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The Importance of Nitrogen in Corn Culture

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Corn is one of the most cultivated cereals in the world and is used for various purposes and its production is linked to its economic importance, requiring the use of means and methods that enable the increase of its production, and one of them is fertilization with nitrogen. The objective of this work is to carry out a brief literature review on the importance of nitrogen for the corn crop, highlighting the benefits of its use and the need for its use in the crop. Plants need many nutrients for their development, and nitrogen is one of the main nutrients, being important for many chemical and physical functions in the plant. In addition, nitrogen is necessary in the corn crop, as it is a nutrient that is required in large amounts and has a great impact on crop production. Nitrogen has many benefits in the corn crop, as it is essential to the plant and to many crops, providing benefits throughout the plant, ensuring an increase in production components. However, the importance of nitrogen in the crop, refers to the plant, its use in the corn crop and the benefits provided, which generate positive results for its use, increasing various components of crop production, demonstrating that it is important for the crop, in its development and in the increase of maize productivity. Thus, it is noted that nitrogen is very important for the development of corn, composes several chemical and physical functions of the plant, it is necessary in the corn crop due to its requirement, provides many benefits to the crop, increasing production components and has many good results with its use in corn.

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1. INTRODUCTION

Corn (*Zea mays* L.) is a plant belonging to the Poaceae family and is the most produced and consumed cereal in the world, being classified as the second most traded commodity, second only to the soybean crop. Its cultivation occurs since the beginning of its discovery, being considered one of the most prominent and important cultures in our country [1,2].

Brazil, one of the great cereal producers, is the third largest corn producer in the world, behind the United States and China (CONAB, 2019). Over the years, with the development of other sectors, the corn production chain became very important, as the grain that was used for human and animal feed became an exportable commodity, in addition to being an energy matrix in the production of ethanol [3] (Souza et al., 2018).

Its large production is directly linked to its economic importance, using it in human and animal food, in fuels, beverages and polymers [2,4,5].

According to FAOSTAT data (2017), 1.13 billion tons of corn are produced in the world, with the United States as the largest producer, followed by China and Brazil, representing the largest producers of this product.

Among the corn producing countries, Brazil produced 97 million tons in 2017, approximately 81 million tons in 2018, and 100 million tons of corn in 2019 [6] (Ibge, 2021).

According to Conab (2021), corn production in 2020 was approximately 102 million tons, but in 2021 a production of 86 million tons of corn is expected, with a variation of 16 tons, with a lower corn production that year.

Despite the large production of corn in Brazil compared to other countries, there is a constant search for greater productivity and profitability of crops, seeking new technologies and means for the cultivation of the cereal [6,7].

To enable the best development of the corn crop, several methods and means can be used, and to realize that it is necessary to adapt all aspects of cultivation, it is necessary to use better cultivation techniques. One of the aspects to be considered is the soil, because by improving soil conditions, better exploration of the plant's root system may occur, seeking to increase nutrient absorption [8,3,2].

Fertilization is one of the techniques used for better crop development, adapting soil conditions, in order to ensure good production, and an important factor for the cultivation of corn.

According to Mortate et al. [7] and Guimarães et al. [3], due to the high production of biomass by corn, there is a high extraction and accumulation of elements from the soil, and fertilization is essential to overcome these deficiencies and in the study by Menezes et al. [9] reports the very high extraction of macronutrients in corn cultivars, with nitrogen being one of the most exported for the corn plant.

Thus, as there is a large extraction and accumulation of nitrogen from the soil by corn plants, hence the need for adequate fertilization to supply the crop and ensure that the soil is in ideal conditions for the cultivation of other plants [2,10] (Sousa et al., 2019).

According to Mortate et al. [7] and Guimarães et al. [3] Nitrogen constitutes only 1% of the plant's total dry mass, but its deficiency causes a reduction in essential amino acids, chlorophyll synthesis and the energy needed for the production of carbohydrates and carbon skeletons, directly affecting the maize crop development.

According to Batista et al. [6] and Bernardi et al. [2] many works show positive results with nitrogen fertilization in corn crop, demonstrating the importance of its application, in addition, nitrogen is considered one of the main nutrients required by corn crop and has positive effects on grain yield.

According to Rockenbach et al. [11] and Mortate et al. [6] corn is a nitrogen (N) demanding crop, requiring approximately 22 kg of nitrogen per ton of grain produced and exporting close to two thirds of the absorbed N to the grains, therefore, N is one of the nutrients which most limits grain yield.

Thus, it is noted that nitrogen is one of the most important elements for the growth of corn requiring its use in the culture, therefore, a

comprehensive study on this topic is necessary to demonstrate and verify the importance of this nutrient in corn crop, how necessary its use is, and its benefits in the corn crop.

The objective of this work is to carry out a brief literature review on the importance of nitrogen for the corn crop, highlighting the benefits of its use and the need for its use in the crop, demonstrating how much fertilization of the crop is necessary for its development and production.

2. LITERATURE REVIEW

2.1 Nitrogen in the Plant

Plants need several factors to obtain their development and production, and one of them is plant nutrition. Adequate nutrition in plants favors their production, as they are less susceptible to attack by pests and diseases, better tolerate periods of drought and other stresses, increase productivity, fruit quality and early start of production [12,13].

Thus, to ensure that the plant can develop it is necessary to apply fertilizers during its initial stages of growth and development. The supply of nutrients is usually more necessary in the early stages, presenting itself as a possible limitation of plant growth, due to any nutritional deficiency, so that subsequent applications are not able to reverse this reduction [13,14].

Among the nutrients necessary for plant growth and development, nitrogen is considered one of the most important nutrients for plants, required in greater quantity compared to other nutrients, and being essential in the chemical and physical processes of agricultural crops [14,4,5,2].

According to Bernardi et al. [2] plants respond differently depending on the form of nitrogen, and the climatic conditions at the time of its application. Therefore, it is necessary to choose an adequate source of nitrogen, which gives the best response to weather conditions, to carry out the application and avoid nutrient losses.

According to Cardoso et al. [15] and Neumann et al. [16] nitrogen is important for the plant, as it is part of the chemical composition of amino acids, proteins, DNA and RNA, pigments, hormones, nucleic acids and vitamins.

In addition, nitrogen acts on cell division in plant meristems, increasing plant leaf area, photosynthetic rate and, consequently, crop productivity [14,17]. Nitrogen is thus a very important element for crops and the the most absorbed nutrient by maize crops. Thus, its deficiency will limit growth and development, causing a drop in productivity [2].

Nitrogen favors plant development and according to Silva et al. [18] and Neumann et al. [16], this nutrient is essential in the processes of photosynthesis, respiration, ionic absorption, multiplication and cell differentiation, impacting the increase in the number of leaves, stem diameter and fresh and dry matter mass.

Plants absorb nitrogen preferentially in the form of nitrate or ammonium and the nitrogen absorption efficiency is usually equal to or less than 60%. During the application and absorption of nitrogen, the transformations and losses that occur in the soil are caused by processes of mineralization and immobilization, nitrification and denitrification, leaching and volatilization [14,19,20].

In the quest to increase the efficiency of nitrogen fertilization, it is important to take into account all these factors. In addition, the history of the area, previous crop, weather conditions, soil type, crop extraction capacity, cultivation system, level of investment and crop management are also very important [21,22,6].

In the quest to increase the efficiency of nitrogen fertilization, it is important to take into account all these factors, in addition to the history of the area, previous crop, weather conditions, soil type, crop extraction capacity, cultivation system, level of investment and crop management [21,22,6].

Furthermore, according to Rodrigues et al. [22] the other factors that are alternatives to increase the absorption efficiency is the time of application and splitting of nitrogen fertilization, thus reducing its losses in the soil.

The release of nitrogen gradually improves nitrogen absorption and ensures greater efficiency by not losing by volatilization or leaching, responding in the best way and being better absorbed by the plant [4,5,23].

The recovery of nitrogen spent by the plant with the application of nitrogen fertilizers is relative, as it depends on the volatilization of ammonia, leaching and nitrate denitrification, standing out

as a nutrient very susceptible to losses in the system [21,22]. Nitrogen fertilizers are very important, but the use of excessive amounts and/or shortages, depending on the nutrient source, can lead to soil degradation, acidification of the environment and base leaching [6,24].

Thus, nitrogen is considered one of the most important nutrients for crops, in addition to being the nutrient that has a great impact on production, requiring its proper application in the soil, with the necessary care to avoid losses in the soil.

2.2 Nitrogen in Corn Crop

For crop management, fertilization is essential, in order to meet the nutritional demand, and corn requires a large amount of nutrients, especially nitrogen [6,24].

In maize crops, nitrogen is the nutrient required in the greatest amount by the crop, being the limiting nutrient for grain yield and in the function of the plant's biochemical processes [12,22,24].

According to Rockenbach et al. [11] and Mortate et al. [7], approximately 80% of the total nitrogen that is absorbed by the corn crop occurs in the first 60 days of the cycle, and this is translocated from the reserve organs (mainly the leaves) to the grains.

According to Batista et al. [6], several studies demonstrate positive effects of nitrogen fertilization in relation to yield, in addition to the application of nitrogen topdressing on corn grain yield. In the studies presented, the use of 80 kg ha-1 of nitrogen in topdressing is enough to present a statistical difference in the treatment without nitrogen fertilization, demonstrating that nitrogen has a great influence on productivity.

In the work by Batista et al. [6] using isolated nitrogen and associated with humic/fulvic, obtained the results that the variables number of grains per row and number of grains per spike showed significant differences between the analyzed treatments, with higher averages observed in those that received topdressing nitrogen. This result demonstrates the importance that nitrogen has on corn yield components.

In the work by Batista et al. [25] to evaluate the interference of plant densities and nitrogen doses, increasing the dose provided a linear increase in stem diameter, plant height, ear insertion height, 1000 grain mass and yield. The higher density resulted in a smaller stem diameter and number of grains per row, but it presented a higher plant stand, with a greater amount of ears and, consequently, higher grain yield, being suitable for the crop.

In the work by Batista et al. [26] evaluating nitrogen fertilization levels and high sowing densities, higher values of number of ears per plant, number of grains per row, number of grains per ear, productivity per plant and per ear were observed in the lowest density. With the addition of nitrogen levels, the number of grains per ear increased, but the other variables were not influenced by the nutrient levels.

In the work by Bernardi et al. [2], evaluating the height and number of leaves of maize plants with nitrogen doses, found results that the highest doses had the highest number of leaves and plant height in an equivalent way and the control (smallest dose) without nitrogen had the lowest plant height.

In the work by Neumann et al. [16] with the objective of evaluating the productivity, the morphological and chemical composition, as well as the rate of disappearance of the dry matter of the corn silage cultivated under increasing levels of nitrogen topdressing, the results were obtained. nitrogen in coverage provided a lower number of dry leaves at harvest.

In the work of Picazevicz et al. [24] in order to evaluate the isolated and combined effects of Azospirillum brasilense, Rhizobium tropici, molybdenum and nitrogen on corn growth, higher corn growth was observed due to nitrogen fertilization.

In the work by Rockenbach et al. [11] with the objective of evaluating the components of corn production and yield as a function of Azospirillum doses. brasilense, associated with the application or not of nitrogen in topdressing, obtained the results that the highest dose of nitrogen in this work presented the highest plant height at 60 days, stem diameter, diameter, length and dry mass of ear, yield and mass of a thousand grains.

Thus, as nitrogen is essential for plant metabolism, as it is linked to the synthesis of photoassimilates and other essential substances, it affects the number of grains per spike,

diameter, height, number of leaves (leaf area), growth, productivity and mass of a thousand grains, thus judging the results presented.

In corn, among all nutrients, the most demanded is nitrogen, but nitrogen fertilization is the most burdensome to its cultivation and has the greatest influence on grain yield [21,24,19]. It is worth noting that the different hybrids and varieties of corn need different amounts of nitrogen, which varies according to their productive potential [22].

In the work by Menezes et al. [9] evaluating the extraction of nitrogen by the corn crop with swine manure, the result was obtained that the extraction of primary macronutrients by the corn crop follows the following decreasing orders of absorption: potassium>nitrogen>phosphorus and nitrogen>potassium> phosphorus, respectively, for the vegetative and reproductive periods.

Thus, the influence of nitrogen on corn crop productivity is noted, as nitrogen is essential for all plants, making up a large part of chemical and physical processes. Furthermore, it is important in the growth and development of crops, thus standing out as an essential nutrient for corn.

2.4 Benefits of the Use of Nitrogen in Corn

The use of nitrogen in the corn crop is linked to its productive potential, and it is essential to seek management strategies to meet the demand for nitrogen, with low cost and less environmental impact, in order to improve economic efficiency and preserve the environment, using - correctly with doses, times and from appropriate recommendations, avoiding excess nitrogen applied, losses and changes in the relationship between nutrients, contamination, excessive use of natural resources, among others [2,24,4,5,26].

The benefits of applying nutrients such as nitrogen to the soil, without excess or shortage, interfere with corn productivity and production, as they provide better performance and efficiency of the crop by generating a more favorable location for plant development without harming the relationship between the nutrients and no losses in the soil [22,24].

According to Rodrigues et al. [22] and Batista et al. [2] nitrogen has other benefits by influencing the initial growth of the corn crop, thus affecting the production of green mass, dry mass, stem diameter and plant height.

Thus, nitrogen brings many benefits, being one of the solutions to maximize the production of biomass, as it is the nutrient responsible for increasing cell expansion, leading to the development of the aerial part of the plant and generating positive effects on physiological processes [24,27].

However, since it is a nutrient exported in greater quantities from the soil to the plant, in which it is translocated in large quantities to the grains, it has a great factor in the plant's productivity. Furthermore, leaves well supplied with nitrogen have a greater capacity to assimilate carbon dioxide and synthesize carbohydrates during photosynthesis [16,24].

Thus, nitrogen presents the various benefits presented, in addition to having great importance for plants, and consequently in corn, thus affecting, in a way, corn cultivation. Thus, with the emphasis of nitrogen in plants due to its great importance in the growth and development processes, the nitrogen of the corn crop in its productivity and need, and the benefits in relation to photosynthesis and other processes, it is noted that this nutrient brings many benefits to the corn crop.

2.5 Importance of the use of Nitrogen in Corn Crop

The corn crop is affected by many factors that contribute to low corn productivity, such as climate, genetic potential and nutrient management [9].

The use of nutrients as already presented is very important for the development of crops, in this case, the corn crop mainly demands nitrogen, resulting in a greater demand for nitrogen sources, seeking higher yields in corn crop [28,12].

In this way, in order to increase productivity, according to Menezes et al. [9], the supply of nutrients is needed, namely nitrogen and other nutrients, through soil fertilization, which can be from mineral or organic sources.

From the benefits of nitrogen, from the use by the plant and in the corn crop, it is essential to apply nitrogen in the growth and development stages, to avoid the reduction of growth or

formation, helping to make it healthier and not being susceptible to climate, stresses, pests and diseases [13,28,29].

In addition, it is noted that nitrogen is directly related to the increase in grain yield, which is an essential element in the cultivation of corn This is attributed to its importance during the chemical and physical processes of the plant, in photosynthesis, growth, development, grain development, reduced susceptibility to pests and diseases, among others [22,24].

The nitrogen dynamics in the soil-plant system is very variable, being influenced by management, cultivation system, nutrient source and edaphoclimatic conditions. Thus, the effects of nitrogen on the plant can be variable, changing with dose, location, time and all factors related to nitrogen uptake in the plant [29,22].

Several studies point to positive effects of nitrogen on yield components and corn grain yield, but the results may vary, with differences caused by particular conditions in each study site, such as climate, soil, precipitation, investment level, cultivation system and management culture [28,12,2].

The importance of nitrogen is linked to its essentiality in the plant, its growth and development, chemical and physical composition, its use in the corn crop, the benefits it provides, whether in terms of mass gain, stem, photosynthesis, among others.

Furthermore, studies have shown positive effects with nitrogen fertilization, such as the work by Portugal et al. [21] in which nitrogen fertilization increased the mass of a thousand grains and crop yield, by Batista et al. [25] by increasing plant height, from Picazevicz et al. [30] increasing plant height, shoot, root and total dry mass, and Neumann et al. [16] in reducing the number of dry leaves and increasing the levels of fibrous carbohydrates in the plant.

Thus, the importance of nitrogen in the corn crop is noted, in addition to being important for plants in general, it stands out in the corn crop, due to its high demand by the corn plant. Thus, the application of nitrogen ensures its growth and development, providing benefits to the corn crop, impacting the final corn yield.

3. CONCLUSION

The corn crop is one of the most cultivated and has great importance in the food sector, and to ensure its supply, proper crop management must be carried out, especially the nitrogen fertilization that is required in large quantities by the crop.

Nitrogen is important for plant development and composes several chemical and physical plant functions, being necessary in corn culture due to its importance for the plant, providing many benefits to the crop, increasing production components and presenting very good results with its use in corn cultivation.

DISCLAIMER

The products used for this research are commonly and predominantly used products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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