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(REVIEW ARTICLE)

Importance of nitrogen source and *Fusarium* species in sugarcane

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Abstract

In sugarcane, heavy losses in cane and sugar yields are caused due to the incidence of several diseases viz., red rot, smut, wilt, grassy shoot, ratoon stunting, and pokkah boeng. Nitrogen was associated with an improved incidence of *Fusarium* species in sugarcane. The most important reason for improving sugarcane quality is to extend the nutritional content, primarily the application of protein. Nitrogen is an essential part of sugarcane management has been reported to be associated with high protein content and excessive yield. N is the most widely reported as an element affecting plant diseases, especially fungal diseases, but in sugarcane unfortunately, very little research has been conducted into the impact of cane nutrition on disease susceptibility.

Keywords: Pokkah boeng; *Fusarium* Species; Nitrogen Availability; Sugarcane; Pathogens

1. Introduction

Sugarcane is cultivated in the tropical and subtropical zone of the country and it has a commercially important crop with many agricultural and industrial uses [1]. Many unique challenges in sugarcane production system have altered N recommendations compared to other growing regions including shorter growing seasons, winter freezing conditions, and high yearly precipitation. Nitrogen is used by sugarcane as an optimal N fertilizer application rate is dependent on many factors, such as soil type, crop age, plant and soil characteristics, climate, length of the growing cycle, and length of growing season [2]. In some areas N is used excessively and leads to N pollution, causing many human and ecological health disorders. Other sector elements are affected by reduced soil fertility, decreased crop production, and other effects of insufficient supply of N [3]. It is an inorganic fertilizer which can be assimilated in large quantities to produce strong, green plants associated with healthy growth and high grain yields. Nitrogen has been the most extensively studied soil nutrient concerning disease development. Extensive nitrogen availability can enhance growth production, extended vegetative period, and delayed crop maturity. The effect of plant nutrition on host-pathogenic relationships, the pathogenic life cycle and interactions that promote infection, the development of disease in the host, and the pathogen's secondary spread and their interaction that facilitates infection [4]. Nitrogen promotes shoot growth, and partially restricts root development. N crop efficiency use of fertilizers will vary widely from 25 to 60 percent, depending on soil type, application methods, cultivar and irrigation system [5]. With drip irrigation and fertigation, N fertilizer use efficiency can be greatly improved and the downside risk of N loss through denitrification will be greatly diminished [6]. Rapid growth consistently implies higher levels of N, humidity and lower sucrose content within the cane plant prior to harvest [1]. By storing N, sugarcane can reabsorb more of N than is necessary for its vegetative growth [7]. The N content of the tissue decreases markedly as physiological age advances and reaches its minimum in well matured cane. The indications of sugarcane pokkah boeng are disposed to develop throughout phases in which high concentrations of nitrogen are applied [8]. Nitrogen availability has enormous consequences on biological and morphological characteristics of the fungus, however also at the biosynthesis of secondary metabolites, consisting of *fumonisin* in *F. Verticillioides* [9]. Fungi can respond via complicated regulatory mechanisms to changes in the availability of nitrogen. The significance of the availability of nitrogen in regulating

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fungal growth, fundamental research is needed to shed light on the perception of nitrogen signals and changes in gene expression.

2. Why nitrogen is important to crop production

Nitrogen an important nutrients for crop growth, and a crucial limiting component for plant growth and production [10]. This is so due to the fact it is a predominant aspect in chlorophyll, the most essential pigment needed for photosynthesis as well as amino acids, the key constructing blocks of proteins [11]. The response of sugarcane to N availability manifests across plant structure and function. Nitrogen availability influences root growth, tillering, canopy development, leaf pigment characteristics, stalk development, water relations, N uptake and use, photosynthesis and radiation use efficiency among others. These and related attributes determine crop performance and yield. Hence, maximizing the impact of the most N responsive and yield-determining traits. Even though it constitutes 78% percent of the atmosphere, it is not obtainable directly for plant use, but is used directly in nitrogen fixation and industrial fertilizer manufacturing [12]. It is utilized by plants in the form of nitrate or ammonium ions through the roots to provide protein and nucleic acids and easily transported from older to more young tissues, which account for the reason why a plant deficient in nitrogen will show yellowing within the older leaves first, because of the destruction of chloroplasts and an absence of the inexperienced pigment chlorophyll. When N is deficient, the whole plant is affected showing stunted growth, reduced stooling and low yields. Yellowing of leaves occurs from the base of plant upward with die-back of the leaf tips and edges of the leaves. Nitrogen within sugarcane crop residues is returned to the soil in the organic form. This organic N becomes available for plant uptake once the organic matter has broken down and the N has been transformed into the mineral forms.

3. Role of nitrogen in *Fusarium*

In addition, the expression of many genes involved in pathogenicity is modified by the nitrogen status of the host [13]. Nitrogen is by far the most extensively reported element affecting plant disease caused by *Fusarium* spp. Several studies demonstrated that high N increased the susceptibility of plants to *Fusarium* species. Problems with *Fusarium* induced root are associated with a complex of *Fusarium* species found in conventional intensive systems with the dominant species being *F. oxysporum* [14]. Nitrogen shortage can also cause changes in biomass allocation. While the growth of leaves is reduced, the root growth may be maintained or even enhanced [15]. *Fusarium* spp. was repressed by forage-based crop rotations [16]. [17] repoted *Fusarium moniliforme* was the casual against of the pokkah boeng of sugarcane. For that reason, pathogenicity test based on the koch's postulates were used to prove that the isolated *Fusarium moniliforme* from diseased plants are the pathogens causing pokkah boeng disease. Conventional crops had more diseased roots in early stages of growth causing the former plants to produce more sets of shoot-borne roots during grain production. This fits the general *Fusarium* pattern of inciting root disease and stimulating root growth. It is possible that aggressive infection by *Fusarium* may disrupt activity because it triggers the plant to massively produce superoxide and hydrogen peroxide in oxidative bursts that also trigger systemic resistance [18*]. Fusarium* spp. infection also induces an extensive range of different plant defense which might also negatively have an effect on bacteria. More research is necessary to understand the role biological nitrogen fixation can play in improving nitrogen use efficiency and in reducing the use of synthetic fertilizer for crop production. For example, few studies have addressed the effect of N fertilization on the infection of fungal pathogens. Nitrogen may affect the virulence of the pathogen by stimulation or inhibiting enzyme synthesis or activity required for pathogenesis. This type of mechanism could be especially important in diseases.

4. Nitrogen availability

High nitrogen concentrations may often increase the extent of disease symptoms, which is endorsed to the specific forms of nitrogen available to the pathogen. The natural mineralization of organic nitrogen to inorganic ammonium and its consequent nitrification to nitrate are dynamic processes resulting in the availability of several forms of nitrogen during plant growth [18]. Thus, the adaptations of pathogens to thrive in these nitrogen-specific environments may be important factors for disease development. Nitrogen is an essential macronutrient required for sustainable growth which has a quick and pronounced effect by the presence of leaves of deep green color. In controlled-release fertilizers, the granules are coated with polymer or non-organic compounds aiming to regulate their release to the environment. Nitrogen, the luminary input of sugarcane production is also a single factor which contributes more to agricultural production. N compounds are absorbed into the plant roots and translocated throughout the plant before being formed into proteins. A plant depleted in N is very easily detected due to the symptoms of N deficiency which manifests itself in the form of yellowing of the leaves [19]. The instantaneous growing concern considering the ecological effects will require the development of best management practices that maximize water and N fertilizer use efficiency.

Fungi have developed a different pathway for the absorption and assimilation of nitrogen in mineral and organic forms, enabling them to use a wide range of organic and mineral compounds [20]. The principal growth factor element in plants is availability or failure to act on both growth and organogenesis nitrogen. An increased supply of nitrogen strongly affects the area of the leaves and the density of foliage. *Fusarium* can have fungicidal effects on ammonia. The ontologies "oxidation-reduction processes'' and "oxidation - reduction activity'' which may be associated with the advent of ammonium were induced. In fact, it seems that one can generalize the rule that biotrophic are favored by nitrate and inhibited by ammonium, while in contrast the necrotrophic are favored by nitrate and inhibited by ammonium [21]. The use of organic nitrogen base may also improve the competition between certain fungi and micro-organisms antagonistic to pathogens in favor of the latter, and thus limit disease outbreaks [22]. The effects of diverse nitrogen sources on *F. verticillioides* lead to pigmentation inconsistency, associated with fungal secondary metabolites, including the red pigments derived from bikaverin, fusarubins, and carotenoids as well as the brown and black pigments referred to as melanins [23].

In environments rich in resources, they are a priority to growth and secondary metabolism is limited, however, when stress limits the growth more than photosynthesis, the theory predicts a larger allocation of resources for secondary metabolism. The availability of nitrogen strongly impacts the expression of defense mechanisms, each constitutive and induced. Theories are intended to predict the relative importance of kinds of secondary compounds for defense in accordance to the environment of the plant [24]. An environment that promotes photosynthesis and limiting nutrients promote the acquisition of defensive compounds primarily based on carbon, such as terpenes or phenols. The availability of N from mineral based fertilizer is well established along with the influences on N on growth [25]. Although there have been a huge amount of studies on expertise N availability from various crops in recent years, there are still some work to be accomplished to maximize N availability. Nitrogen influence physiology of the plants by causing changes in their structures, it also affect the growth and virulence of the pathogen and also cause changes in the biotic and abiotic environment of the plants. The cropping systems investigated were designed to replicate realistic agricultural enterprises and while the baffled factors prohibit the investigation of effects of isolated changes in management, we believe the systems approach is particularly useful in agroecosystem investigations as it allows comparisons of realistic management systems rather than individual management practices whose piecemeal adoption may be unlikely.

5. Conclusion

The compatible and incompatible interactions between *Fusarium* and sugarcane were also documented in this study. Differences in the colonization pattern of *Fusarium* associated to defense responses of resistant have been identified by comparing a susceptible and resistant. The nitrogen fertilization influences the outcome of the *Fusarium* interaction with sugarcane using a variety of mechanisms, including changes in pathogenicity and virulence. We envision that integrative systems biology in combination with genomics approaches will play a more prominent role in generating integrated dynamic models of *Fusarium* responses to nitrogen in the future.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors declare no conflict of interest.

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