Applicable Approaches for the Integrated Nitrogen Management and Sustainable Farming

Abstract:

Nitrogenous fertilizers play vital roles in many growths and developmental processes of plants. Nitrogen is applied for taking adequate production of crops, but the excessive use leads to leaching from soil and causes environmental problems like eutrophication. Only 30 to 50% NUE is recorded in plants, the remaining is used by soil microbes, leached down in soil or volatilized. Globally, nitrogen use has been increased effectively. In the past 4 decades, its use has been increased to 100-fold. There are different factors that are the major source of Environmental health hazardous for living organisms. Moreover, nitrogen is being depleted slowly from our agricultural lands. Crop output has been reduced dramatically. Hence, it is needed to follow the updated, modern and best performed agricultural practices to get the maximum yield of crops. By utilizing the updated approaches and expert's suggestions, Nitrogen use efficiency can be improved efficiently and reliably.

Comment [H1]: Leaching from soil? No, leaching of N through the soil profile.

Comment [H2]: Explain first the meaning, then put the acronym.

Comment [H3]: Each sentence seems to have an idea. Therefore, the ideas were loose throughout the Abstract.

Introduction

Nitrogenous fertilizers are the most vital inputs for all the crops grown globally, besides that half of the world population also depends upon that fertilizers for food supply either directly or indirectly. Nitrogen (N) is a~~n essential~~ plant nutrient needed for growth and development, it improves the yield of agricultural crops, but it also causes series environmental problems in aquatic ecosystems. Using any kind of fertilizer, including organic and inorganic form could pose a serious threat to the environment if misused. N fertilizer consumption was expected to increase globally from 112.5 million tons to 118.2 million tons in 2019 (see figure 1.1 and 1.2) and with population growth expected to reach 10.5 billion in 2050 and the demand for feed, food, fiber and fuel[1].

Comment [H4]: The same about the Abstract. Each sentence contains a different idea about N. Authors need to make a connection between these ideas.

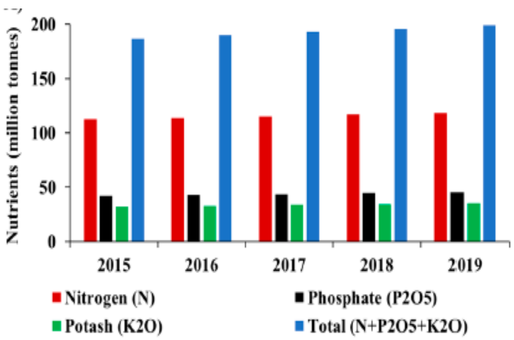

Fig 1.1

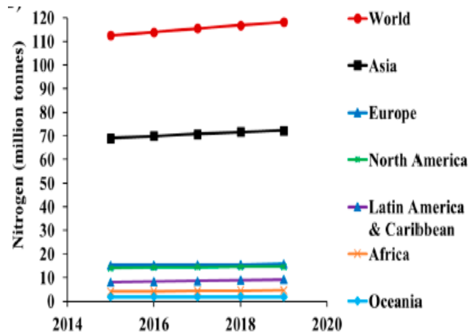

Fig 1.2

Figure 1.1, three major nutrients (Nitrogen, Potash, and Phosphate) and total fertilizer demand globally, predictions, 2015-2019. Figure. 1.2, Regional and worldwide Nitrogen demand forecast, 2015- 2019. (Adopted from FAO 2016 and [2])

Commonly, fertilizers are considered as a vital part to increase the crop's production, but the excessive use of nitrogen can lead to reducing the full potential of crop's output. ~~Moreover, an adequate supply of nitrogen does not become part of the plant's system.~~ This excessive part is leached and cause environmental problems and human health hazards[2]. Only 30 to 50% NUE is recorded in plants, the remaining is used by soil microbes, leached down in soil or volatilized[3] Healthy plants retain 2-4% Nitrogen[3]. Nitrogen plays an important role in the preparation of proteins. In the case of Nitrogen deficiency, plant's growth is stunted[2]. From the previously performed experiments, it has been noted that nitrogen is lost from the soil. In high rain-fed areas and light texture soils (sandy soil), leaching is a common problem.

Nitrate form of N does not strongly absorb on soil surface because nitrate is the mobile in nature, and easily move beyond the soil profile by process of leaching[4]. Through this mechanism, as much as 25–50% of the applied N can be lost[4]. From the soil, N can be lost through the water as well as wind erosion. Loss of N through water erosion is a major problem for humid and sub-humid climatic areas while wind erosion is a more commonly reported mechanism of N loss in the arid and semiarid climatic region[5]. Soil Physical, chemical properties and genoptypes cause 18%, 5% and 12% losses, respectively. Due to less fertility, 50% of agricultural lands are not producing the crop with full yield potential. Except this, Low NUE also due to the excessive use of Nitrogen in the fields.

Comment [H5]: What means?

Comment [H6]: Absorb or adsorb?

Comment [H7]: Make a connection between these ideals and the rest of the paragraph.

Excess use of nitrogen declines the crop yield[6]. Different kind of practices is being used to improve the nitrogen use efficiency (NUE). The main objective of NUE is to enhance the performance of the overall cropping system. Nitrogen use efficiency (NUE) also addresses the sustainability of agriculture system with respect to soil fertility and some other soil quality components[6]. In this manner nutrient, expert diagnosis different N management strategies such as nutrients are applied at the right time, at the right place as per requirement of the crop[7].

In this review, we have discussed the optimum quantity of nitrogen that is required by plants; excessive use of nitrogen, problems due to excessive use and the strategies to improve the nitrogen use efficiency, and its impacts on plant's output.

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1. Nitrogen is a key and basic element for crops:

It's the foremost objective of agricultural scientists to increase the food production to meet the requirements, but the environmental protection is also an important factor to save the world regarding climate change[8]. Globally, nitrogen use has been increased effectively. In the past 4 decades, its use has been increased to 100-fold[9]. Now scientists are recognizing the needs of crops that utilize nitrogen efficiently and in a quick way[3]. For the proper growth of plants, some nutrients are basic and very effective. Nitrogen is one of them that is responsible for the full-fledged growth of crops. In the last years, agricultural scientists around the globe, are taking ~~passionately~~ interest on the optimum use of nitrogen for the lavish growth of agricultural crops[2, 10].

Comment [H9]: Some nutrients? Or all the nutrients?

Healthy plants contain 2-4 % nitrogen. Deficiency of nitrogen results in the appearance of chlorosis in plants. By facing the deficit problem, protein quantity is decreased, while sugar content is increased. Protein is made by carbon compounds, and without the availability of nitrogen, these are not built[11]. Deficiency of macronutrients results in the stunted growth as nitrogen deficiency can limit the growth of plants. Not only for crops but nitrogen is also is an important element in the lives of the living organism, but the most limiting factor only for plants. By applying the adequate supply of nitrogen according to the requirements of plants, enough food can be produced. Optimum use of nitrogen can lead to maximum productivity of plants[12]. ~~Deficiency of macronutrients results in the stunted growth as nitrogen deficiency can limit the growth of plants.~~ To get the adequate production from plants, generally fertilizers are applied, but excessive use of nitrogen is no more part of the plants. It is leached down, this can be part of the environment in the form of environmental pollution.

Therefore, it is recommended to use the fertilizers according to the needs of plants, in this way productivity and profitability are increased as well maintained. Past research explains well about the positive correlation between nitrogen concentration and chlorophyll content in the leaves of plants. In maize, by measuring the chlorophyll content, nitrogen requirement is estimated[13]. Photosynthetic activity of plants is increased as the nitrogen increases. Majority of leaf nitrogen is represented by the proteins of the Calvin cycle and thylakoids[14]. In one of the published papers, nitrogen and chlorophyll content were measured at the flowering stage and found the close relationship between nitrogen content and chlorophyll content. Moreover, chlorophyll structure is composed of nitrogen. As the nitrogen application is increased, the nitrogen that is derived from the soil decreases; only that part of nitrogen is used which is applied through basal dressing and topdressing. Maximum nitrogen is lost by using a basal dressing method than topdressing[14].

2. Excess of anything in life is poison:

Soil fertility is declining continuously. It is considered the main problem of the green revolution era. Intensive cropping is responsible for the removal of ~~fertile~~ nutrients. Use of Inorganic fertilizers is being increased to replenish the soil. Farmers are not well aware of the proper use of nitrogen fertilizers and apply without quantification. More than adequate quantity is applied to agricultural soils, and many other macro and micronutrients are ignored, including Potash, Phosphorus, Zinc e.t.c. Upon application of fertilizers, mineralization is started and it depends upon different factors, including soil microbes, irrigated water, and type of fertilizer[15]. One of an excess of nitrogen is lost to running waters and enters in the freshwater lakes, and algal growth appears on the water surface. Due to the algal growth, the creature under the water surface dies[16].

Excessive use of nitrogen fertilizer creates many reduced yield problems. Continuous use of huge quantity leads to elevation of NO_3-N concentration in groundwater, causing human health disorders, moreover, day by day, its efficiency is declining. With the groundwater, it is also affecting the surface freshwater resources and becoming the major factor of water pollution[17].

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It is quite odd that to increase food production, more and more fertilizers are being applied in agricultural land, but nobody cares about environmental pollution. Global nitrogen cycle has been changed effectively. For getting maximum output, the use of nitrogen has been increased[18]. Only 30 to 50% NUE is recorded in plants, the remaining is used by soil microbes, leached down in soil or volatilized[19]. Plants can use nitrogen in the form of NH_3 (ammonium). 82% nitrogen is present in ammonia. When plants are unable to use that ammonia, it is converted in nitrates and enter into the plant roots and causes soil pollution.

Like plants, humans are also the victim of nitrates and becomes the part of vegetables that causes severe human health problems[20]. In the agricultural system, these effluents disseminate in the environmental air in the form of ammonia (NH_3), nitrate (NO_3), and nitrogen oxides (NO_2). These are highly toxic to human and animals health. Therefore, it is a serious concern of present era and a difficult challenge for policymakers. In one of the performed research, it was revealed that if nitrogen content increases, the nitrate concentration in lettuce is also increased[21]. to get sustainable production and clean environment, NUE should be increased. NUE is dependent upon the performance of different steps, comprising of using up, translocation, assimilation, and remobilization. These steps are linked with the environmental and genetic interaction. In this hour of need, by doing well management, NUE can be increased[6].

3. Losses of Nitrogen:

(a) Nitrogen Loses in Field

Urea is a major source of nitrogen, as allied to crops, some of its quantity is taken up by the crops and utilized for their growth and development, but in the soil-plant production system, most of the quantity of the applied fertilizers are lost by the processes of de-nitrification, soil erosion, surface runoff, leaching, volatilization of ammonia and phosphorus fixation in the soil due to the lower concentration of calcium in the soil[22].

(b) Soil Erosion and Surface Runoff:

From the soil, N can be lost through the water as well as wind erosion. Loss of N through water erosion is a major problem for humid and sub-humid climatic areas while wind erosion is a more commonly reported mechanism of N loss in the arid and semiarid climatic region[5].

(c) Loss through Leaching and Microbes:

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Comment [H13]: What matters here is talking about nitrogen fertilizers.

In high rain fed areas and light texture soils (sandy soil), leaching is a common problem. Nitrate form of N does not strongly ~~absorb~~ adsorb on soil surface because nitrate is the mobile in nature, and easily move beyond the soil profile by process of leaching. Through this mechanism, as much as 25–50% of the applied N can be lost[4]. This loss can be highly dependent upon the quantity of N applied, climatic conditions and crop production system practices[22].

In arid to semi-arid areas, leaching problem is documented very less. Soil microorganisms are used the much quantity of applied nitrogen. If microorganism has a ready food supply in the form of organic matter, they readily assimilate nitrates-nitrogen. ~~This is one of the major reasons; microbes can get about more than half the applied nitrogen from the soils~~.

(d) Ammonia Volatilization and Denitrification:

Comment [H14]: Authors need to make the relationship between one sentence and another. This should be done throughout the text.

When ammonium and/or urea are applied on the surface of the soil, nitrogen is lost in the gaseous form through the reduction process (volatilization) in which NH4 convert into NH3 gas. The discussed the phenomenon of N loss is more severe when chemical nitrogenous fertilizers and organic manures is applied on soil surface through broadcasting method[5]. Losses of N in the form of ammonia is a major problem for alkaline soils. Higher concentration of ammonia is not recommended for the nitrification process, as it resulted in un-budgeting of nitrites in the soil. This mechanism is most common in alkaline soil and warm climatic conditions, and more than 20% of N may volatilize by this process and lost to the atmosphere within a short period[23]. Under this condition, as much as 10-15% of applied nitrogen has been lost. Denitrification is a more common problem for heavy texture soil with poor natural drainage[24].

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4. Responsible Factors for Low NUE:

To get healthy and high food production, 40% population rely on nitrogen to get healthy and extreme yield. Maize is using 56% of the total nitrogen production. From the total applied fertilizer, only 50% is utilized by plants. While the remaining one is wasted in the form of environmental pollution. The efficiency of applied nitrogen fertilizers depends upon its demand and losses. (crop environmental and management factors affecting nitrogen use efficiency). Agronomic management can increase or decrease of NUE, it depends upon the efficient strategies to use fertilizer according to the need of maize crop. In one of the conducted research, 3 kinds of strategies were applied for managing the fertilizers

Comment [H16]: Population? Via fertilization?

accordingly, including OPT-1 (Optimized management strategy), OPT-2, and OPT-3. In comparison to OPT-1, OPT-2 showed yield increment. Additionally, farmers fields did not show a significant increase of NUE, but it depends upon the agronomical management strategies (Concurrent Improvement in Maize Yield and Nitrogen Use Efficiency with Integrated Agronomic Management Strategies).

Different factors affect the NUE like soil condition, water, and weather. on daily basis, many studies are published. Agronomical management practices, Soil physical and chemical properties, and genotypes cause 18%, 5%, and 12% losses, respectively. Due to less fertility, 50% of agricultural lands are not producing the crop with full yield potential.

Except this, Low NUE also due to the excessive use of Nitrogen in the fields. Excess use of nitrogen declines the crop yield[6]. Except for the decrease in yield, upon increasing the nitrogen rate, Photosynthetic activity is also reduced[25].

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5. Influences of Different Agricultural Practices:

Already, worldwide, agriculture land is finite for the production of food. To meet the demand for food, production per unit land area should be increased. To utilize the agricultural land efficiently, proper planning and management strategies should be applied[26]. According to the estimated statistical report, by 2050, the population will be increased to 9 billion, and to feed the whole world, we will be needed to increase food up to 70-100%[26]. For increasing the production, farmers have to rely on the more use of nitrogen, with the increase of its use, efficient utilization is also required to get the maximum yield. Upon the unreasonable use of the nitrogen fertilizers, its yield is decreased.

Appropriate methods, time and application rate always matters, otherwise increased nitrogen rate is no more useful for plants and lost[27]. Different methods of fertilizers are being applied. Again, the point matters; which method is suitable to increase the nitrogen use efficiency? Before the cultivator use, fertilizers are applied across the whole field; its called as a broadcast method. This method results in non-uniform fertilizer rate across the filed. some places receive more fertilizers. Banding fertilizer method is used to place the fertilizers near the roots, and it is helpful in decreasing the costs and kills weeds maximum. Chih-Li Yu and his team carried out a 3 years study experiment to check the soil respiration, physiological parameters, and yield. Maize behaves Differently in different agricultural practices. Yet, it's the reasoning of differential behave is unclear.

Application methods showed different behavior ~~accordingly~~. Different parameters including, transpiration, photosynthesis, plant height, soil respiration, and yield were measured to asses the differences by adopting six different agricultural practices. Different results showed that application methods do not give significantly different results but the agronomical management practices increase the production of maize[28]. Likewise the fertilizer application method, application rate also matters a lot for increasing the maize production and nitrogen use efficiency. Luiz Fernando Pricinotto and his team in 2014 published a study on the effects of application time in maize production. Five different nitrogen rates (0, 45, 90, 135, 180) kg ~~/~~ha^{-1} were applied. Among these, all application rates, average estimated rate, 130.1 and 131.5 kg ha^{-1} ~~kg/ ha~~ proved to produce higher grain yield[29]. Nowadays, a new kind and effective use are being applied to increase the production and nitrogen use efficiency of plants because CRU is coated with less soluble compounds that make it efficient to use gradually[30]. Xiang Gao et al. (2007), carried out a study to check the CRU effects on potato and environment. Results clearly depicted that CRU decreases the NH_4^+ and Nitrates ~~No3~~NO_3^-, thus it does not permit to emit different gasses and increases the NUE[31]. Different studies proved that split nitrogen fertilizer application time is a determinant of higher yield and increase the nitrogen use efficiency. Pre-planting application and side dressing, both are highly effective techniques to increase the yield and nitrogen use efficiency[28]. The timing of fertilizer can synchronize the demand and uptake of nitrogen fertilizers.

If management strategies are ignored, the full potential of maize yield and nitrogen recovery efficiency cannot be achieved. Silas et al. (2018), carried out an experiment by using the labeled Nitrogen. Nitrogen was applied at five different stages, including Oat tillering, before 15 days of maize planting time, at the time of corn planting, at three-leaf growth stage V3, and split application at V3 and six-leaf growth. Early nitrogen application is not suited for the availability of nutrients to plants. Soil microbes use the early applied fertilizers and they make it unavailable for plants. Suitable timing of fertilizers increases the nitrogen recovery efficiency and nitrogen content[32].

6. Need to Increase Nitrogen Use Efficiency:

(a) The Concept and Importance of NUE

Meeting this requirement in a sustainable manner, is a big challenge today, especially when parallel to historical cereal yield trends which have been linear for nearly half a century.

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Improving nitrogen use efficiency (NUE) is environmentally and economically desirable traits for crops. NUE is an emerging concept for assessing crop production systems and highly be influenced by fertilizer management. It indicates the potential for nutrient losses to the environment from cropping systems as managers strive to meet the increasing global food and fibre demand.

(b) Nutrient Use Efficiency

The main objective of nutrient use is to enhance the overall productivity of cropping systems in a sustainable manner while minimizing losses of nutrient from the field. Nitrogen use efficiency (NUE) also addresses the sustainability of agriculture system with respect to soil fertility and some other soil quality components[33]. Therefore, the main objective of NUE is to enhance the performance of the overall cropping system[34]. 78% nitrogen is present in the air but it can not be utilized directly by plants. One acre has 34, 000 tons nitrogen but its direct use is impossible for plants. Nowadays, for the increment of food and make efficient use of nitrogen, highly effective management strategies are needed. Synthetic nitrogen fertilizers are soluble in water and can be readily available to plants.

~~In the 20th century, nitrogen fertilizers were prepared by the Harbor-Bosch process and that was considered as the most important invention[33]. Now, nitrogen use is being increased.~~

In the world, China is the leading importer of chemical fertilizers. According to one of the published study, for agricultural outputs, China is consuming 30% of the world's total nitrogen production[18]. Although Harbor-Bosch process works for making synthetic fertilizer and to be ~~is~~ the great invention of the 20th century, ~~but~~ its minimum and maximum use disturb the plant's output and creates health hazardous for humans. However, ~~Alone~~alone nitrogen is not highly useful for plants to boost the production of crops. In the 19th century, two scientists put forth the law of the minimum, this law clearly states that in the absence of phosphorus or potassium, nitrogen can not give fruitful results. It shows nil behavior. No more yield is increased. ~~Use of nitrogen is directly involved with the plant health and environment.~~ By using different extra activities, nitrogen use efficiency can be increased[35]. In this scientific arena, by employing different biological approaches, nitrogen use efficiency can be measured quickly and precisely. By improving assimilation and management, nitrogen use efficiency is increased.

By employing different breeding schemes and biotechnological tools, new lines with the higher nitrogen use efficiency can be developed. It's a very difficult task to manage the fertilizers according to the requirement of plants. Its tried to manage the nitrogen fertilizer alone or with the combination of other fertilizers. The nitrogen use efficiency is actually the optimum assimilation of nitrogen. Leguminous crops perform better due to their higher nitrogen use efficiency because it is stored in the root system, does not lose in soil or in the air. Nitrogen use efficiency is a very complex trait that is associated with genetic and environmental interaction. Around the world, nitrogen use efficiency is considered lower than standards. Nitrogen use has been increased drastically from 79 million pounds in 2009 to 99 million pounds in 2012.

However, the use of nitrogen can be improved by designing proper plants and management strategies. According to one of the study, the main problem in the decrease of nitrogen use efficiency is that farmers apply more nitrogen before planting. By doing proper management and previously performed experiments, farmers should use the knowledge and wait for the time of active nitrogen absorption[1]. Different kind of agricultural practices is being used to increase nitrogen use efficiency. For managing the nitrogen use, the first step is to do the analysis of plant and soil. Soil analysis components are used to manage the nitrogenous fertilizers, including a quantity of soil organic matter, nitrogen-nitrate credit from the previous crop data, yield targets, and nitrogen credit from irrigation water and manures. Variable nitrogen management zones (MZ) should be identified to apply the fertilizers accordingly, in this way nitrogen use efficiency can be improved.

By applying the nitrogen fertilizers according to the demand of specific soil parts, plants perform uniformly and give maximum and uniform yield[36]. Sometimes, by comparing with C4 plants, nitrogen is recommended to use. For example, by making a comparison to wheat, corn needs less nitrogen for a given biomass[37]. Another technique to determine the nitrogen requirement is to predict yield target by having knowledge about the previous 5 years performance. Some researcher finds it useful if growing conditions are favorable but sometimes, if the climate is not good, them this suggestion leads to a decrease in nitrogen use efficiency. Because weather conditions are not suitable all time[38],[39]. Worldwide, agriculturist goes beyond the thinking and solve the problems by utilizing the research skills. Nowadays, there are many sensitive plants are present and these are used for as responsive indicators to fertilizers, weather and soil. For example, chlorophyll in increases, if more nitrogen is applied. So, these plants show the concentration in the form of their phenotypic appearance. And as chlorophyll content in increases, the photosynthetic activity also increases. Previous studies showed that photosynthetic activity has a positive correlation with the nitrogen concentration [40].

Nitrogen concentrations are used as an indicator of maximum crop growth. Critical nitrogen requirement is the optimum amount of nitrogen that can produce maximum yield. Initially, in the plants, nitrogen concentration is higher than the maturity level. As plants grow, nitrogen concentration is decreased [41]. The ratio of actually available nitrogen in plants to the critical nitrogen is called as nitrogen nutrition index (NNI). Now, agricultural scientists are using the NNI (nitrogen nutrition index). This approach is being used in wheat, rice, sorghum, and grasses[42]. In maize, this approach can not be used with much efficiency. At early growth stages, critical nitrogen cannot provide a reliable nitrogen status. Usually, nitrogen concentration is decreased as maize shifts toward maturity, and it is called nitrogen dilution[43]. Up to silage maturity, critical nitrogen dilution curve gives effective results. In corn, this system could be used only at small scale[44].

7. Strategies to Enhance NUE:

(a) Agronomic Practices

Nutrient use efficiency can be enhanced by adopting local as well as scientifically available means of nutrient management to ensure more efficient use of various agricultural inputs such as fertilizers, irrigation water, and land that will minimize its losses while enhancing beneficial use of these inputs.

Strategies used for enhancing the nutrients use efficiency of crops should be focused on two major bases (1) either it enhances the efficacy of externally applied nutrient (2) either it enhances the budget of nitrogen in the soil by reducing N losses through different mechanisms and ensure more uptake of conserved N by crops[45]. Application of the nutrients at a suitable rate, right time, and in the right place is the major and basic principle for attaining the higher nutrients use efficiency[46]. Different practices based on the above-discussed principle for enhancing the nitrogen use efficiency are discussed below: Best nutrient management in wheat-maize cropping systems should aim to apply fertilizers based on the requirement of crops and select a suitable method for maximizing the nutrients use efficiency and reduce its losses[47]. In this manner nutrient, expert diagnosis different N management strategies such as nutrients are applied at the right time, at the right place as per requirement of the crop[7].

(b) Right Rate:

Several crops are highly dependent on location, climate and season so it is essential that accurate yield goals are established and that fertilizers are applied to meet the target yield (Fertilizers Europe, 2011). Excess or low supply of the nutrients will result in reduced NUE and significant losses in yield and grain quality. Soil testing analysis also one of the most powerful and easily conductible tools for determining the capacity of the soil for providing the nutrient to crops. Soil testing approaches also be useful for formulating appropriate fertilizer recommendations, good calibration data in the proper way[7].

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(c) Right Time (site-specific nitrogen management):

Great relation between crop requirement and nutrient supply is necessary to enhance the NUE, especially for nitrogen. During the growing season, application of nitrogen in split doses, rather than a single dose at once time are known to be effective in increasing nitrogen use efficiency[48]. For assesing the nitrogen status of growing crops, tissue testing is a cheapest and famous method, but other diagnostic techniques are also commonly available. The use of chlorophyll meters also found as an easy diagnostic tool for enhancing the nitrogen use efficiency in crops[49]. Use of leaf colour charts also recommended for maize crop when nitrogen is applied in split doses[50].

(d) Right Place:

Selection of suitable application method has always been crucial in ensuring the nutrients use efficacy. Selection the right placement is an important factor for determining the right application rate. Currently, different placements are available, but surface or subsurface application before or after planting are more common. Prior to planting, nitrogen can be broadcast, or applied as a band on the soil surface, or applied as a subsurface band (15-20 cm deep). Commonly, with banded application method, nutrient recovery efficiency tends to be higher as compared to another method because under band application less nutrient contact with the soil lessens, which reduce the chances for nutrient loss by the leaching process. Selection of the Placement highly dependent on the crop and edaphic factors, which interact to influence the availability and uptake of nutrients. Adequate and balanced application of nutrients is one of the most common practices for enhancing the efficacy of nitrogenous fertilizer both in developed and developing countries[33].

(e) Chlorophyll Meter and Leaf Colour Chart:

Chlorophyll meter (CM) can be successfully used to estimate the crop nitrogen content because most of the nitrogen is found in the chloroplast of the plant[51]. CM helps in measuring the chlorophyll content and can calibrate it for different climatic, soils and crop cultivars. It is also being recommended to check the effectiveness of late applied nitrogen in standing crops to enhance the protein content and crop productivity. Leaf color chart also used as an indicator of leaf color, color intensity, leaf nitrogen status and helps in selecting the right time of nitrogen application. As a diagnostic tool, it also provides the guideline to the farmers for making appropriate decisions regarding appropriate time, appropriate dose and right method of nitrogen application in standing crops. As concluded, it works on the base of relative greenness of leaves which directly co-related with chlorophyll content of leaves.

(f) Integrated Nutrient Management:

Nitrogen is a basic component of leaf chlorophyll so its measurement over different phenological stages serves as the indirect basis for nitrogen management in different crops[51]. Integrated nutrient management involves balanced use of indigenous nutrient components such as crop residues, organic manures, biological nitrogen fixation as well as chemically available nutrients r and their complementary interactions to increases the recovery of N recovery[51]. positive effects of the integrated use of organic as well as inorganic nitrogen are either due to optimum Physio-chemical conditions of the soil or due to the better architecture of root and more supply of micronutrients to the plants[51]. The exploitation of these positive effects among the plant nutrient is the major detriments for increasing the productivity of cropping system as well as the efficiency of applied nitrogen. The paired interaction of N with other secondary and micronutrients could result in improvement in crops yield and nitrogen use efficiency. Therefore, balanced and judicious use of nitrogenous fertilizers will lead to achieving higher productivity.

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(g) Increase the Use of Modified Fertilizers and Slow Released Fertilizers:

These are various fertilizer products which are used for enhancing the fertilizer use efficiency of crops by reducing losses of nutrients associated with the production system. These products are based on two basic concepts either they can release in slow or either interfere with nutrient transformation processes and thus reduce their losses. Slow release nitrogenous fertilizers and inhibitors are two important classes of fertilizers. The selection of the suitable type of applied nitrogenous fertilizers has a pivot role in reducing the various nitrogen losses hence, affecting the availability and recovery of nitrogen. As Compare with ammoniums and amide containing nitrogen fertilizers, nitrate fertilizers are more susceptible to leaching. But in contrast, ammonium and amide containing fertilizers are more susceptible to volatilization process than nitrate fertilizers.

A variety of slow-release fertilizers is now easily available in the market which has the potential to increase the nitrogen use efficiency and reduces the nitrogen losses[48]. Polymer-coated products are commonly used in agriculture, which can be designed to supply the nutrients to crops in a controlled manner. Nutrient release rates are highly dependent on properties of the polymer coating, soil temperature, and moisture conditions. In developing countries, non-availability and high manufacturing cost are two major reasons for the limited use of these compounds. In additions, some others approach to enhance the nitrogen use efficiency is the use of N stabilizers which increase the nitrogen use efficiency not only by minimizing leaching losses but also by reducing the de-nitrification losses[52].

Conclusion:

To increase the crop production fertilizers play a vital role. Among fertilizers nitrogen is more important as it helps the plants in the preparation of protein. Its deficiency effects the growth of the plant and its excess reduces the crop yield. Plant uses an optimum level of nitrogen and the remaining is leached down into the soil. The excess of nitrogen in the field cause environmental problems and health hazards. Plants have low NUE. It is the need of the time to increase the nitrogen efficiency of the plants. Different experiments are going on to increase the NUE of plants. Agronomic practices can also help in this regard. Nitrogen given at the right time and right place can increase the plant efficiency to use to effectively. Now a days slow release fertilizers are also in use to control the loss of nitrogen by the plants. Moreover, for the better development of plant more practices and improvement in plant is needed to use nitrogen more effectively.

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