4-5]. Higher plants can absorb and utilize various forms of nitrogen fractions from soil, the most important being the inorganic ions ammonium (NH4+) and nitrate (NO3-). Nitrate (NO3-) and ammonium (NH4+) are the main forms of N absorbed. NH4+ is directly absorbed from the rhizosphere by ammonium radical transporters (AMTs) and then assimilated into glutamate by the glutamine synthetase/glutamate synthase (GS/GOGAT) cycle. Nitrate (NO3-) needs to be reduced to ammonium (NH4+) before assimilation and utilization. Ammonium is generally more readily absorbed than nitrate when both compounds are provided to plants at similar concentrations[6-8], because plants must expend extra energy before reducing nitrate to ammonium to be converted to organic compounds[9]. "Therefore, the use of NH4+ as a nitrogen source saves a great amount of energy for plants; in nature, ammonium and nitrate are rarely present in the same amount, and their concentrations in soil can vary by orders of magnitude, from micromoles to hundreds of millimoles[10]" Cells have evolved many transporters that efficiently take up ammonium and nitrate across a wide range of concentrations.

2.2. Nitrogen supply and plant defense

To resist pathogen attack, plants have basic defense structures, such as cell wall, cuticle cuticle and wax layer, etc. Plants can also be activated at the site of infection or throughout the body including gene expression, Reactive oxygen Species (ROS) production, Defense responses include cell wall thickening, callose deposition, Pathogenesis related proteins (PR), and synthesis of antimicrobial secondary metabolites[11-12]. The molecular mechanism of plant defense response activation is extremely complex. The main defense hormones involved include salicylic acid and jasmonate. Ethylene, gibberellin, auxin, absciinic acid, cytokinin, and brassinosteroids can also act as modulators of immune response[13-14]. Ammonium transporter mutants of Arabidopsis showed increased resistance to Pseudomonas syringae and Bacillus subtilis [15]. Other studies also found that ammonium salt transport genes AMT1.1 and AMT1.2 were induced under biotic and abiotic stress conditions [16]. The ammonium salt transport genes SbAMT3.1 and SbAMT4 in sorghum were also highly induced in roots infected with arbuscular mycorrhiza [17].

2.3. Effect of nitrogen on the virulence of pathogens

Nitrogen supply can affect plant-pathogen interactions by affecting pathogen virulence. Sensing of nitrogen nutrient status by pathogens can control the generation of virulence factor activation and metabolic signals [18]. Pathogenic bacteria can activate the infectious process under nitrogen starvation conditions. For example, the development of filamentous forms required for basidiomycete infection of plants is stimulated by nitrogen starvation[19]. "In bacteria, the hrp gene encoding the components of the type III secretion system can be induced in vitro in basal medium, but it is inhibited by asparagine and histidine [20]." It has also been found that genes for effector proteins that affect fungal or oomycete virulence are also up-regulated under nitrogen starvation [21]. Junpeng Jiang[22] (2018)characterized the expression of 10 ammonium salt transport genes in wheat. The results showed that most ammonium salt transporter genes, including *TaAMT2.3a*, were significantly up-regulated during wheat-puccinia triticum interaction. The expression of *TaATM2.3a* gene was induced by Puccinia triticina in rhizomes and leaves, especially in roots. These results suggested that Puccinia striata might regulate the expression of TaAMT2.3a gene to obtain nitrogen from host cells and promote the infection of puccinia striata.

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