Nitrogen Management

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Nitrogen (N) management remains a global challenge for the sustainability of diversified farming systems. Field crops are often over-supplied with nitrogen by farmers aiming to high productivity. Although the increase of nitrogen rates leads in many instances to high yields, degree of effectiveness for nitrogen use remains low. Urease and nitrification inhibitors are technologies which have been present in the fertilizers market at least 50 years. Inhibitors exploitation ensures long-term nitrogen release and improved N-uptake by plants and N-storage in seeds and silage. Avail of inhibitors, such as the decline of nitrogen leaching in form of NO_3^-, reduction of emissions in NH_3 form, and rise of yield, are some of the desirable attributes that are derived from their integration in fertilization schedules. This review reports the evaluation of applied nitrogen, with inhibitors, and field crops based on nitrogen indices. The examined N-indicators include Nitrogen use efficiency (NUE), Nitrogen Utilization Efficiency (NUtE,) Nitrogen Agronomic Efficiency (NAE), Nitrogen Harvest Index (NHI), and N uptake.

nitrogen indices | urease inhibitors | nitrification inhibitors | field crops

1. Introduction

While the world population has almost doubled in last 50 years, and meat consumption has been skyrocketing, an increase in agricultural production is required to match projected demand; therefore, agriculture aims to rise crop performance [1][2][3]. As a result, over the past decade, intensification of crops has been achieved through excessive amounts of nitrogen application [4]. For the time being, many researchers have observed that more than half of the applied N fertilizer in crops is currently lost to the environment [5][6][7]. In particular, Lassaletta et al. demonstrated that only 47% of globally applied nitrogen is transformed into harvest products, in contrast to 68% in the 1960s [6][8].

Inefficient N use in agriculture has created several environmental problems and concerns [9]. The over application of inorganic fertilizers to the soil, along with nitrogen leaching is responsible for the contamination of groundwater [10]. Another problem that has arisen due to the excessive use of inorganic fertilizers is eutrophication, a form of water pollution, caused mainly by nitrogen [11]. Moreover, regarding water quality issues related to agriculture, an inspection of N emission from different routes and sources in inland waters and water catchment areas are attended, in order to guarantee water quality [12][13].

Since intensive agriculture has such an important impact on climate change and the environment, more environmentally friendly practices have been adopted in the last few years. Consequently, cultivation practices must be accomplished in a more precise way to increase crop performance; hybrid breeding is considered one of these practices [14]. Furthermore, the capacity for land, natural resource management, and conflict prevention need to be improved [15]. At the same time, although the fertilizer industry has changed considerably [16], nitrogen remains by far the main element used in synthetic fertilizers [17]. However, the need for improved nitrogen use efficiency in crops is imperative to design sustainable farming systems [5]. As a result, novel fertilizers with inhibitors and new technologies were introduced in the global market to reduce nitrogen leaching and enhance nitrogen utilization [18]. Slow-release fertilizers (SRF) are regularly related to nitrogen-based fertilizers [19]. Nitrogen management must be improved to minimize the undesired and detrimental environmental degradation, while achieving sustainable nourishment of the multiplying population. The overall efficiency of applied N differs widely among climatic zones and crops [20].

2. Impact of N Inhibitors on Fertilizer N Indices of Field Crops

The addition of inhibitors has been reported to regulate the allocation of nitrogen in individual plant parts and lead to an increase of stored nitrogen in fruits, such as tomato cultivation [21]. Moreover, N losses to the environment due to leaching and emissions, in this way increasing the nitrogen use efficiency, are moderated with the use of inhibitors [22][23][24][25]. However, this attribute should be combined with proper nitrogen rates in order to be ensured efficient yield and reduced emissions simultaneously [26]. Utilization of (N-(n-butyl) thiophosphorictriamide (NPBT) result in increased yield from 0.8 to 10.2% in various crop species [27]. Concerning the operating costs of the enhanced efficiency nitrogen fertilizers, application rates are crucial for sufficient yield and exploitation of environmental benefits [28][29].

A lot of inhibitors have been incorporated worldwide in many fertilization plans in many crops. Except from synthetic inhibitors, lower-cost materials, such as calcium chloride, sodium thiosulphate, and other natural NI, have been suggested for further evaluation in field-scale [30][31]. Nitrification and urease inhibitors performance is significantly affected by timing (relevant crop growth stage), type (single or split), and rate of application [32][33][34][35][36]. Soil pH is also a key factor that guides the effectiveness of various inhibitors; while soil pH rises, slow release fertilizers activity is benefited and action of the inhibitors is not repressed [37]. It is imperative to be paid attention in increased rates of applied nitrogen since risk for N losses to the environment simultaneously raises [38][39]. However, some researcher observed that nitrogen use efficiency after the introduction of inhibitors is not always improved in complex cropping systems in terms of yield [25][40]. Therefore, it is imperative that use of inhibitors should be defined in today's agriculture [18][41].

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