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The Effects of Nitrogen Fertilizer on Plant Growth

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ABSTRACT

Nitrogen is an essential element for plant growth and development; however, due to environmental pollution, high nitrate concentrations accumulate in the edible parts of these leafy vegetables, particularly if excessive nitrogen fertilizer has been applied. The consumption of these foods can be harmful to human health, thus it's critical to design an effective plan for applying nitrogen fertilizer to crops. This study used organic, inorganic, and liquid fertilizers to look at how they affected nitrate levels and lettuce growth. The healthy growth of trees is ensured by nitrogen fertilization. The study's objective was to determine how different nitrogen fertilization techniques affected a few chosen criteria. This analysis was thought to be a hazy representation of the demands of cherries produced in herbicide barren fields. The amount of chlorophyll in leaves, the amount of minerals in two layers of soil, and their effects on tree growth were all examined. The effects of nitrogen fertilizer on plant growth will be covered in this essay.

KEYWORDS: *Nitrogen, Element, Plant Growth, Development, Environmental, Pollution, Organic, Inorganic, Fertilizers, Soil, Leaves, Tree*

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INTRODUCTION

Nitrogen fertilizer is necessary for many plants. Even though soil frequently contains nitrogen and other essential elements, it is not usually sufficient to promote robust, long-term plant development. The three key nutrients nitrogen, phosphorus, and potassium are present in the majority of fertilizers, with nitrogen playing a particular role in plant development. And you can use a nitrogen fertilizer to give plants the nutrition they require since they require less phosphate and potassium than they do nitrogen. [1]

Effects on Plant Growth:

Nitrogen helps plants grow quickly and promotes the healthy growth of fruit and foliage when added to garden soil. In light of this, nitrogen fertilizer is particularly suitable for young plants that require rapid growth in order to establish themselves in the soil. Since lawns only have green growth and no flowers, they also need a high-nitrogen fertilizer. [2]

Types of Nitrogen Fertilizer:

Nitrogen must be present in fertilizer in one of two forms: nitrate nitrogen or ammonium nitrogen. Ammonium nitrogen can be absorbed by soil particles because it has a positive charge. Within a month of treatment, warm soil temperatures above 50 degrees F convert ammonium to nitrate. Because nitrate does not adhere to soil particles and is prone to being leached from the ground, some plants require reapplication at different periods of the year. Leaching describes the process by which water pushes nutrients deeper into the soil until plant roots are unable to access them. [3]

Urea Nitrogen:

When nitrogen is added to the soil as urea, a chain of events is triggered. Urea nitrogen is first converted to ammonia nitrogen by soil enzymes, which then combines with the soil to generate ammonium nitrogen. The ammonium is subsequently changed into nitrate nitrogen by the microorganisms in the soil. This procedure typically takes two to four days, excluding cold weather that inhibits the conversions. It may be leached from the soil after it transforms into nitrate. [4]

Soil Acidity:

Ammonium nitrogen fertilizers steadily reduce the pH of the soil over time, increasing its acidity. Some ammonia solutions, such as urea, can temporarily raise the pH of soil and even burn plant roots. However, as the ammonia turns into nitrate, acidic residue is created, raising the acidity of the topsoil

above that of the deeper soil. The top 2 inches of the soil should be tested around every other year to ensure that it is not too acidic for good plant growth. If it is, the soil will need to be amended with limestone to prevent issues from this. [5]

In South Asia, where there is a lack of arable land and a low ratio of cultivated land to population, nitrogen fertilizers are being used more frequently to increase crop yields and quality. This is because there is a high demand for food due to the region's expanding population.

Continuous application of nitrogen fertilizers to nonlegume crops and high application rates in some areas have resulted in unfavorable effects, including decreased agricultural yields and deteriorated soil and environmental quality due to soil acidification, nitrogen leaching, and greenhouse gas (N2O) emissions. This chapter covers the effects of N fertilizer on crop yields, soil quality, and environmental safety. [6]

Nitrogen in Plants:

In the tissues found above ground, healthy plants frequently have a 3–4% nitrogen content. Compared to other nutrients, this concentration is substantially higher. Only three other nutrients are found in larger concentrations: carbon, hydrogen, and oxygen. These three nutrients don't often play a big part in soil fertility management schemes.

Nitrogen is essential because it is a key component of chlorophyll, which plants utilize to convert carbon dioxide and water into sugars during photosynthesis. It is also a crucial part of amino acids, which serve as the building blocks of proteins.

Plants deteriorate and perish without proteins. In plant cells, some proteins serve as structural components, while others function as enzymes, enabling many of the metabolic processes that are the basis of life. Energy-transfer substances like ATP (adenosine triphosphate) contain nitrogen as one of their constituent parts. Cells can store and utilize the energy produced during metabolism thanks to ATP.

The genetic material that enables cells (and eventually entire plants) to develop and reproduce, nucleic acids like DNA, include a considerable amount of nitrogen. There wouldn't be life as we know it without nitrogen. [7]

Review of Literature:

For crop growth and output, nitrogen is a crucial mineral nutrient (Xu et al., 2012). In order to raise crop yields over the past three decades, N application rates have rapidly grown and excessive amounts of N fertilizers have been employed. Excessive N application, however, has the potential to damage the soil environment and cause soil acidification, which would ultimately have a detrimental effect on crop growth and production. [8]

As a result, crop productivity was impacted. Nitrogen fertilizer can also change plant physiological traits as chlorophyll concentration, plant metabolic enzyme activity, and soluble protein levels. The amount of leaf chlorophyll is a crucial measure of photosynthetic capacity for assessing the N status of plants. Key enzymes in nitrogen assimilation include glutamine synthetase (GS) and nitrate reductase (NR). According to Yang et al. (2004), sucrose synthase (SS) and sucrose phosphate synthase (SPS) activity is correlated with sink strength and crop production when N fertilizer is used. These enzymes are crucial for converting sucrose to starch. [9]

Fertilizing with nitrogen can have a big impact on soil qualities. Productivity is impacted by soil variables because they are linked to nutrient cycling in the soil and plant nutrient uptake. Invertase, phosphatase, and urea play important roles in the N, P, and C cycles of soil. Different biochemical reactions in the soil are directly impacted by these enzyme activity. Crops can directly take nutrients from the soil, which improves the fertility of the soil. Some significant soil activities, including soil respiration, soil aggregate stability, and water holding capacity, are caused by soil organic matter (SOM). These soil characteristics are thought to be crucial in influencing soil quality (Gong et al., 2015). [10]

The most common agricultural chemical in the world and a vital mineral fertilizer for plant growth and development is nitrogen. In Turkey and other nations, various nitrogen forms are frequently employed in the production of vegetables. In times of rapid growth, it plays a crucial role as a fundamental component of protein, nucleic acids, chlorophyll, and growth hormones. However, farmers have raised the amount of N fertilizers they apply to their land each year without taking into account how different species react to varying amounts and types of N. Utilizing fertilizers in excess beyond what the crop requires has detrimental effects on the environment, especially groundwater pollution and the health risks it brings, especially when it comes to N. (2008) (Korkmaz et al.). [11]

Objectives:

- Easy to transport, store, and apply.
- For supplying a specific nutrient, we can select a specific fertilizer due to its nutrient specific nature.
- Water-soluble and can easily dissolve in the soil. Hence, they are easily absorbed by the plants.
- They have a rapid effect on the crops.

- Increase the crop yield and provide enough food to feed the large population.
- Predictable and reliable.

Research Methodology:

This study's overall structure was exploratory. Due to the abundant availability of N fertilizers and their superior capacity to boost yields compared to other organic fertilizers, including manure and compost, nitrogen fertilization is one of the most widely employed practices to increase crop yields worldwide. [12] Dry matter and grain production increased as fertilizer rates and plant population grew. The harvest index (HI) decreased as nitrogen dosages increased, whereas the harvest index (HI) rose as plant population density grew. [13]

Result and Discussion:

Figure 1: Fertilizers

Fertilizers are supplied to the crops with additional materials to boost their output. Farmers utilize these on a regular basis to boost crop productivity. These fertilizers include nitrogen, potassium, and phosphorus, which are crucial elements needed by plants. They also increase the soil's fertility and its ability to retain water.

Types of Fertilizers:

Fertilizers are mainly classified into two main types, organic and inorganic fertilizers.

Organic Fertilizers:

Organic fertilizers are unprocessed fertilizers that come from plants and animals. It enriches the soil by introducing carbonic molecules needed for plant growth. In addition to increasing the amount of organic matter in the soil and promoting microbial growth, organic fertilizers can change the physical and chemical makeup of the soil. It is considered one of the crucial components for foods that are green.

Organic fertilizers can be obtained from the following products:

- Agricultural Waste
- Livestock Manure
- Industrial Waste
- Municipal Sludge

Inorganic Fertilizers:

Inorganic fertilizers are those produced chemically using processes that contain nutrients for crop growth. The types of inorganic fertilizers are as follows:

Nitrogen Fertilizers:

Nitrogen fertilizers have the nitrogen that crops need to grow. Nitrogen, a vital component of chlorophyll, aids in maintaining the process's balance during photosynthesis. It comprises protein and is a component of the amino acids found in plants. Fertilizers containing nitrogen increase the quantity and caliber of agricultural output. [14]

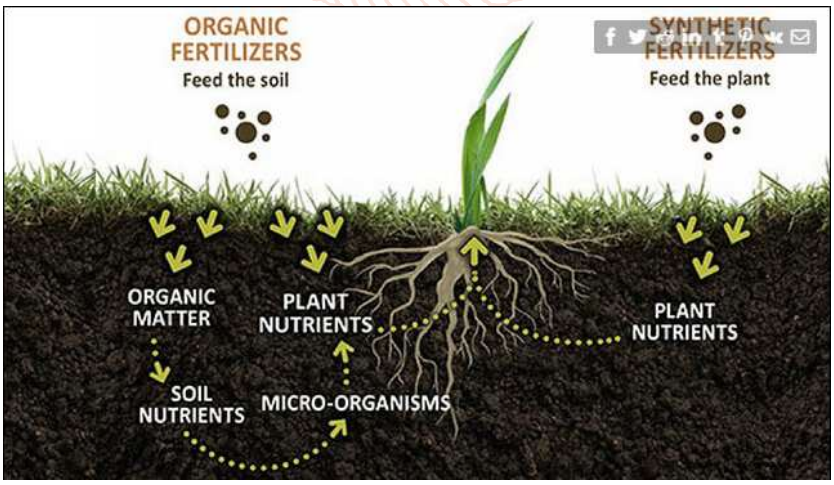

Figure 2: Types of Fertilizers

Plant Nitrogen Needs and Uptake:

Plants can take up nitrogen from the soil as NH4+ and NO3 ions, but most of it is taken up as nitrate due to how common nitrification is in agricultural soils. As plant roots take up water, nitrate readily travels in their direction. Once inside the plant, NO3 is converted to NH2 and absorbed to create more advanced chemicals. In order to allow for unrestricted uptake, a broad root system is necessary since plants require very high levels of nitrogen.

Even though the soil has an acceptable amount of nitrogen, plants with roots that are constrained by compaction may exhibit indicators of a nitrogen shortage.

Table 1: Utilization of Nitrogen by Various Crops

Utilization of Nitrogen by Various Crops		
CROP	**YIELD PER ACRE**	**N**
Alfalfa	8 tons	432
Corn	180 bu	180
Soybeans	60 bu	294
Spring Wheat	80 bu	176
Winter Wheat	80 bu	152

Source: TFI

The majority of plants continuously uptake nitrogen from the soil throughout their lifetimes, and the requirement for nitrogen typically rises with plant size. A plant that receives enough nitrogen develops quickly and produces a lot of lush, succulent leaves. An annual crop, like corn, can develop to full maturity without being delayed if enough nitrogen is present. Because it lacks the nitrogen required to produce sufficient structural and genetic resources, a nitrogen-deficient plant often grows slowly and is modest in size. Because it doesn't have enough chlorophyll, it typically has a pale green or yellowish hue. As the plant shifts nitrogen from less important older tissues to more important younger ones, older leaves frequently develop necrotic and die.

On the other hand, when given too much nitrogen, some plants may grow so quickly that their ability to produce sufficient cell walls and protoplasm is outpaced. These plants are frequently rather frail and may be vulnerable to mechanical harm. One example of such a result is the development of weak straw and the lodging of small grains. [15]

Fertilizer Management:

Nitrogen Cycle:

The crop to be grown, the desired yield, and the amount of nitrogen that the soil may be able to supply all influence the nitrogen fertilizer rates. Rates required to attain various yields with various crops vary by region, and such choices are typically based on advice and experience from locals.

Factors that Determine the Quantity of Nitrogen Supplied by the Soil:

- The quantity of nitrogen released from the soil organic matter
- The quantity of nitrogen released by decomposition of residues of the previous crop
- Any nitrogen supplied by previous applications of organic waste
- Any nitrogen carried over from previous fertilizer applications.

By assigning these variables nitrogen credits (shown in lb/acre), one can calculate their contributions. For instance, using manure reduces the amount of nitrogen fertilizer required to achieve a specific production goal when corn is planted after alfalfa rather than corn is planted after corn. Similar to rates, credits are typically determined by regional factors.

More frequently, soil testing is recommended as an alternative to using nitrogen credits. The drier areas of the Great Plains have long found it advantageous to test their soils for nitrogen, and in those areas, fertilizer rates are frequently changed to take into account any NO3 that is discovered in the soil before planting. In the more humid areas of the eastern United States and Canada, there has recently been some interest in testing cornfields for NO3 using samples taken in late spring, after crop emergence, rather than before planting. This method, known as the pre-side-dress nitrogen soil test (PSNT), has gained a lot of attention and appears to give some insight into the necessity of additional side-dressed nitrogen.

Fertilizer Placement:

The availability of nitrogen to crops should be increased, and possible losses should be minimized. Because a plant's roots often won't spread into another plant's root zone, nitrogen needs to be supplied in a location where

all plants can directly access it. Applications for broadcasting achieve this. When every crop row is immediately adjacent to a band, banding is still effective. Because all rows have access to the fertilizer, banding anhydrous ammonia or urea ammonium nitrate (UAN) in alternate row middles is typically just as effective as banding in each middle for corn.

It is vital for nutrient uptake that the soil be moist. Because roots are more likely to locate nitrogen in moist soil with such placement, placement below the soil surface can boost nitrogen availability under dry conditions. When dry weather follows side-dressing, injecting UAN may result in better corn yields than surface treatment. Subsurface placement is less important in years where there is immediate rainfall after application.

Normally, subsurface placement is employed to limit nitrogen losses. To stop the gaseous ammonia from being directly lost through volatilization, anhydrous ammonia must be positioned and sealed below the surface. By incorporating or injecting, one can regulate the rate of volatilization from urea and UAN solutions. In no-till settings where volatilization is increased by significant volumes of organic material on the soil surface, incorporation of urea materials (mechanically or by rainwater quickly after application) is especially crucial. However, it often poses little risk to use small amounts of "starter" nitrogen like UAN in herbicide sprays.

When phosphorus and nitrogen are combined, phosphorus uptake is frequently increased, especially when the nitrogen is in the form of NH4+ and the crop is growing in an alkaline soil. The cause of the effect is unclear, although it could be because nitrogen increases root activity and phosphorus uptake potential, and nitrification of NH4+ produces acidity, which improves phosphorus solubility.

Minimizing Fertilizer Losses:

Denitrification, leaching, and volatilization are the main mechanisms for nitrogen fertilizer loss. While volatilization most frequently occurs when soils are barely moist and are drying, denitrification and leaching occur in extremely wet soil conditions.

Practices for Avoiding Nitrogen Fertilizer Losses:

Because the hydrogen ions (H+) generated during the nitrification of the NH4+ are the primary contributor to soil acidity, using an NH4+ source of nitrogen causes the soil to become acidic. Acidification and a decrease in soil pH can become significant over time.

The soil becomes significantly less acidic over time as a result of nitrogen fertilizers that contain NO3 but no NH4+, but they are typically applied in considerably less quantities than the others. Agricultural fields are significantly acidified by NH4 nitrogen, although this acidification can be easily regulated by following standard liming procedures.

Table 2: Acidity or Basicity of Different Nitrogen Sources

Acidity or Basicity of Different Nitrogen Sources

MATERIAL	% NITROGEN	APPROX. $CACO_3$ EQUIVALENT LB/TON OF MATERIAL*	PER LB OF N
Anhydrous Ammonia	82%	-2,960	1.80
Ammonia Sulfate	21%	-2,200	5.20
Urea	46%	-1,680	1.83
Diammonium Phosphate	18%	-1,400	3.8
Urea-Form	38%	-1,360	1.79
Monoammonium Phosphate	10%	-1,300	6.5
Ammonium Nitrate	33.5%	-1,180	116
Nitrogen Solutions	19-49%	-750 to -1,760	197-179
Calcium Nitrate	15%	+400	None
Potassium Nitrate	13%	+580	None
Sodium Nitrate	16%	+520	None

*The amount of calcium carbonate equivalent in pounds needed to neutralize the acid produced by adding one ton of the substance to the soil is indicated by a negative sign. (Take note that if ag-lime is used, nearly two times this amount would be needed.) The material is basic in nature when there is a plus symbol. [16]

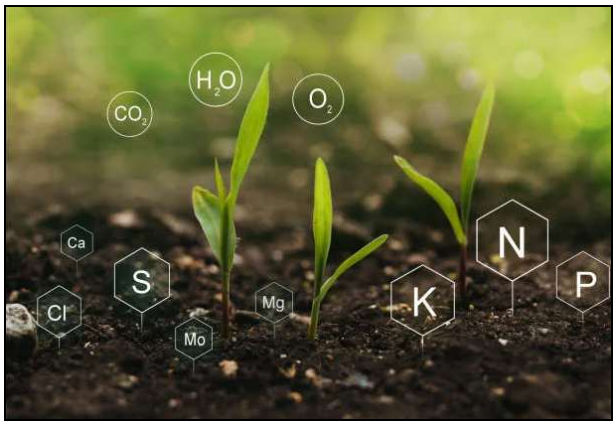

Figure 3: Nitrogen fertilizers

One of the fertilizers that we use most frequently today is nitrogen. Fertilizer is similar to food for plants, however nitrogen-based compounds are typically the most affordable and widely used. Depending on the crops that are grown, nitrogen fertilizers can have a range of contents between 26% and 32%. There are various subgroups of nitrogen compounds, including urea and ammonium nitrate. Due to the inability of legume plants to obtain nitrogen from the soil as they would if there were no other sources, this kind of fertilizer can only be used on nonlegume crops like corn.

A crucial essential for plant growth is nitrogen. One of the most popular forms of fertilizers used to manufacture nitrogen so that plants can thrive and grow strongly is nitrogen fertilizer. Ammonium nitrates, urea, tetra amines, sodium nitrate, and chloride are typical sources of plant-based nitrogen. There are also "synthetic" sources (such monoammonium phosphate) that solely contain one form of nitrogen. [17]

Using complete dried leaves and/or fresh petiole sap, the researcher can sample the plant during the growing season to determine its nutrient concentrations. These samples will enable the researcher to demonstrate that the yield response was correlated with the nutritional status of the plant. Normally, soil samples are not used because there is a possibility that a fertilizer particle may be present in the sample or because it may be unclear where to sample if the fertilizer is delivered through a drip tape or a band. Seasonal photos are helpful for capturing both growth and potential signs of plant deficiencies. [18]

At the proper harvest time(s), the crop response of interest—typically marketable yield—is measured. Vegetable fruits are graded in accordance with USDA criteria to identify any fertilization-related changes in fruit quality (size, color, sugar content, etc.). The current commercial units per area of production are used to express yields (for example, 28-lb boxes/acre, 42-lb crates/acre, bushels/acre, tons/acre, etc.). To understand the kind and size of the reaction, the raw data should be shown in a scatter diagram (Figure 4). Plotting the raw data enables the researcher to look for outwardly anomalous data points that might point to mistakes made during the data entering process.

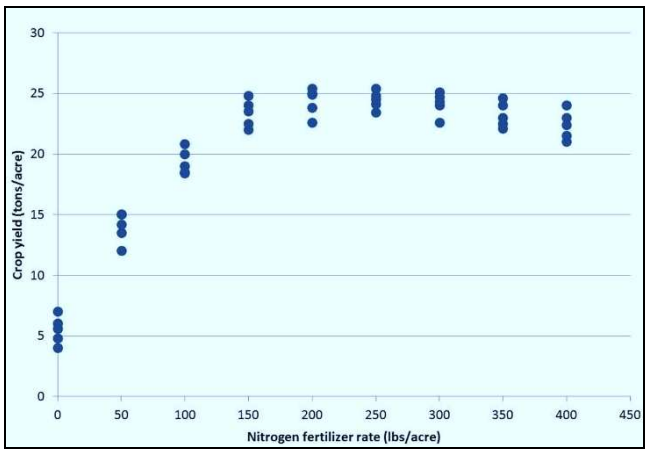

Figure 4: Nitrogen Fertilizer Rate (Crop Yield)

Figure 4: Theoretical crop response to nitrogen fertilization (not real measured data). Each N rate was replicated five times (some data points are obscured by others). Note the quick increase in production with the first few N fertilization increments, followed by a leveling off and perhaps a hint of a drop in yield with too much fertilization. Also take note that there is some output even when no fertilizer is used; in this example, it amounts to around 20% of the maximum yield. The term "percent relative yield" will be used to describe this proportion of the maximum yield. After 150–200 lbs./acre N, the yield seems to have plateaued. This example is provided for illustrative purposes only; in actual field experiments, there is generally more variation between the replications, particularly at lower fertilization rates. [19]

Conclusion:

The key nutrient that limits crop yields and quality is nitrogen (N). N fertilizer is therefore frequently used in enormous quantities to boost crop output all over the world. In many developing nations, the use of N fertilizers has enhanced crop yields and led to the achievement of food self-sufficiency. However, excessive N fertilizer use beyond what crops require has had unfavorable effects, including soil, water, and air quality damage.

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