www.kosmospublishers.com
contact@kosmospublishers.com
DOI: 10.37722/AAHAE.202111

Case Report Advances in Agriculture, Horticulture and Entomology AAHE-144
ISSN 2690-1900

A study on: Nutrients in Sustainable Cropping Systems

Attia El Gayar[*]

Soil, Water and Environmental Research Institute (SWERI), Agriculture Research Centre (ARC), Giza, Egypt

Received Date: March 05, 2021; **Accepted Date:** March 11, 2021; **Published Date:** March 22, 2021;

[*]**Corresponding author:** Attia El Gayar, Soil, Water and Environmental Research Institute (SWERI), Agriculture Research Centre (ARC), Giza, Egypt; Email: attiaelgayar@yahoo.com

Abstract

The concept of sustainable agriculture has gained high priority. It includes the successful management of agricultural resources to meet human needs while maintaining or improving environmental quality and conserving natural resources. The plant's needs for water and nutrients are interrelated. Water is not only essential for the growth of plants, but it is also the medium through which nutrients are transported to and absorbed by the roots. A good supply of water improves the nutritional status of crops, and an adequate supply of nutrients saves water. With properly coordinated management of nutrients and water, a farmer can greatly increase crop yields through their efficient use. This is true for both rained and irrigated conditions. Using optimal nutrients without getting enough water leads to misuse of the nutrients used. Likewise, the use of low nutrient doses under adequate conditions of good nutrient management practices and vice versa. Soil moisture affects solubility and thus the availability of all nutrients. Biological activity in soil is particularly restricted under very wet or very dry conditions. Under extremely dry conditions, the breakdown of organic matter slows down and with it the mineralization of organic forms of nitrogen and other nutrients into forms of minerals available to the plant.

This paper focuses on mineral nutrition, plant nutrients and plant nutrition, strategies for optimizing nutrient management and economically analyzing the content of micronutrients and macronutrients present in soil - water system. Soil-water system plays a vital role in agriculture. The amount of nutrients available to plant roots is the main factor limiting crop yields. Climate and crops grown during previous years, fertilizer requirements differ within the field and throughout the year. The Macro nutrients and micronutrients are essential for healthy plant growth. Total nutrients are required in large amounts and micronutrients are required in smaller quantities. Micro and macro nutrients are naturally obtained from the soil roots.

Keywords: Economically Analyzing; Nutrient Management Practices; Soil Nutrients; Soil Water on Crop Nutrition; Sustainable Agriculture

Introduction

The basic elements for plant growth are generally classified as macronutrients or micronutrients based on the amount of element required for normal growth of plants. Macronutrients are required in large quantities and usually constitute 1000 mg / kg (0.1%) or more of the dry weight of the plant. Micronutrients are required in relatively small amounts and usually constitute less than 500 mg / kg (0.05%) of the plant's dry weight. Plants contain small amounts of 90 or more elements, but only 16 are known to be essential for higher plants. An element is only considered essential if the challenge from it makes it impossible for the plant to complete its life cycle. Carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S) are classified as macronutrients, with zinc

(Zn), iron (Fe) and manganese. (Mn), copper (Cu), molybdenum (Mo), boron (B), and chlorine (Cl) are classified as micronutrients. Macronutrients, their chemical symbols, the ionic or molecular shape (s) commonly available to the plant from air or soil solution, and the year in which each element has been shown to be essential are shown in Table M1. Macronutrients can be further divided into pieces based on the source of each of the elements. Carbon, H and O are largely obtained by the plant from air and water while N, P, K, Ca, Mg and S come mainly from the soil and absorbed by the plant through the root system. Nitrogen can be provided to the plant in relatively large quantities from air and soil. Rhizobia bacteria, found in the nodules on legume roots, are able to fix dinitrogen (N2) from the air and convert it into inorganic forms for plant use. Soil total nutrients, nitrogen (N), phosphorous (P) and potassium (K) are essential elements for crop growth Kant, & Kafkafi, (2002). The use of commercial fertilizers N, P and K contributed to a massive increase in yields of agricultural crops that nourish the world's population. However, the excessive use of these fertilizers has been cited as a source of pollution of surface and groundwater. Ideally, application rates should be adjusted based on estimates of optimal production requirements at each site since there is high spatial variability for N, P, and K within individual agricultural fields. Healthy soil forms the basis of a diet. Healthy soil produces healthy crops. Maintaining healthy soil requires care and effort from farmers. In recent years, a downward trend in total factor productivity and compound growth rates of major crops and reduced nutrient use efficiency has been observed due to deteriorating soil health.

The main cause of soil health degradation is a) a wide gap in nutrients between nutrient demand and supply, b) high nutrient turnover in the soil and plant system along with low and unbalanced fertilizer use, c) low organic matter status, d) an emerging deficiency of micronutrients Secondary, e) problems of nutrient leaching and fixation, f) soil contamination, soil acidity etc. Deficiency of micro and secondary nutrients in soil leads to mineral deficiency disorders. Therefore, in order to promote sustainable production, it is important to timely test soil nutrients and prevents soil degradation by improving soil health.

Mineral Nutrition

Introduction

Sixteen nutrients are essential for plant growth and reproduction. The source of carbon (C) and oxygen (O) is air, while water is the source of hydrogen (H). Ninety-four percent or more of dry plant tissue is made up of C, H, and O. The remaining thirteen elements, which account for less than 6 percent of dry matter, are often divided into three groups. The primary nutrients are nitrogen (N), phosphorous (P), and potassium (K). Secondary nutrients are sulfur (S), calcium (Ca), and magnesium (Mg). The plant needs micronutrients in very small quantities. They are iron (Fe), manganese (Mn), boron (B), zinc (Zn), copper (Cu), molybdenum (Mo), and chlorine (Cl). The nutrient removal from soybeans according to the corresponding grain grade and biomass is approximately 100 kg N, 23 to 27 kg P2O5, 50 to 60 kg K2O, 13 to 15 kg CaO, 13 to 16 kg MgO and much less quantities than other nutrients . In general, the fertilizer requirements for soybeans are lower than the requirements for other crops such as corn and wheat. The concentrations of nutrients in the dry matter of fully developed leaves on top of the plant without stems at the flower end as follows: 4.50-5.0% N, 0.35-0.60% P, 2.5-3.70% K, 0.60-1.50 % Ca, 0.30-0.70% Mg, 25-60 ppm Zn, 30-100 ppm Mn, 25-60 ppm B, 10-20 ppm Cu and 0.5-1.0% Mo Lavado, et al. (2001).

Nitrogen

Symbiotic nitrogen fixation (N) had an important role in the supply of legume plants including soybeans, by N. It is estimated that through this source a correlation of 40 to 300 kg N / ha / yr is possible (Bethlenfalvay et al., 1990). Field studies showed that soybeans are able to stabilize more than 300 kg N / ha when soils are low in available nitrogen and effective strains of Bradyrhizobia are provided in large numbers. Also, a portion of the nitrogen needs of pulses is normalized by absorption into mineral forms, mainly in the forms of NO3 and NH4 +. Soybeans contain an average of 1.5 to 1.6% and 6.5 to 7.0% nitrogen in the dry matter of the aboveground fraction and grains, respectively. Remove N amounts from soil with soybeans depending on many external and internal factors. For the formation of 1 tons of grain and the corresponding vegetative mass of soybeans, about 100 kg N are needed. About 40 to 60 million metric tons of N2 annually are fixed by important agricultural legumes, with another 3 to 5 million metric tons being repaired by legumes in natural ecosystems, providing nearly half of all nitrogen used in agriculture. Therefore, biological nitrogen fixation by leguminous plants is an important source of nitrogen available in both natural and managed ecosystems. That contributes to soil fertility and replaces the use of synthetic nitrogenous fertilizers Messick, (2003).

The host plant provides the carbon substrate as an energy source, and the bacteria reduce N2 in the atmosphere to NH3 which is exported to plant tissues for eventual protein synthesis. Nitrogen fixation occurs at different densities in the soil, as similar plant energy is used up, and because of this, bacterial activity forms an unbreakable relationship with plants. The proportion of nitrogen derived from fixation varies widely from zero to as high as 97%, with most estimates dropping between 25% to 75 %. N is motile in plants and moves rapidly from old to young organs. For this reason, the symptoms of nitrogen deficiency (bright green first and later yellow leaf color) appear on old leaves. In more stages they are found dropping of flowers and pods. Excess nitrogen has had unfavorable effects on soybean yield, mainly due to susceptibility to disease, low temperatures and drought. Overwidth symptoms of N increase from plant height, taller indoor bodies, and accidents of residence. Soy is the legume most vulnerable to nitrates. Under these conditions, inhibition of nodule formation and nitrogenase activities was found. . Also, the high nitrate content of the soybean apoplast had an effect on increasing the pH, iron fixation, and the development of chlorosis in soybeans. The N supply of soybeans can be estimated by the number and activities of bacterial nodules of the genus Rhisobium and Bradyrhisobium, the contents of total and mineral nitrogen in the oil, the activities of nitriteiductase etc. Bacterial activities are reduced under good soil supply by N (as a result of either high nitrogen fertilization or favorable conditions for mineralization of organic matter) and acidic soil pH Mondalet al (2001).

Recommendations for fertilizing soybeans are based on soil test results and planned crops. Under conditions of northern Croatia, the recommended quantities of nitrogen are mainly 60 to 90 kg N / ha mainly in spring. The application of nitrogen urea in autumn at more than 100 kg / ha resulted in no nodule bacteria present or reduced amounts. By testing 12 sites in fertile soils (chernozem and similar soils) in Vojvodina (Serbia), it was found that pollination had much greater effects on soybean yield compared to nitrogen fertilization and that using 90 kg N / ha no nodules were found on bean root Soy. Based on experiments from highly fertile soils in Ohio ., it is not recommended to use soybeans for nitrogen fertilization in the presence of sufficient quantities of nitrogen fixing bacteria and only in the first soybean cultivation on the individual soil recommendation, 45 kg N / Hectare. . Also, in Illinois, mineral N fertilization had no effect on soybean yield even in gang fertilization cases near soybean rows. Also, nitrogen fertilization was unnecessary for corn in the rotation of soybeans and corn. However, experiments from the USA cannot be applied in the less fertile soils of Central and Eastern Europe Mondalet al (2001).

Soil acidity is often a limiting factor for symbiotic nitrogen fixation. Soils with low pH values lack calcium, and have an excess of toxic aluminum, so that soybean roots in acidic soil do not have a mucous coating on the surface, and its purpose is to dissolve pectin roots, enable root hair curl and bacteria penetration into hair roots. This is very important during the first few days after pollination, that is, after the fertilized seeds have been planted. Therefore, soils with a pH of less than 5.5 (acidic soil) are not suitable for growing soybeans, because they lack the conditions for the development of beneficial bacteria whose growth is slowed down or completely enabled. Strains on soybean roots in this type of soil are often ineffective, and when cut in half they are green. The situation is completely opposite in fertile neutral or moderately alkaline soils such as chernozem. In these types of soil nitrogen fixing bacteria, not only do they have good conditions for growth, but they can also survive in large numbers for many years after growing soybeans. On such soils, it is not necessary to carry out seed germination if soybeans rotate every four years.In the event that the effect of inoculation on the growth of the nodule bacteria is reduced, it is recommended to take 50 kg N / ha as calcium ammonium nitrate (27% N) in the near term of flowering or at the beginning of flowering .Organic fertilizers alone cannot meet the heavy demands of nutrients in intensive soybean production due to their limited availability and limited supply of nutrients. The supplementary use of organic and mineral fertilizers may achieve the goal of an adequate and balanced supply of required nutrients to crops. The yield of soybean beans with the recommended NPK fertilization and 25 kg N / ha + 1 tonne neem cake / ha was much more than the only chemical and organic source of nutrition.

Phosphorous

Phosphorous (P) contents in plants are extensive, mainly from 0.1 to 0.8% P in dry matter. The reproductive organs, especially legume plants, contain high levels of phosphorous around 0.6% P. Phosphorous uptake in plants is intense in the early stages of development and in the period of organogenesis . Phosphorous is stored in plants, especially in grains, mainly in the form of phytic acid. P efficiency is closely related to soil water and temperature systems. Under optimum soil moisture, phosphorus absorption can be three times higher than with dry soil. An increased supply of water, cold weather, and a low pH also reduce phosphorous absorption in plants. The percentage of phosphorous removal by plants ranges from 10 to 45 kg of phosphorus, while the percentage of phosphorous removal ranges from 15 to 30 kg of phosphorous / ha / year by soybeans. The end of growth is the first symptom of phosphorous deficiency. The leaves are dark green and at a later stage they develop to violet and chlorine in color as a result of increased antociane synthesis. Dead spots, leaf dryness and fall are the latest stages of phosphorous deficiency. Active nodules (dark pink center) of N-fixing bacteria are absent or few under conditions of P. deficiency. Also, a decrease in protein and chlorophyll synthesis was found.

P excess is scarce. Decreased plant growth and dark spots appearing in the leaves are observed. The intensity of plant growth increases and as a result early flowering, grain formation and aging are formed. Excess phosphorus supply can be a cause of some nutritional imbalances, for example zinc, iron, manganese and copper deficiencies B. P, in combination with N and K as NPK fertilizers, can be used by infusing and incorporating them into the soil prior to sowing or used as a starter at seeding time. With lower levels of soil testing, scale application of fertilizer is more efficient than broadcast. If applied as a beginner, the recommendation for composting is in the range of 2 inches to the side and 2 inches down the seed. P materials such as triple superphosphate or from liquid or dry formulations of ammonia phosphate are available to improve soil condition P. However, organic soybean cultivation has limitations in the use of phosphorous and is limited to rock phosphate or fertilizers as sources of P Zheng, et.al. (2010).

The phosphorous deficiency in soil is an important growth limiting factor in western phospholipid, Nigeria. Lime application may not be feasible for resource-poor farmers. However, the complementary benefits (lime and nutrient supply) of organic fertilizers and rock phosphates can adequately improve acidic soil conditions and significantly reduce the cost of phosphorous fertilizers for efficient and sustainable soil fertility management. The effects of P on three soybean cultivars (CKB1, SJ5, and CM60) based on seed oil content (SOC) and seed protein content (SPC) and to assess physiological responses associated with changes in bud use efficiency (Palmer's pits). The experiment was conducted during 2008 and 2009 in a separate design at the Department of Agricultural Engineering, Kasetsart University, and Bangkok, Thailand. Master plots were tested for three levels of phosphorous in nutrient solution (0.5, 1.0 and 2.0 mmol), with subshells of the three soybean varieties. The results indicated that at maturity, the P levels of 2.0 mmol of SPUE decreased by 27% compared to the levels of 0.5 mmol (control). The SOC was not significantly affected by the level P. For the control, the trophic P levels of 1.0 and 2.0 mM led to a significant decrease in SPC of 4% and 5%, respectively. There were no significant differences in SOC between cultivars. The SPC of CKB1 was 8% greater than that of SJ5 but showed no significant difference from CM60.

On the effectiveness of application of P in improving regional soybean yields under drought pressures in the 2007 planting season in northern China including Heilongjang, Jilin and Liaoying provinces. The total soybean area in this region was about 4.5 million hectares, which is about 5% of the total soybean area in the world. Contemporary climate change is characterized by an increase in the frequency and severity of droughts. A total of 118 soybean fields throughout Hailun Prefecture, northern China. Regression trees analysis showed that the regional variation in the soybean yield was mainly a result of available phosphorous in the soil and the amount of phosphorous applied, which explained 16.3 and 15.2% of the yield variance, respectively. Soybean yield did not increase over the area when the phosphorus application rate reached 55.67 kg / ha Zheng, et.al. (2010).

Potassium

Potassium (K) is an essential nutrient for plant growth. The potassium concentrations in the plant dry matter vary between 1.0 and 6.0% and more and are generally higher than all other cations. The exact function of K in plant growth has not been clearly defined. Through numerous investigations it has been found that K stimulates early growth, increases protein production, improves water efficiency (drought resistance), and improves disease and insect resistance and habitat .Soils that mainly contain massive amounts of potassium, but depending on soil types, 90-98 percent of total potassium is not available. The unavailable K is slowly believed to be trapped between layers of clay minerals. Potassium deficiency occurs predominantly in light, acidic soils with low cation ability or in soils with a high content of three-layered clay minerals that are often loose soils with shiny clays. Soy requires large amounts of potassium and potassium deficiency and is easy to recognize (leaf edges necrising - leaf margins turn light green to yellow) and correcting them is inexpensive as potassium is the least expensive of the main nutrients. Deficiencies of K were found as a result of strong potassium fixation and high levels of available magnesium (Mg) in heavy soils in the Sava Valley region of Croatia. By improving the yield of potassium chloride, the fertilization crops of corn and soybeans increased significantly due to the improvement of the nutritional status of the plant Zheng, et.al. (2010). Deficiency of K in soybeans is found in dried gleyols which have insufficient K and Mg exchange rates (low case K and Mg high). These soil properties influenced the K and Mg status of soybean plants .Increased rates of KCl over dried Cerna glycol. Soybeans responded with yield increases of 16% and 30% in the first and second years, respectively. Soybeans were contained under normal and unfertilized fertilization at a mean of 0.82% K (severe K-deficiency with corresponding symptoms) and 1.49% mg. The nutritional status of soybeans was significantly improved by fertilization with potassium (mean 1.29% K and 0.76% mg). The response of soybeans and maize to increased rates of application of potassium in the form of KCl over a clay loess glycol developed on lime loess. Low levels of exchangeable K, high levels of exchangeable Ca and Mg and strong K fixation were found by soil testing (Vukadinovic et al., 1988; Kovacevic & Vukadinovic, 1992). Also, the proportion of clay (35.2% of soil) was as follows: vermiculite / chlorite 30%, smectite 30%, mixed layer minerals 20%, illite 15% and kaolinite 5% (Richter et al., 1990). By means of improved K fertilization, the soybean yield was significantly increased (3-y mean: 1286 and 2607 kg / ha, for control and a higher rate of K) and were closely related to the improvement of the condition of the K and Mg leaf.

In Ontario, Canada, studies looked at soybean response to potassium fertilizer in relation to K leaf tissue levels. The data collected during that study formed the basis for updated Critical and Normal values for potassium in soybeans. Below the K-leaf concentration of 2.0% (on a dry matter basis), most coupons showed a response to the K fertilizer added. Above this level, most of the plots were unresponsive. Based on the results of these experiments and other similar studies, the critical concentration of potassium in soybean tissue was determined at 2.0% and the maximum normal concentration was from 2.5 to 3.0%. According to this criterion, in our investigations under strong K stabilization conditions only by application of massive K rates were the K leaf concentrations increased to the normal level. However, despite the significant improvement in soil and plant condition K, yields of the high-yielding soybean variety were less than 3.0 t / ha. Long-term studies on integrated nutrient management in the soybean and wheat system (Singh & Swarup, 2000) revealed that continued use of FYM in conjunction with the recommended NPK for crop cycle 27 not only restricts K mining by reducing the non-exchangeable K contribution In pill formation but also boosted system K uptake Casanova, (2000).

Secondary nutrients

Calcium, magnesium, and sulfur are formed from the secondary group of nutrients. The documented deficiencies of these three components are few Lavado, et al. (2001).

Calcium

The plant species vary greatly in their calcium needs. The total calcium content in plants mainly ranges from 0.5 to 1.0%

in dry matter. Calcium absorption by plants is affected by calcium status, soil pH value, and concentrations of other cations, especially K and Mg. Calcium deficiency in legumes prevents the growth of nodule bacteria, which affects N fixation. Calcium-containing substances are used to correct the soil pH from acid to nearly neutral. Soil pH between 5.5 and 7.0 is optimal for symbiotic N fixation in soybean root nodules by Bradyrhizobium japonicum bacteria. Under such soils, availability of nutrients such as N and P and microbial degradation of crop residues are favorable. Calcium deficiency is unlikely if soil pH is maintained above 5.5.

Magnesium

The total magnesium content in plants generally ranges between 0.1 and 0.5% in dry matter. Magnesium is the central atom of chlorophyll and is vital for photosynthesis, biological production and the conversion of matter in plant metabolism. Magnesium deficiency occurs in strongly leaky, sandy acidic soils with low cation exchange capacity. Magnesium deficiency can be caused not only by low Mg state but also by high concentrations of other cations, for example H +, K +, NH4 +, Ca +, and Mn2 +. In Croatia, nutritional problems have been found for absorption of potassium by soybeans and corn caused by an excess supply of magnesium and strong potassium fixation. Frataric et al (2006) reported increases in soybean yield by 5%, cereal protein contents by 0.7% and oil by 0.7% as a result of foliar application of a 0.5% MgSO4 (Epsom salt) solution to eutric cambisol Lavado, et al. (2001).
For tested the response of six varieties of soybeans (Kona, Una, Nada, Ica, Lica, Tessa) to foliar fertilization (FF) with Epsom salt ($MgSO_4.7H_2O$; 5% w / solution at 400 L / ha) on Osijek. eutric cambisol. Fertilization was applied to standard fertilization either once or twice (pretreated labels FF 1x and FF 2x, respectively), while untreated cuttings served as a control (standard fertilization). The first FF was synthesized in soybean phase V2-V3 and second FF at ten days prior to soybean phase R1. The added nutrient quantities were as follows (kg / ha): 3.2 MgO and 2.3 kg S, as well as 6.4 MgO and 4.6 kg S, for treatment FF 1x and FF 2x respectively. In the growing season, 1999 was 22% higher than 1998. Ika cultivar was 23% higher than Una. FF resulted in moderate yield increases of up to 5% compared to the control. The differences in yield between FF 1x and FF 2x were insignificant. The oil content was higher in 1998 and 2000 (average 21.27%) compared to 1999 and 2001 (average 20.55%), while the differences between cultivars (from 20.77% to 20.96%) were not significant. Overall, FF resulted from moderate but significant increases in oil content (20.45%, 21.15% and 21.12%, for treatment 0, FF 1x and FF 2x, respectively). The protein content varied greatly between years from 38.53% (2000) to 39.38% (2001) and between cultivars from 38.30% (Lyca) to 39.48% (Nada). ESFF resulted in significant increases in protein content (38.62%, 39.11 and 39.21% for 0, FF 1x and FF 2x, respectively).

Sulfur

Soils of humid and semi-humid regions contain mainly total sulfur (S) in the range of 100 to 1000 mg / kg, which is a similar range to total P. It is divided into inorganic and organic forms but in most organic soils. The main S. tank provides. S in organic matter can be divided into two parts, S bonded to carbon and non-carbon S. The inorganic form of S in oil is mainly composed of sulfates. In arid regions, the soil may accumulate large amounts of salts such as $CaSO_4$, $MgSO_4$, and $NaSO_4$. Sulfates as phosphates are absorbed into sesquoxides and clay minerals, although the binding strength of sulfates is not as strong as that of phosphates. Under water saturation conditions, the inorganic S occurs in abbreviated forms as FeS, FeS_2, and H_2S. It results in S oxidation in the formation of H_2SO_4 and enhances additional soil acidification factor. Sulfate acid soils are very low with high pH and very rich in Al. Soil acidification is recommended by adding element S to lower the pH of alkaline soils Fontes, & Cox, (1995).

The sulfur content in plants mainly ranges from 0.1 to 0.5% in dry matter. S is absorbed by plants in the form of sulfate, but plants can absorb S also in gaseous form as SO_2. Sulfates must first be reduced by the plant to sulfide before they are mainly incorporated into the S-containing amino acids containing methionine and cysteine. S deficiency in plants is relatively rare due to constant input of sulfate with NPK fertilizer and presence of SO_2 in precipitation (acid rain). Soybeans use a large amount of sulfur. S deficiency mainly occurs during cool, damp weather in highly filtered sandy soils low in organic matter and in small manufacturing areas. In some cases, there is potential damage due to an increase in S due to acid rain. In tested the effects of soybean fertilization with S and B alone or together up to 50 kg S / ha and u up to 4.0 kg B / ha. The yield, protein and oil content of soybeans were significant when S and B were applied separately, but their interaction was not significant. The highest biological yield and most traits were obtained from the treatment combination of 30 kg S / ha and 1 kg B / ha Fontes, & Cox, (1995).

6- Micronutrients (Zinc, Manganese, Iron, Copper, B, Cl, Mo)

Zinc

Soybeans, corn and flax are among the field crops most vulnerable to zinc deficiency. It is often found in sandy soils with low organic matter, on high pH soils and calcareous soils, as well as in soils rich in the aroma of available P., cold and moist weather that promotes zinc deficiency. Nitrogen improves, while iron and phosphorous in particular reduce zinc absorption by plants. The first symptom of zinc deficiency in soybeans is usually a light green color that develops between the veins on old leaves. The new young leaves will be abnormally small. Bronze may occur to old leaves. When the deficiency is severe, necrotic spots may appear on the leaves. The short indoor columns will give the plants a stunted pink appearance. Zinc is an essential component in the metabolism of proteins, carbohydrates and fats. Zinc is a compound of some enzymes (carbohydrase, hydrogenase glutamate and malate, alkaline phosphatase, proteinase, peptidase, etc.). Zinc affects auxin synthesis, respiratory intensity and absorption of copper and manganese, especially P. Zinc also contributes to increasing resistance to virus diseases, dehydration and stress caused by low temperatures. The soil and leaf test is used to diagnose zinc status in plants. Also, important is the P / Zn ratio Lavado, et al. (2001).

Inorganic zinc can be incorporated in the form of $ZnSO_4.7H_2O$ (2-22 kg zn / ha) or organic Zn in chelated form (03-6.0 kg weight / ha), as well as foliar fertilization (0.5% zinc sulfate solution). Used to correct zinc defects. Nutritional disturbances were found in soybeans grown on eutrical cambisol. Growth retardation and chlorosis have been associated with alkaline or neutral soil reaction. Through a paper diagnosis, he found zinc deficiency. Zinc deficiency was enhanced by increased phosphorous or iron / aluminum in plants while K deficiency was associated with increased magnesium absorption. For example, chlorinated soybeans mean 16 ppm of Z in dry matter (in regular soybeans 27 ppm of zinc). Meanwhile, the P: Zn ratio was 239 (normal levels less than 180), while the Fe: Zn ratio was 34 (normal levels less than 15). Similar values for regular soybeans were 150 and 7, respectively. High soil pH and excess plant P available supply are factors promoting zinc deficiency in soybeans Stipesevic,et al (2008).

The response of four soybean species to foliar fertilization with zinc ($ZnSO_4.7H_2O$ prior to flowering) was studied at three sites in central and northwest NSW. In Narrabri, a single spray of 4 kg / ha gave an increase in yield of 13%. In Trangi and Briza, two sprays of 4 kg / ha increased yields by 57% and 208%, respectively. I had the least responsive species on every site, and Dodds and Forrest were the most responsive to applied zinc. The use of zinc fertilizer increased plant height, zinc oil, and oil contents (in two locations), but decreased phosphorous in the leaves. Leaf-P in untreated plots was an indication of taxon sensitivity to zinc deficiency within and between sites. They tested twelve nutrient blends consisting of three levels of nitrogen (30, 60, 90 kg nitrogen / ha), phosphorus (40, 60, 80 kg P_2O_5 / ha) and two levels of potassium (30 and 60 kg). K_2O / ha) and one level of zinc (25 kg zinc / ha) with control. Zinc fertilization with N, P, and K resulted in a significant increase in the growth characteristics and grain yield of soybeans, and the highest number of pods per plant and grain yield were obtained with the combined application of N, P, K and Zn at rates of 90, 80, 60 and 25. Kg / ha, respectively Stipesevic,et al (2008).

Iron

Legume plants need more iron than cereals. Iron is involved in many metabolic processes including protein synthesis. Under conditions of F deficiency, high levels of low-molecular N-substances, especially the amino acid arginine, were found. Soybeans are prone to iron deficiency. Iron deficiency is a common factor limiting the production of soybeans grown in limestone soils with high pH, as well as in some poorly drained soils seasonally. Periods of coolness and humidity promote iron deficiency. Iron may not be available for absorption by the roots, nor transported after absorption, or the plant may not use it. In Iowa and Minnesota, more than ten million dollars in potential soybean production annually was lost due to iron chlorosis. With the potential increase in the alkalinity of the Texas soil due to irrigation, decreased soybean production could become an issue. The problem can result from lower yields per acre or from lower productivity spaces due to increased alkalinity. It is not easy or inexpensive to correct an iron deficiency in this area. It would take five tons of sulfuric acid per acre to neutralize one percent of calcium carbonate in a 16.5 cm layer of soil. Iron deficiency produces a characteristic yellowing of the veins in new leaves and can cause significant loss of soybean yield. In some years, it has developed during the early growth stages and disappears as the plants mature. In more severe cases, chlorosis can persist throughout the season. There is wide variation in susceptibility to iron deficiency among soybean varieties Franzen, & Richardson, (2000).

Soybeans in areas with chlorophyll had lower concentrations of chlorophyll in the leaves, stunted growth, and poor nodule growth for non-chlorinated plants. Also, compared to non-chlorinated areas, soils in chlorinated areas had greater soil moisture content and concentrations of soluble salts and carbonates. Iron chlorosis correction often requires a range of management practices including variety selection, application of ferrous fertilizers with seeds (eg iron chelate Fe-EDDHA) or foliar treatment with a 1% solution of ferrous sulfate. In tested soil factors that influence iron staining with soybeans. A total of 12 Red River Valley sites were studied in North Dakota and Minnesota betwee 1996-98. The equivalence of calcium carbonate and soluble salts has often been associated with symptoms of chlorosis. The plant response to iron chlorosis varies between cultivars and environmental conditions. Iron reduction at the root surface from Fe to Fe is an adaptive mechanism used by iron-efficient plants to overcome iron deficiency. Soybean varieties such as Hawkeye have been shown to be moderately effective in facilitating iron absorption in this way. Iron absorption is (1) as iron bound with chelate molecules and (2) as ionic iron after chelate cleavage. Plants with high iron efficiency have an increased rate of iron uptake after syncytial division during iron deficiency stress (IDC); Plants lacking iron do not (Romheld & Marschner, 1981). It is said that plants with iron efficiency and iron inefficiency can be distinguished in terms of the extent of iron absorption as a function of phosphorous content in the soil.The increased phosphorous inhibited increased iron absorption of the inactive species and slightly reduced iron absorption from the active species Franzen, & Richardson, (2000).There are significant differences in the resistance of soybean cultivars to iron coagulation. Growing more tolerant varieties is the solution to alleviate the nutritional problems caused by iron deficiency.In tested in greenhouse conditions in nutrient solutions that affect zinc on the growth and genotyping of soybeans with efficiency in iron (Hawkeye) and inactive iron (PI-54619-5-1) in different levels of iron. . In general, increased zinc levels led to decreased growth in both genotypes with inactive iron plants being more sensitive to the zinc level. The iron-efficient genotype had higher iron content than the inactive iron at the corresponding processing levels.

Manganese

Plants vary widely in their manganese requirements and only 20 ppm levels are often sufficient for normal plant growth. Manganese levels in plants vary more with different types and soil characteristics than those found in other nutrients. Plants generally absorb manganese from the soil as Mn2 +. Manganese is important in plant metabolism due to its redox properties and thus its ability to control redox and carboxylate reactions in carbohydrate and protein metabolism. Manganese deficiency causes stunting of soybean plants. The leaves are yellow to white but with green veins. Manganese deficiency is most pronounced in cold weather on slow-moving alkaline and alkaline soils rich in organic matter. Soil pH is the most important factor affecting manganese availability because it is highly soluble at low pH and insoluble at high pH levels.

Foliar fertilization of small and medium-sized crops with 8-15 kg MnSO4 / ha as a 1-2% solution (2-3 uses) is recommended for prevention of manganese deficiency in soils with high pH value.

Deficiency of manganese in oats and soybeans, mainly in areas of the coastal plain of North Carolina. This problem was associated with a high soil pH, and thus this observation was probably the first evidence of "over-surfacing". Soils in the coastal plain are naturally low in manganese, especially soils that are poorly drained, as manganese can be reduced and leached in the soil formation process. Intervenous chlorosis is a clear symptom of manganese deficiency. When used both extractable manganese from Mahesh-1 extract and soil pH and developed a prediction of yield response and interpretation of manganese soil test for soybeans. The concentrations extractable at the critical level, which ranged from 3 to 9 with Mehlich-1 depending on the pH, were sufficient for easy measurement. Critical levels of manganese in soybean leaves at different growth stages and effective fertilization rates to correct manganese deficiency in soybeans Hansen, et al (2003).

Copper

Rarely, copper (Cu) is deficient in soil. Only in soils high with organic matter and under conditions above pH 6.0 is copper likely to be deficient. Legumes and forage plants deficient in copper are greyish-green, bluish green, or olive green. The interiors are shortened to produce a dense type of plants. Soy has low copper requirements. The observed that crops grown in clay soil in North Carolina often respond to the use of copper. This observation research centered on the aspect that copper may be a catalyst in oxidation-reducing processes in soils Lavado, et al. (2001).

Boron

Total boron (B) content in soil ranges from 20 to 200 mg / kg dry weight, most of which is not available to plants. The available portion that is sufficiently soluble in hot water in the soil provided with B ranges from 0.5 to 2.0 mgB / L. Soluble B is mainly composed of boric acid which is inseparable in most soil pH conditions (pH 4-8). In soils of arid and semi-arid regions, B may accumulate to toxic concentrations in the upper soil layer due to lack of drainage and reclamation of this soil requires about three times the amount of water in saline soils. Soil organic matter is closely related to the accumulation and availability of B in soils. Vitamin B deficiency disrupts the growth and development of plants Sarker, et al. (2002). It is known that B affects carbohydrate metabolism, sugar transport, household DNA and protein, N metabolism, flower formation and pollen germination, household water, active processes of phosphorylation and dephosphorylation, etc. Conditions favoring B deficiency are high pH (7.0- 8.0), soils low in organic matter, drought, and high concentrations of iron and aluminum hydroxide. The difference between adequate and toxic concentrations of B is very small. Soy is highly susceptible to toxicity b. Alfalfa and sugar beet have high requirements for B. Broadcasting and incorporation of 0.5 to 1.0 kg B / ha (eg, borax is the most widely used) meets the needs of alternating crops for a few years Lavado, et al. (2001).

Chlorine

Chlorine (Cl) is in a group of elements that can have beneficial effects on plant growth. Plant tissues usually contain a large amount of chlorine, often in the range of 2 to 20 mg / kg dry weight. Soils that are low chlorine less than 2 mg water soluble chlorine / kg soil which is rare. The effects of excess chlorine in plants are a more serious problem.Crops grown on salt-affected soils often exhibit symptoms of chlorine toxicity. These include burning at the tips of the leaves, bronzing, early yellowing and retraction of the leaves. Plant species differ in their sensitivity to Cl. Some leguminous species are highly susceptible to chlorine toxicity and it is recommended to use sulfates in place of chlorine fertilizers Ganesh, et al. (2009).

Molybdenum

Molybdenum (Mo) is an essential nutrient for plants. Mo concentrations may vary from less than 0.1 to more than 300 ppm. The roots contain more magnesium than the aboveground part or the seeds. Molybdenum is needed by soybeans and other leguminous plants themselves and also by the nitrogen fixing bacteria Rhizobia in the soil. Unlike other micronutrients, molybdenum availability increases with soil pH. There is rarely a deficiency of molybdenum with a soil pH above 6.0. Since the element is important for nitrogen fixation, pale green or yellow plants are identical to nitrogen deficiency. In this case, the leaves generally start to turn yellow first on the lower leaves. It goes without saying that symptoms usually do not occur in soils with a high nitrogen content to compensate for the lack of nodule fixation. The efficiency of N2 symbiotic fixation can be limited by deficiency of micronutrients, especially molybdenum. Soybeans generally respond positively to fertilization with Mo in soils of low fertility and in fertile soils depleted of Mo due to long-term cultivation. Sodium or ammonium molybdate is mainly used to correct the deficiency of molybdenum either as a solid substance in the soil or by spraying the leaves or by treating the seeds. However, the first step is always to determine the appropriate soil pH. Micronutrients could be provided by treating the seeds, however toxicity of Mo sources was observed in Bradyrhizobium strains applied to seeds as a pollinator, resulting in bacterial death, and decrease in nodule, N2 fixation and grain production Sugiyama, & Noriharu (2009). Therefore, the use of Mo-fertilized seeds could be a viable alternative for external seed treatment. The feasibility of producing molybdenum-rich seeds for several soybean varieties, by two foliar sprays of 400 g mu / ha between R3 and R5 phases, with a minimum interval of 10 days between sprays. In most cases, Mo-rich soybean seeds required no additional application of Mo fertilizer.

Harmful elements (cadmium, chromium, mercury, and lead) and toxic heavy metals

Heavy metals are the primary component of the environment. It usually accumulates due to the unplanned disposal of municipal waste, mining, and widespread use of pesticides. Other agrochemical uses as chemical fertilizer are the main cause of rise in the environment. The results of a greenhouse study on cadmium and zinc accumulation in soybeans. The highest dose of cadmium (100 mg / kg) decreased plant height and dry weight (down to 40% and 34% of control, respectively), while the standard data for highest dose of zinc (2000 mg / kg) were 55% and 70%. Respectively. With both minerals, the plants were roughly the same size as the cadmium-treated plants only. When both minerals were added to the soil, 80-100% cadmium and 46-60% zinc was bioavailable. Concentrations of both minerals were higher in the root tissues (10 times higher for cadmium and 2 times higher for zinc). Although relatively little cadmium was transported into pods and seeds, the seeds of all plants (including those found in control and zinc-treated plants) had concentrations of cadmium 3-4 times higher than the 0.2 mg / kg limit you set. This was surprising given that the cadmium in the soil was only 1 mg / kg well below the maximum permissible agricultural soil.The heavy mineral content of municipal and industrial wastewater sludge and pig manure lake sludge is very high in copper and zinc and causes accumulation of elements in the soil and for this reason it has potential toxicity to the environment. Physiological effects of zinc toxicity in soybeans evaluated the effects of high concentrations of zinc and copper on soybean condition. In studied soil factors affecting the concentrations of these elements in plants in soil amended with clay. When heavy metal concentrations are high, knowledge of their solubility becomes important Mottaghian, et al (2008). They tested cadmium absorption and distribution of cadmium in 17 types of soybeans grown in pots (three soils: medium cadmium soil, high cadmium soil, low cadmium soil) and under field conditions in unpolluted soil (low cadmium field)). The sources of cadmium contamination are thought to be mine waste in the case of medium-cadmium soils, and refining of plant waste in high-cadmium soils. The cadmium seed concentration was lowest in the En-b0-1-2 soybean variety, and the highest in Harosoy. The cadmium seed levels of Tohoku 128, a cross between Enrei and Suzuyutaka, were intermediate between parental levels. For four soils, containing 0.2 to 6.5 mg kg of extractable cadmium, the soybean genotypes arrangement based on cadmium seed level were similar, indicating the presence of a genotype involved in the varied differences in cadmium concentration. The lower levels of cadmium present in the seeds of certain types of soybeans can be a result of the combination of lower initial absorption and the retention of higher levels of cadmium in the roots, limiting its transfer to the shoot Putwattanaa, et al. (2010).Various measures can be taken to reduce the absorption of cadmium in plants. Adding modifications such as calcium carbonate, zeolite, and manganese oxide can reduce cadmium absorption in plants. In this respect, zeolite was more effective in suppressing plant absorption of cadmium than calcium carbonate or manganese oxide. Also, organic modification such as farm manure and compost with a high content of moisturizing organic matter can reduce the bioavailability of Cd and other heavy metals in the soil.The effects of potassium supplementation on mitigating cadmium toxicity in a hydroponics trial. K supplementation at 380 mg / L with addition of cadmium (1 μg) or without cadmium. K supplementation attenuated reduced growth, photosynthesis, and nutrient absorption in cadmium-treated soybean plants. It was concluded that cadmium toxicity could be mitigated by improved potassium feeding in soybeans. The soybean varieties show significant differences in cadmium seed concentrations, mainly due to genetic factors rather than environmental factors. One - six of the total soybeans produced in Japan exceeded 0.2 mg / kg, the international standard proposed by the Codex Alimentarius Commission. Moreover, soybean crops contained significantly higher Cd content than other field crops Mottaghian, et al (2008). Chromium (Cr) is a non-essential and phytotoxic element. Chromium interferes with many metabolic processes, causing toxicity to plants as evidenced by reduced seed germination or early seedling growth, root and biomass growth, chlorination, impaired photosynthesis, and finally plant death. The normal range for Cr ranges from 10 to 50 mg / kg depending on parental substance. Researchers have shown experiments with plants associated with high levels of chromium. Thus, 1-5 ppm of chromium present in the available form in the soil solution, either Cr (III) of Cr (VI), is the critical level for a number of plant species. Increasing chromium (VI) concentration by 10-800 mg / L in culture medium led to detection of inhibitory growth factors. There was a decrease in growth, dry weight and strength index in four soybean soy genotypes with concentrations of 5-200 mg L of chromium, according to the control application .Mercury (Hg) and its compounds are among the most powerful toxic substances for plants, and they are also very dangerous for humans and animals. It is a component of many crop protection agents. Uncontaminated soil contains only 0.003 to 0.03 mg / kg of mercury. Mercury levels of about 0.04 mg / kg in dry matter can be considered normal in plants. The maximum tolerance 0.05 mg / kg of fresh material suggested for foodstuffs. The uptake of mercury in plants is very insignificant because it makes a strong drink in the soil, mainly by complexing with organic matter. Besides growth retardation, symptoms of mercury toxicity include chlorosis, necrotic lesions and death. These are mainly the result of severe root damage and consequent inhibition of nutrients and water absorption. Since so little mercury is transported from the rootstock, there is little risk of it entering the food chain through the soil. Mobility and uptake of mercury by plants can be greatly reduced by liming. Lead (lead) is a major chemical pollutant for the environment, and it is very toxic to humans. The main source of lead contamination arises from the combustion of gasoline. This source accounts for about 80% of all lead in the atmosphere. Lead is toxic because it mimics many aspects of calcium's metabolic behavior and inhibits many enzyme systems. There is evidence that lead contamination can cause brain damage in humans and aggressive behavior in animals. Lead toxicity interferes with iron metabolism and blood formation. Total concentrations of lead in agricultural soil range from 2 to 200 mg / kg soil. It is quite evident that lead contamination follows highway areas. Plants on the side of the road may have levels of 50 mg / kg of dry matter but at a distance of only 150 meters from the highway the level is usually around 2 to 3 mg / kg. Contamination occurs only on the outside of the seed, leaves and stem of the plant and a high percentage can be removed through washing.

Plant nutrients and plant nutrition

Plants convert light energy into biomass through photosynthesis and produce various products of economic value (grains, fibers, tubers, fruits, vegetables, forages) and others. To do this, plants need adequate lighting, adequate temperature, materials such as water, carbon dioxide, oxygen, and a number of nutrients. The survival and well-being of humans and animals depends on plant production, which in turn depends heavily on the availability of minerals and other nutrients. This is why plants and animals (including humans) share many essential nutrients. Like all living things, green tall plants need nutrients for their growth and development. Nutrients are indispensable as plant components, for biochemical reactions, and for the production of organic matter referred to as photosynthesis (carbohydrates, proteins, fats, vitamins, etc.) by photosynthesis. In agriculture (including horticulture), optimum crop nutrition is an important prerequisite for obtaining high yields and quality products. Plants obtain the required nutrients from soil reserves and external nutrient sources (fertilizers, organic fertilizers, atmosphere, etc.). Almost all of the 90 natural elements can be found in green plants although most have no function (such as the heavy metallic gold).

Plant nutrients

Essential phytonutrients

A total of only 16 elements are necessary for the full growth and development of the top green plants. These criteria are: A deficiency of an essential nutrient makes it impossible for a plant to complete the vegetative or reproductive phase of its life cycle.

This deficiency is specific to the element in question and can only be prevented or corrected by providing this element. The element is directly involved in plant nutrition far from its potential effects in correcting some unfavorable microbiological or chemical conditions of soil or other culture media. The basics of most micronutrients for higher plants were established between 1922 and 1954.. However, this list may not be considered final and it is possible that more items may be necessary in the future. Of these sixteen elements, carbon (C) and oxygen are obtained from carbon dioxide gas, and hydrogen (H) is obtained from water ($H2O$). These three elements are required in large quantities to produce plant ingredients such as cellulose or starch. The other 13 elements are called mineral nutrients because they are taken up in mineral (inorganic) forms. They are conventionally divided into two groups, macronutrients and micronutrients, according to the quantities required. Regardless of the required amount, physiologically they are all equally important. The thirteen mineral elements are taken up by plants in specific chemical forms regardless of their source. Oxygen, C and H make up 95 percent of plant biomass, and all other elements comprise 5 percent. The difference in plant concentration between macronutrients and micronutrients is enormous. The relative content of nitrogen and molybdenum (Mo) in plants in the ratio of 10,000: 1. Plants need about 40 times more magnesium (Mg) than iron. These examples indicate the big difference between macronutrients and micronutrients. Chapter 6 provides more details on the concentration of nutrients in crops and crop products.

Beneficial nutrients

Many elements other than essential nutrients have beneficial functions in plants. Although they are not necessary (as a plant can survive without them), beneficial nutrients can improve the growth of certain crops in some ways. Some of these nutrients can be of great practical importance and may require external addition: Nickel (Ni): Part of the enzyme urease to break down urea in the soil, and imparts a beneficial role in disease resistance and seed development.

Sodium (Na): For beets, it is partially able to replace K (absorption as Na +). Cobalt (Co): for nitrogen fixation in legumes and other plants (absorption as Co2 +). Silicon (Si): to stabilize the grain stalk especially rice (absorbing it as the silicate anion). Aluminum (Al): for tea plants (absorption as Al3 + or similar forms).Other important nutrients Campo, et.al. (2009). Since humans and pets need many nutrients in addition to those required by plants, these additional nutrients must also be considered in food or feed production, and their deficiencies corrected with appropriate inputs. In addition to plant nutrients, the essential elements for humans and pets are: cobalt (Co), selenium (Se), chromium (Cr), and iodine (I).

Nutrients - their functions and portability in plants and symptoms of impotence / toxicity

Some knowledge of the properties and functions of phytonutrients is useful for managing them efficiently and hence for good plant growth and high yields. It can absorb nutrients available in soil solution by roots, transfer to leaves and use according to its functions in plant metabolism. Nutritional ions are of extremely small size, like atoms. For example, there are more than 100,000 million K cations within a single paper cell and more than 1,000,000 anion molybdates, the micronutrients required in the smallest amount. In general, N and K make up about 80 percent of the total mineral nutrients in plants; P, S, Ca, and Mg together make up 19 percent, while all micronutrients together make up less than 1 percent. Most of the phytonutrients are taken up as positive or negatively charged ions (cations and anions, respectively) from the soil solution. However, some nutrients can be eaten as whole molecules, for example boric acid and amino acids, or organic compounds such as mineral chelates and urea to a small extent. Whether the original sources of nutrient ions in the soil solution are from organic matter or from inorganic fertilizers, plants ultimately absorb them only in mineral forms Shamsi, et al (2010). Plants show many shades of green but a medium to dark green is usually considered a sign of good health and active growth. Chlorosis or yellowing of the leaves can be a sign of marginal deficiency and is often associated with late growth. Chlorine is a light green or somewhat yellow color of the whole or parts of the leaf due to the low chlorophyll content. Since the cells remain largely intact, the yellowing symptoms are reversible, i.e. the leaves can turn green again after adding the lost nutrients (responsible for the formation of chlorophyll). Acute deficiency leads to tissue death (necrosis). Necrosis is a brown discoloration caused by tissue decomposition, which is destroyed irreversibly. Dead leaves cannot be restored by adding the lost nutrients, but the plant may survive by forming new leaves. Deficiency symptoms can serve as a clue to diagnosing nutrient deficiency and the need for corrective measures. However, yellowed and necrotic leaves may also result from the toxic effects of nutrients and pollution, as well as from disease and insect attacks. Therefore, confirmation of the cause is important before taking corrective measures.

Nitrogen

N is the most abundant mineral nutrient found in plants. It constitutes 2-4 percent of the dry matter of the plant. Aside from the N fixation that occurs in legumes, plants absorb N as either the nitrate ion (NO_3^-) or the ammonium ion (NH_4^+). N is part of chlorophyll (the green pigment in leaves) which is an essential component of all proteins. It is responsible for the dark green color of the stem and leaves, vigorous growth, branching / tillering, leaf production, size enlargement, and crop formation. The absorbed N through the xylem (in the stem) is transferred to the leaf umbrella as nitrate ions, or it can be reduced in the root zone and transported in organic form, as amino acids or amides. N mobile in the phloem (the plant tissue through which the sap containing dissolved nutrients passes down to the stem, roots, etc.); As such, they can be re-transferred from older leaves to younger ones under lack of nitrogen and transferred from leaves to developing seeds or fruit. The main organic forms of N in phloem sap are amides, amino acids, and urides. Nitrates and ammonium ions are not present in this sap Mondalet al (2001). Lack of nitrogen in plants leads to a significant decrease in the growth rate. Nitrogen deficient plants have a short, delicate appearance. Tillage is poor, and the leaf area is small. Since N is a component of chlorophyll, its deficiency appears as yellowing or yellowing of the leaves. Usually this yellowness appears first on the lower leaves while the upper leaves remain green because it receives some N of the older leaves. In case of severe deficiency, the leaves turn brown and die. As a result, crop yields and protein content decrease (percentage nitrogen in seeds x 6.25 = percentage of protein content). The effects of N toxicity are less pronounced than those of its deficiency. It includes a period of prolonged (vegetative) growth and delayed ripening of crops. High NH_4^+ in solution can be toxic to plant growth, especially when the solution is alkaline. Toxicity results from ammonia (NH_3), which is able to spread through plant membranes and interfere with plant metabolism. The potential hydrogen (pH - negative record of H^+ concentration) determines the equilibrium between NH_3 and NH_4^+.

Phosphorous

P is less abundant in plants (compared to N and K) having a concentration of about one-fifth to one-tenth of the N concentration in plant dry matter. Phosphorous is absorbed as an orthophosphate ion (either as $H_2PO_4^-$ or HPO_4^{2-}) depending on the soil pH. As the pH of the soil increases, the relative H_2PO_4 and HPO_4^{2-} ratio decrease. P is necessary for growth, cell division, root elongation, seed and fruit development, and early ripening. It is part of several compounds, including oils and amino acids. P-adenosine diphosphate (ADP) and adenosine triphosphate (ATP) act as energy carriers within plants. P moves easily within a plant (as opposed to soil) in both xylem and phloem. When the plant experiences a P (stress) deficiency, phosphorous from old leaves is easily transferred to young tissues. With such a moving element, the pattern of redistribution appears to be determined by the characteristics of the source (old leaves and stems) and the basin (stem tip, root tip, leaf expansion and subsequently in the developing seed). Plant growth is significantly restricted under phosphorous deficiency, which retards growth, cultivation, and root development, and delays ripening. Deficiency symptoms usually begin in the old leaves. It develops a bluish green to reddish color, which may result in bronze and red pigments. Lack of inorganic phosphates in chloroplasts reduces photosynthesis. Due to the reduced RNA synthesis, protein synthesis is also reduced.

Low stem / root ratio is a feature of P deficiency, as is the low overall growth of the peaks. Very high levels of phosphorous can lead to symptoms of poisoning. These generally appear as a watery edge on the leaf tissue, which later becomes necrotic. In very severe cases, phosphorous toxicity can lead to plant death Zheng, et.al. (2010).

Potassium

K is the second most abundant mineral nutrient in plants after N. It is 4-6 times more abundant than the macronutrients P, Ca, Mg and S. plants. K is involved in the work of more than 60 enzymes, in photosynthesis and the movement of their products (photosynthesis) to storage organs (seeds, tubers, roots and fruits), the water economy and providing resistance against a number of pests, diseases and stresses (frost and drought). It plays a role in regulating stomatal opening, and thus in plants' internal water relationships. General symptoms of potassium deficiency are chlorosis along leaf borders followed by burning and browning of the tips of old leaves. The affected area moves inward as the deficiency increases in severity. Symptoms of K deficiency on older tissues are due to movement of K. affected plants generally stunted and internal nodes shortened. Such plants have: slow and stalled growth. Weak and habitable stems; Increased spread of pests and diseases; Low yields withered grain and generally poor quality of crops. Slow plant growth can be accompanied by a higher respiration rate, which means wasted water consumption per unit of dry matter produced. Plants with K deficiency may lose control of the rate of transpiration and experience internal drought Casanova, (2000).

Calcium

Calcium (Ca) is classified with Mg, P, and S in the group of the least abundant macronutrients in plants. Absorbed by plant roots as the divalent Ca2 + cation. Ca is part of the structure of cell walls and membranes. Participates in cell division and growth, root elongation and enzyme activation or inhibition. Calcium is immobile in the phloem. Calcium deficiency is first noticed in the developing tips and young leaves. This is the case with all nutrients that are not highly mobile in plants. Calcium deficiency problems are often related to the inability of calcium to move through the phloem. Problems occur in organs that do not ooze easily, i.e., large, fleshy fruits developing. Leaves deficient in calcium become small, distorted, cup-shaped, wrinkled and dark green. They stop growing, become disorganized, crooked, and die in severe deficiency. Although all growth points are sensitive to calcium deficiency, those in the roots are severely affected. Peanut shells may be hollow or poorly stuffed as a result of incomplete kernel development Putwattanaa, et al. (2010).

Magnesium

Mg ranks with Ca, P, and S in the least abundant macronutrient group in plants. Plants take Mg as Mg2 +. Magnesium occupies the central spot in the chlorophyll molecule and is therefore vital for photosynthesis. It is related to enzyme activation, energy transfer, maintenance of electrical balance, production of proteins, carbohydrate metabolism, etc. Mg is motile inside plants. Since Mg easily passes from the old plant parts to the younger parts, the symptoms of its deficiency appear first in the old parts of the plant. A typical symptom of a magnesium deficiency is chlorosis in the veins of old leaves, where the veins remain green while the area between them turns yellow. When the deficiency becomes more severe, the leaf tissue becomes uniformly pale, then brown and necrotic. Leaves are small and break easily (brittle). Twigs become weak and fall off early. However, the diversity of symptoms in the different plant species is so great that their generalized description is more difficult in the case of magnesium than for other nutrients Putwattanaa, et al. (2010).

Sulfur

Crops require S in amounts similar to P. The concentration of normal total S in vegetative tissues is 0.12 - 0.35% and the total N / total S ratio is about 15. The plant roots absorb S mainly as the sulfate ion (SO42-). However, it is possible for plants to absorb sulfur dioxide (SO2) from the atmosphere in low concentrations' is part of the amino acids cysteine, cysteine, and methionine. Hence, it is essential for protein production. S is involved in the formation of chlorophyll and in the activation of enzymes. It is part of the biotin and thiamine (B1) vitamins, and is necessary for the formation of mustard oils, sulfidryl bonds which are a tingling source in onion oils, etc Messick, (2003). S moves upward in the plant as the inorganic sulfate anion (SO42-). Under low S conditions. Mobility is low as S cannot be transported in skeletal vehicles. As the plant's S state rises, so does its mobility. This mode of mobility means that in plants with sufficient S, sulfates are preferentially transported to actively growing young leaves. As S supply becomes more restricted, young leaves lack S, thus deficiency symptoms appear. In many ways, S deficiency resembles N. deficiency and begins with the appearance of pale yellow or light green leaves. Unlike N deficiency, S deficiency symptoms In most cases it appears first on younger leaves, and is present even after applying N. S-deficient plants are small and have short, slender stems. Growth is delayed, and ripening of beans is delayed. The complexity in legumes is weak and N. fixation decreases. Often the fruits do not ripen completely and remain light green in color. Deficient oilseed crops in S produce a low yield and the seeds contain less oil. S toxicity can occur under very low conditions, possibly as a result of sulphide (H2S) injury. Most plants are exposed to high levels of sulfur dioxide in the atmosphere. The normal concentrations of sulfur dioxide range from 0.1 to 0.2 mg of sulfur dioxide / m3. The symptoms of toxicity are observed when they exceed 0.6 mg of sulfur dioxide / m3. Symptoms of poisoning S appear in the form of necrotic spots on the leaves, and then spread over the entire leaf Fontes, & Cox, (1995).

Boron

Plants likely take boron (B) as unconjugated boric acid (H_3BO_3). Most B uptake appears to follow primarily the flow of water through the roots. Plant B is similar to mortar in a brick wall, bricks being cells of growing parts such as meristems. The main roles of B relate to: (1) Membrane integrity and cell wall development, affecting permeability, cell division and extension; And pollen tube growth, affecting the seed / fruit set and thus the yield. B is relatively immobile in plants, and the B content often increases from the lower parts to the upper parts of plants. Vitamin B deficiency usually appears on the developing points of roots, buds and young leaves. Young leaves are deformed and arranged in the shape of a rose. There may be a crack and a cork in the stems, stems and fruits; Thickening of the stem and leaves. Interodes shorten, wilt or die of growth points and decrease bud, flower and seed production. Other symptoms are: premature dropping of seeds or fruit dropping. Crown and heart rot in sugar beet; Clusters of hen-and-chicken type in grapes; Barren cobs in corn; the hollow heart in peanuts. Unsatisfactory vaccination and poor fusion transmission. The death of the growing limb leads to the growth of the auxiliary meristem and the dense, broom-type growth. The roots become thick, sticky, and have brownish necrotic spots. Toxicity B can arise under excessive use of B, in arid or semi-arid regions, and where irrigation water is rich in B content (more than 1-2 ppm B). Symptoms of toxicity B are yellowing of the tip of the leaf followed by gradual necrosis of the tip and leaf edges, which spreads towards the center (central vein). Leaves burn and may drop early Sarker, et al. (2002).

Chlorine

Chlorine (Cl) is absorbed in the form of the chloride anion (Cl^-). It is believed to be involved in the production of oxygen during photosynthesis, in raising the osmotic pressure of the cell and in maintaining tissue hydration. Some workers consider it only necessary for palm and kiwi fruits. Deficiency of chlorine leads to chlorosis in young leaves and generally wilting as a result of a possible effect on transpiration. Symptoms of chlorine poisoning are: Burning leaf tips or edges. Bronze. Premature yellowing of fall foliage; the poor quality of burning tobacco.

Copper

Copper (Cu) is taken as Cu^{2+}. It appears to be absorbed by the metabolism process. However, copper uptake is largely independent of competitive influences and primarily related to available copper levels in the soil. Copper is involved in the formation of chlorophyll and is part of many enzymes such as cytochrome oxidase. Up to 70 percent of the copper in plants may be present in chlorophyll, which is largely associated with chloroplasts. It is involved in lignin formation, protein and carbohydrate metabolism, and may be necessary for symbiotic N fixation. Copper is part of the plastocyanin, which forms a link in the electron transport chain involved in photosynthesis. Copper does not migrate easily in the plant and its movement is highly dependent on the state of copper in the plant. Symptoms of copper deficiency first appear in the form of narrow, twisted leaves and pale white tips. At maturity, clusters of flower / ears are poorly filled and even empty where deficiency is severe. In fruit trees, a retrograde death of the final growth can occur. In corn, yellowing occurs between the leaf veins, while in citrus the leaves appear mottled and there is death of new branches. Symptoms of copper toxicity are more variable with the species and less constant than symptoms of its deficiency. Excess copper leads to iron deficiency, so chlorosis is a common symptom Shamsi, et al (2010).

Iron

Plant roots absorb iron as Fe^{2+} and to a lesser extent as Fe chelates. For effective use of chelated iron, the iron must be separated from the organic binder on the root surface, after the Fe^{3+} has been reduced to the Fe^{2+}. The absorbed iron is fixed in the phloem. Iron is generally considered the most abundant micronutrient with a dry matter concentration of about 100 μg / g (parts per million). It plays a role in chlorophyll synthesis, carbohydrate production, cell respiration, chemical reduction of nitrates and sulfates, and in nitrogen assimilation. Iron deficiency begins first on the younger leaves. Other than that, the symptoms of its deficiency are somewhat similar to those of manganese, as both iron and manganese lead to a failure in the production of chlorophyll. Yellowing of areas between the leaf veins (commonly referred to as iron chlorosis) occurs. In severe deficiency, the leaves become almost pale white due to loss of chlorophyll. In the grains, alternating yellow and green stripes may be observed along the leaf blade. A complete fall of the leaves can occur and the buds can die. The toxicity of iron in rice is known as bronze. In this disorder, the leaves are first covered with small brown spots that progress to a uniform brown color. It can be a problem in very low paddy soils as flooding may increase dissolved iron levels from 0.1 to 50-100 mcg / g iron within a few weeks. It can also be a problem in very dry acidic soils and lowlands Franzen, & Richardson, (2000).

Manganese

Plants take manganese (Mn) as the divalent ion Mn^{2+}. It is known to activate various enzymes and act as an automatic catalyst. It is necessary to separate the water molecule during photosynthesis. It has certain properties similar to Mg. It is also important in nitrogen metabolism and in the assimilation of carbon dioxide. Like Fe, it is generally immobile in the phloem. Symptoms of manganese deficiency are similar to the symptoms of iron and magnesium deficiency, as chlorosis occurs between the veins in the leaves. However, symptoms of manganese deficiency appear first on younger leaves while in magnesium deficiency, old leaves are affected first. Manganese deficiency in oats is characterized by a "gray spot" where gray lesions appear on the leaf blade, but the tip remains green and the base dies and the deltoid may be empty.

In dicots (such as legumes), young leaves have yellow spots between the veins (somewhat similar to magnesium deficiency). Symptoms of manganese toxicity lead to brown spots, especially on old leaves, and uneven green color. Some of the disorders caused by manganese toxicity are: Wrinkled leaf spot in cotton. Leg line potato gnaws. And necrosis of the inner bark of apple trees Putwattanaa, et al. (2010).

Molybdenum

Molybdenum is absorbed as the MoO42-molybdate anion and its uptake is metabolically controlled. Mo is involved in many enzyme systems, especially nitrate reductase, which is necessary to reduce nitrates, and nitrogenase, which is involved in BNF. Hence, it is directly involved in protein synthesis and N fixation by legumes. Mo appears to be moderately moving at the plant. This indicates relatively high levels of molybdenum in the seeds, and that symptoms of a deficiency appear in the middle and older leaves. Molybdenum deficiency in legumes can be similar to nitrogen deficiency due to its role in nitrogen fixation. Molybdenum deficiency can cause marginal burns, leaf rolling or leaf cupping, and yellowing and stunting of plants. Citrus yellow spot disease and cauliflower tail flagellum disease is usually associated with molybdenum deficiency. Forages containing more than 5 µg / g of molybdenum in dry matter are suspected to contain toxic levels of molybdenum in grazing animals (associated with molybdenum disease) Campo, et.al. (2009).

Zinc

Zn is taken as the divalent Zn2 + cation. Early work suggested that zinc absorption was passive, but recent work indicates that it is active (energy dependent). Zinc is required directly or indirectly by many systems of enzymes and auxins and in protein synthesis, seed production, and ripening rate. Zinc is believed to enhance RNA synthesis, which in turn is necessary for protein production. Low zinc movement. The transfer rate of zinc to smaller tissues is particularly low in zinc deficient plants. Common symptoms of zinc deficiency are: Stunted plant growth. Poor tillering development of light green, yellowish, whitish spots; Yellowed bands on both sides of the middle muscle in monocots (especially corns); Rusty brown spots on leaves in some crops, which in severe deficiency of zinc as in rice may cover the lower leaves; And in fruit trees, the buds may fail to expand and young leaves may clump together at the tip into a rosette-type clump. The condition of young leaves is also a common symptom. Internodes short. Flowering, fruiting and ripening can be delayed. Buds may die and leaves may drop prematurely. Deficiency symptoms are not the same in all plants. Zinc toxicity can lead to a decrease in root growth and leaf expansion, followed by chlorosis. It is generally associated with tissue concentrations greater than 200 mcg / g zinc Putwattanaa, et al. (2010).

Beneficial Elements

Nickel

Ni is part of the enzyme urease, which breaks down urea in the soil. It also plays a role in transmitting disease resistance and is essential for seed growth. Information regarding various aspects of nickel as a micronutrient is gradually becoming available.

Silicon

Si is taken up as the unbound Si (OH) 4 monosilic acid. The predominant form of Si in plants is hydrated amorphous silica gel (SiO2 in H2O), or polymerized silic acid, which is immobile in plant. The beneficial effects of silicon on plants include increases in yield that can result from increased leaf erection, reduced habitability, reduced incidence of fungal infections, and prevention of manganese and / or iron toxicity. Hence, Si is able to counteract the effects of N elevation, which tends to increase housing. In lowland or wetland rice that is low in Si, vegetative growth and grain yield are severely reduced and deficiency symptoms such as necrosis of mature leaves and wilting can occur. Likewise, sugarcane suffers from reduced growth under conditions of low Si availability Ganesh, et al. (2009).

Cobalt

Co is the divalent Co2 + cation. It is necessary for nitrogen fixing microorganisms, regardless of whether they live freely or symbiotic. Co is the mineral component of vitamin B12. Consequently, Co deficiency inhibits formation of ligemoglobin, thus fixation of N2. The Co content in buds can be used as an indicator of Co deficiency in legumes, with critical levels being between 20 and 40 ppb dry weight of buds.

Plant nutrition

Plant nutrition is governed by some basic facts and principles regarding nutrient supply, absorption, and transportation and production efficiency.

Supply and demand for nutrients

Plants require nutrients in balanced quantities depending on their stage of growth and yield levels. For optimum crop nutrition, there must be an adequate concentration of individual nutrients in the leaves of the plant at any time. It requires an optimal supply of nutrients:

- Adequate available nutrients in the soil root zone;
- Rapid transfer of nutrients in the soil solution towards the root surface;
- Disease root growth to gain access to available nutrients;

- Unimpeded nutrient absorption, especially with a sufficient amount of oxygen;
- Pathological movement and nutrient activity within the plant.

The concentrations of nutrients required in plants, or rather in active tissues, are usually indicated on the basis of dry matter, as this is more reliable than fresh materials with their variable water content. The leaves usually contain higher nutrient concentrations than the roots. It is usually specified as a percentage of a macronutrient and in micrograms per gram (parts per million) for a micronutrient.

The law of the world and its effects

In plant nutrition, there is a law known as Liebig's law for minimum. It is named after its author, Justus von Liebig, who said that plant growth is restricted to less-supplied nutrients (in relation to plant need).

Absorption of nutrients per time and contents

The nutrient uptake pattern follows an sigmoid (S-shaped) curve in most cases, being low first in the early stages of crop growth, increasing rapidly when dry matter production is at its maximum and then decreasing toward crop maturity. During vegetative growth, the absorption of daily nutrients increases as growth progresses and reaches its maximum during the main growth period. N, P and K are mainly taken up during active vegetative growth to have high photocatalytic activity. The rate of nitrogen absorption generally exceeds that of dry matter production in the early stages. Phosphates have additional small peak requirements for early root growth. Modern high-yielding varieties of cereals continue to absorb phosphorous near maturity, as N, 70-80 percent of the absorbed phosphorus ends up in flower clusters or ear heads. For fast-growing, high-yield crops, the daily supply of nutrients should be adequate, especially during the period of maximum requirements. Field crops generally absorb potassium faster and then absorb N and P. In rice, 75 percent of the plant's K requirement can be absorbed up to the priming stage. Between tillering and worm initiation, average daily absorption rates can approach 2.5 kg K2O / ha / day. Unlike N and P, only 20-25 percent of the absorbed K is transferred to the grains, the remainder in the straw. During the last stages of growth as the plant approaches the stage of reproduction before maturity, the absorption of nutrients decreases. Perennial plants recover most nutrients from the leaves before they fall and transport them for future use. In some plants, such as jute, a large proportion of the absorbed nutrients is returned to the soil through defoliation before the crop ripens. While the total amount of the nutrient within a plant increases steadily, the concentration (percentage) of the nutrient generally decreases, even with a good supply Singh, (2001). The highest concentrations of nutrients are found in leaves in the early stages of growth, and lowest in leaves near harvest. This decrease in nutrient concentration over time is due to transfer to other organs and also the so-called dilution effect, which results from a greater increase in dry matter compared to the nutrient content. For example, young plants containing 50 kg K in 1500 kg of dry matter contain 3.3 percent Kelvin, but plants that approach flowering at 100 kg K in 5000 kg of dry matter have 2.0 percent K. The dilution effect makes interpretation of plant analysis results difficult, but it can be taken into account by relating plant data to a specific stage of growth.

Nutrient transport and its effect on deficiency symptoms

While nutrients are easily transported from the roots to the buds, redistributing them from the place of original deposition is more difficult for the so-called fixed nutrients. In the event of a lack of nutrients, partial reactivation is required to supply newly formed leaves from reserves of old leaves. The relative mobility of nutrients within the plant helps to understand the causes of the varied appearance of nutrient deficiency symptoms as discussed above. For example: Deficiency symptoms on old leaves indicate a lack of mobile nutrients because the plant can transfer some amounts of nutrients from old leaves to new leaves. The appearance of deficiency symptoms on younger leaves indicates a lack of non-motile nutrients due to a lack of supply from old to younger leaves.

The extent of nutrient supply from deficiency to toxicity

The nutrient status of the plant can range from acute deficiency to acute toxicity. A broad division of nutrient status into three groups which are deficient, ideal, and redundant may be beneficial for general purposes. To get a more accurate assessment of the nutritional status of plants, a detailed classification is required in six different ranges. Acute deficiency: is associated with pronounced symptoms and poor growth. Usually, the addition of the deficient nutrients increases growth and productivity. This range should be avoided as its occurrence is a sign of reduced nutrient supply or poor nutrient management and poor crop performance. Marginal or latent deficiency: This is a small scale with or without visible deficiency symptoms. However, growth and yield are reduced. Adding nutrients that reduce yield increases yield but this may not be visible. Perfect nutrition prevents hidden hunger. Optimal view: This is your target range. Here all the nutrients are at the required level. In this range, healthy green plants, good growth and high yields of good quality can be expected. This range is generally broad for most nutrients. The optimum width is reached above the critical concentration, which is generally related to 90 percent of the maximum output. The critical focus serves as a diagnostic indicator of nutrient supply through plant analysis. Luxurious Supply: Although there is no definite limit between optimal supply and luxury, it is beneficial to define this range of unnecessarily high supply of nutrients Singh, (2001). Even if there are no negative effects on the growth or yield of the plant, the nutrient input is wasted and the quality of the product may decrease as well as disease resistance especially in the case of excess nitrogen. Therefore, the consumption of luxury food should be avoided. In other words, the optimum width must be maintained and not exceeded except in special cases, such as the need to enrich the protein in the grains for quality considerations.

Marginal or mild toxicity (subtle): here the nutrient concentration shifts towards toxicity. Above the critical toxic concentration, crop and yield growth begins to decline due to the harmful effects of excess nutrients, or toxic substances, on biochemical processes and imbalances. As in the case of hidden hunger, there may be no symptoms. Acute Toxicity: This is the other end of over-supply or poor nutrient management. Plants are damaged by toxic levels, resulting in symptoms of toxicity, poor or no growth, poor yield, low quality, soil damage and plant health. The resistance of plants to disease may also decrease and the plant may die. This range should definitely be avoided for any feeders Loncaric et al (2007).

Nutrient interactions

It is not easy to fully provide plants with sufficient quantities of all nutrients, and the task becomes more difficult due to the numerous interactions between nutrients. On the one hand, nutrients have their individual specific functions as described above. On the other hand, there are also some common functions in addition to interactions. These can be positive or negative. When the nutrient interaction is synergistic (positive), their combined effect on plant production is greater than the sum of their individual effects when used alone. In a hostile (passive) reaction, their combined effect on plant production or tissue concentration is less than the sum of their individual effects. When they do occur, hostile reactions mainly occur due to unbalanced nutrient supply and substandard nutrient ratios for satisfactory growth and development. Therefore, from a practical point of view, many unwanted (negative) hostile reactions can be avoided by maintaining a balanced food supply. The safety of a nutrient management program can be judged from its ability to harness the benefits that accrue from positive interactions between nutrients and other production inputs. The synergistic advantage would have been lost and the nutrient utilization efficiency (NUE) would be reduced if only one nutrient was used and the other neglected. Positive interactions have a very high payoff for farmers, and research should enable all possible positive interactions for farmers to use and also tell them how negative interactions can be kept a safe distance from their fields Singh, (2001). The need to harness positive interactions will increasingly emerge as the intensity of agriculture increases and investments in inputs increase. “In highly developed agriculture, significant increases in yield potential will often come from the effects of interaction. Farmers must be prepared to test all new developments that may increase the production potential of their crops and be prepared to experiment with a mixture of two or more Practices. "

Root growth and nutritional absorption

Since plants mainly absorb nutrients through their roots, regardless of the type of plant, good growth and root reproduction are essential for efficient nutrient absorption. Root growth can be promoted or hindered by the physical and chemical factors of the soil. Even young roots should be able to penetrate the rooting volume in both the lateral and vertical directions. The bulk of the nutrients are absorbed from the root filaments, which are about 1-2 mm long and 0.02 mm wide. These are extensions of the epidermal root cells. The root hairs greatly expand the root surface area. Many plants grow several million of these hairs with a total length of more than 10 km. Since very close contact with the soil is required, the amount of fine roots is critical and the number and efficiency of the root hairs are also important. Many root bristles only last a few days, but this is sufficient to extract available nutrients from the volume of neighboring soil. As the main roots grow, new root hairs are formed and hence, there is a continuous exploration of soil volume to access available nutrients. Anything that affects root growth and vigor affects nutrient absorption.

Absorption of nutrients from the soil solution

The forms of nutrients available in the soil are free to move in the soil solution by mass flow or diffusion or up and down in the soil profile with the movement of water.The processes in the vicinity of the root hair. Nutrient acquisition depends on the size and smoothness of the root system, the number of root filaments, the capacity of cation exchange (CEC) of apparent free space (AFS) or apoplast, etc. Higher CEC results in increased absorption of divalent cations, especially Ca2 + (as is the case with legumes). The decrease in CEC increases the absorption of monovalent cations such as K +. The first step in absorption is the entry of the nutrient ion and its passage to the outer layer. Nutrients can enter the cell wall undisturbed. Due to their small size (aqueous K ions have a diameter of about 0.001 µm), they are able to penetrate into the cell wall tissue of root hairs. This tissue appears to be a free space, and hence it is called AFS or apoplast, which is a place that differs from the cytoplast (real cell substance).

The second step in nutrient uptake involves the movement of the nutrient ion into the cytoplast by crossing the membrane. Nutrients must be actively taken inside the cell. The energy required for this absorption is provided by root respiration, a process that requires oxygen from soil air and special absorption mechanisms. Thus, the absorption of nutrients by the roots can be active or passive: Nutrients can passively flow through the cell wall (AFS) of the root hairs along with the water. The free flow ends at the membrane surrounding the active cell material (the cytoplast).Nutrients are actively transported through the membrane by special ion transporters (ion carriers).Active absorption of energy needs from root respiration, which requires sugar and oxygen (O2).Cations are taken for H + and anions for bicarbonate ions (HCO3-) at the root surface.

Plants can choose nutrients preferentially

The fact that nutrient absorption is an active process explains some of its properties. Not only do plants accumulate nutrients against a concentration gradient, but they are also able to select from nutrients present on the root surface according to their requirements (preferential absorption). In addition, due to its ability to select, it can exclude unwanted substances or even toxic substances, but this ability to exclude is limited. After being absorbed into the cytoplast, the nutrients are transported to the following cells and finally reach the xylem, which is the tissue through which water and dissolved minerals travel up from the roots to the stem and leaves. They move to leaves in water transport vessels where they are used in photosynthesis and other processes.

Absorb nutrients from leaves

Aside from the gaseous forms of the nutrients (CO2, SO2, etc.), leaves are able to absorb nutrient ions (Fe2 +) or even molecules (urea). Although the outer layer of the leaf cuticle closely protects the plant from water loss, nutrients enter the leaves either through stomata, which serve to exchange gases, or mainly through the tiny pores of the epidermis and in stroke. Nutrients are applied to the leaves through dilute solutions so that the leaf cells are not damaged by the osmotic effects.

Effective use of nutrients

Most sources of nutrients added to soil involve financial expenditures, and therefore, they should be used, as much as possible, during the vegetative growth period in order to obtain a fast yield. Some of the remaining effects during the next season should be acceptable, but losses must be kept low. The size and duration of the residual effect depends on the nutrients, soil properties and crop density. A balanced and adequate supply of plant nutrients is important to achieving a high degree of nutrient utilization by crops, which also results in reduced losses. In a broader sense, efficient use of nutrients can only be achieved by looking at the entire production system. Plant nutrition must be integrated into all aspects of crop management. This requires the INM to become fully effective.

Optimizing plant nutrition

General Aspects

The goal of optimum plant nutrition is to ensure crop plants have access to adequate amounts of all phytonutrients needed to produce high yields. Nutrients must either be present in the soil or provided through appropriate sources in quantities and forms suitable for use by plants. Soil water must be able to deliver these nutrients to the roots at rates high enough to support the rate of uptake, subject to differential demand at different stages of plant growth. Optimum plant nutrition should ensure that there is no nutrient deficiency or toxicity and that the maximum possible synergy is between nutrients and other production inputs.

It may not be easy to achieve the ideal state of ideal plant nutrition in open field. However, it is possible to approach it through the dependence of nutrient application on soil fertility status (soil testing), plant analysis, crop characteristics, production potential, and finally the practical and economic application of this approach. The correct choice of nutrient sources, timing, and method of application are just as important. Ultimately, farmers should be able to maximize their net return on investment in all production inputs including nutrient sources. In many countries, farmers do not have the financial resources or access to credit in order to fully implement the set of inputs free of the recommended constraints. Thus, for optimum plant nutrition to be of value to most growers, it must also aim to maximize the benefit at different levels of investment. Despite all the theoretical and practical progress towards efficient crop production, it still depends on some uncontrollable and unexpected factors, and on interactions between nutrients and inputs. Decisions regarding fertilization are usually based on certain assumptions of future events, for example weather conditions, which may be assumed to be normal but may not be. Due to general uncertainty, many underlying data can only be roughly estimated. Thus, some errors in estimation are inevitable - neither by farmers who toil at low yields nor by those seeking high yields, not even in scientific experiments, observations and advice. From a farmers' point of view, improving nutrient supply appears to be challenging given the many aspects of nutrient supply, uptake, requirements and utilization efficiency. This is facilitated by improving soil fertility overall, which means, to a large extent, not only an uninterrupted ideal food supply but also generally favorable preconditions for its efficient use. Therefore, extension personnel and growers are advised to keep the fertility of their soils in good working condition and to constantly improve it Singh, et al (2001).

Balanced crop nutrition

Feeding balanced crops

Plants need an adequate supply of all macronutrients and micronutrients in a balanced proportion throughout their growth. The basics of balanced fertilization are governed by Liebig's Minimum Law. Previously, it was rightly concluded that in many soils, the use of nitrogen without a simultaneous supply of phosphate and potassium is meaningless. Today, in light of the lack of multiple nutrients and the increasing costs of crop production, fertilizing with nitrogen or nitrogen without ensuring adequate supplies of all other restricted nutrients (S, Zn, B, etc.) is meaningless and, in fact, becomes unproductive by reducing efficiency Nutrients to be applied.

Therefore, in view of the widespread deficiency of other nutrients, the scope and content of the same balanced fertilization has changed. It now includes the deliberate use of all these nutrients that the soil cannot provide in sufficient quantities to produce an ideal crop. There is no established prescription for balanced fertilization for a specific soil or crop. Their content is crop and site specific, hence the growing focus on SSNM. SSNM's approach to rice production systems is in different stages of development in many countries, for example China, India, Indonesia, Philippines, Senegal, Thailand and Viet Nam. With special reference to irrigated rice, the SSNM approach includes the following steps: A field-specific estimate of potential local supplies of N (INS), P (IPS), and K (IKS) and diagnoses of other trophic disorders in the first year. Field-Specific Recommendations for NPK Use and Mitigation of Other Nutritional Problems.Optimizing the quantity and timing of N.'s application. Decisions regarding timing and segmentation of N applications are based on: (1) 3-5 applications segmented according to season-specific agricultural rules tailored to specific sites; or regularly monitor the plant's N status up to flowering, using chlorophyll scale or leaf color charts Loncaric et al (2007).

Estimate the actual grain yield, straw returned to the field, and the amount of fertilizer used. Based on this, the input-output balance P and K is estimated and used to predict the change in IPS and IKS resulting from the previous crop cycle. The predicted IPS and IKS values are then used to develop fertilizer recommendations in the subsequent crop cycle. All other factors are optimal; any deficiency of one phytonutrient will severely limit the efficiency of the other nutrients .An unbalanced nutrient supply causes the extraction of soil nutrient reserves. It can also lead to a loss of supplied nutrients, such as N, by reducing their rate of use. Also, the unbalanced availability of nutrients encourages the luxury consumption of the nutrients that are supplied in excess. This reduces the production efficiency of all nutrients applied. Unbalanced fertilization is ineffective, uneconomic, and wasteful and should be avoided. Balanced feeding of crops is not the same as balanced fertilization. The latter should make the former possible. For example, poor soil should be fertilized with equal amounts of nitrogen, phosphorous and potassium with these three nutrients in balanced quantities. This can best be done using soil test data and crop removal. When the soil is rich in a single nutrient, fertilization should be directed to the deficient nutrients in order to make balanced crop nutrition possible. Thus, the goal is not balanced fertilization as such but balanced nutrition of crops through the application of balanced nutrients in order to supplement those nutrients which are deficient in the soil.

Crop nutrition in relation to yield

Optimum feeding requirements depend largely on the type of crops grown and the yield level to be achieved. The level of expected yield largely determines the amount of external food input needed. It is not the yield per se that determines this, but the amount of nutrients removed from the field along with the yield and efficiency .Of the applied nutrient. Sometimes the replacement of nutrients removed at a certain crop level is used to keep the soil fertility in the constructed soil to the desired level. Here, two sets of criteria for fertilizer use are used, one for fertility accumulation, and the other for fertility preservation, specifically in the case of P. As yield targets rise, the "basket of nutrients" the crop requires becomes more diverse and complex. The soil may have sufficient fertility to support a yield of 2 t / ha but may not be able to support a yield of 5 t / ha on its own. At high yields, it is not simply a matter of saving N or NPK. This was already observed in many intensely cropped areas which, in the early 1960s, only needed N. Over a period of time, it became necessary to apply N + P, then N + P + K or N + P + Zn. Many regions now require the application of at least five nutrients (N, P, K, S and Zn) from outside sources in order to maintain high yields. This is well illustrated by the example of nutritional needs for increasing tea yield levels in South India. The principle is the same for all crops, except that the range of nutrients differs Loncaric et al (2007).

Prevention of excessive fertilization

Excessive fertilization or excessive fertilization is a waste and should be avoided. It conflicts with the concept of improving crop nutrition and also reflects the misapplication of scientific findings and unprofessional marketing practices. It can also have negative impacts on the environment. When using high rates of water-soluble fertilizers on crops, transient salt damage to the roots of small, delicate plants should be avoided. Moreover, an excessive or excessive supply of a single nutrient can create adverse effects that upset the nutrient balance. For example, high doses of K reduce magnesium absorption even when there is a satisfactory supply of magnesium. Over-fertilization not only reduces crop yields and production quality, but also produces suboptimal economic returns. The optimum utilization rate of a nutrient can be seen as a stopping point that should not be crossed in most cases. A grower can continue to benefit from sub-optimal application rates although the benefit is always less than optimal. In this respect, fertilizers and other nutrient carriers differ from inputs such as pesticides, which must be used in a certain critical dose to be effective. Thus, nutrient use is more flexible, similar to water use, in that it enables farmers to operate at a wide range of rates based on their resources and availability of inputs. While excessive fertilizing with nutrients such as P can produce significant residual benefits for the next crop, excessive use prevents farmer's capital unnecessarily. Over-fertilizing with N always results in lower nitrogen utilization efficiency, greater habitability, attack of pests and diseases, greater nitrogen losses and negative impacts on the environment. Over-fertilizing with micronutrients can poison them, which in many cases is difficult to dilute.

From fertilization to integrated nutrient management (INM)

Due to the widespread use of fertilizers containing N, P, and K and their effectiveness in increasing crop yields worldwide, the term fertilization has become synonymous with the use of commercial NPK fertilizers. This is a rather narrow and outdated concept that does not do justice to the broad scope of plant nutrition or impacts related to unwanted environmental impacts. Although fertilizers have benefited from more regular and clear production and marketing, there are other effective sources of phytonutrients. It includes crop residues, organic fertilizers, various recyclable wastes and bio-fertilizers. Farmers all over the world have been using organic fertilizers for a very long time.

Definition

Although the term fertilization still has a place to describe the actual supply of nutrients to crops, it is now gradually being replaced by the broader concept of Integrated Plant Nutrition System (IPNS) or INM. Fertilizers are and will be a key component of INM to produce high yields of good quality on a sustainable basis in many parts of the world. The basic concept behind IPNS / INM is to maintain or adjust soil fertility / productivity and optimum plant nutrient supply to maintain the desired level of crop productivity. The aim is to achieve this by optimizing the utilization of all potential sources of plant nutrients, including locally available sources, in an integrated manner while ensuring environmental quality. This provides a crop feeding system in which plant nutrient needs are met through pre-planned integrated use of the following: mineral fertilizers; Organic fertilizers / fertilizers (such as green fertilizers, recyclable waste, crop residues, and FYM); And vital fertilizers. The appropriate combination of different nutrient sources will vary according to the land use regime and the environmental, social and economic conditions at the local level.

The need for INM

The need to adopt a broader concept of nutrient use that goes beyond and does not exclude fertilizers is caused by many changing conditions and developments. Here they are: The need for more rational use of phytonutrients to improve crop nutrition through balanced, efficient, yield-oriented, site- and soil-specific nutrient supply. Mainly switching from the use of mineral fertilizers to formulations of organic and mineral fertilizers obtained on and off the farm. Shifting from providing nutrition based on individual crops to optimal use of nutrient sources on the basis of a crop system or on the basis of crop rotation. Shifting from studying the direct effects of fertilization (nutrient effects in the first year) to long-term direct effects in addition to residual effects. To a large extent, this is also achieved when crop feeding is based on a crop system rather than on a single crop basis.

Transition from fixed nutrient scales to nutrient fluxes in nutrient cycles.

An increasing focus on monitoring and controlling unwanted side effects of fertilization and potential negative consequences for soil health, crop diseases, and water and air pollution. Shifting from managing soil fertility to managing total soil productivity. This includes improving problem soil (acid, alkaline, solid, etc.) and taking into account the resistance of crops to stress such as drought, frost, excess salt concentration, toxicity, and pollution. Shifting from exploiting soil fertility to improving or at least maintaining soil. Shifting from neglecting on-farm and off-farm waste to an efficient use through recycling.mThese achievements have expanded the concept of fertilization to one of INM, in which all aspects of the optimal management of plant nutrient sources are integrated into the crop production system. To develop INM practices, cropping systems rather than a single crop, and farming systems rather than a single field, is the focus of attention. In contrast to organic farming, INM includes a needs-based external input approach, taking into account a holistic view of soil fertility. One of INM's goals is to obtain high yields and good product quality - in sustainable agriculture with practically no adverse effects on the environment. INM offers great potential for saving resources, protecting the environment and promoting more economical crops. Moreover, the National Institute of Farm Management works to improve the productive capacity of the farm through the application of external plant nutrient sources and modifications, efficient treatment and recycling of crop residues and organic waste on the farm. It empowers farmers by increasing their technical expertise and decision-making ability. It also encourages changes in land use, crop rotation, and interactions between forest, livestock and crop systems as part of agricultural intensification and diversification. INM includes risk management (risk reduction) and promotes synergies between crop, water and plant nutrition management.

While accrediting INM, special attention should be paid to the sources of nutrients that may be mobilized by the farmers themselves (fertilizers, crop residues, soil reserves, BNF, etc.). Reducing losses and replenishing nutrients from both internal and external sources is of great importance. While INM strives for the integrated application of diverse inputs, the use of organic sources cannot replace the use of mineral fertilizers. Although the effects of organic inputs go beyond the nutritional aspects, by contributing to improving the physical properties of the soil and improving the efficiency of fertilizer use, recycling of organic matter is not sufficient to completely replenish the nutrients removed by harvesting the crops. Therefore, it is necessary to increase the use of mineral fertilizers and increase their effectiveness in most developing countries in the medium term. In countries where a broad concept of crop feeding beyond fertilization has been recognized, many INM guidelines have already been considered but have not been widely adopted. In countries with intensive crop production where modern codes of good agricultural practices have been accepted, there is a trend towards better plant nutrient management or integrated crop management systems. This results in more efficient use of nutrients, which partly leads to lower fertilizer inputs - even if that means a slightly lower yield.

Optimizing Crop Nutrition

Initial soil fertility status

The application of balanced nutrients is a major controllable factor to improve crop nutrition in any field.

Information on what nutrients to apply and at what rates should be based on a good soil test report. It is assumed that soil testing has already been verified by a high degree of association with the crop's response to the use of the respective nutrients. Nutrient use rates can be based on soil tests for a single optimum crop level or pre-defined crop targets. Usually the optimum level of return is the maximum return of profit and not the highest return that can be achieved in itself. Thus, information on soil fertility status as stipulated in soil testing data is an essential piece of information to optimize crop nutrition for most nutrients, with the possible exception of N. in the absence of reliable soil tests to apply N and N in many advanced applications. Agricultural areas are improved based on soil characteristics and growing conditions and nitrogen removal of crops at expected production levels. Soil testing as a tool to estimate the nutrient status of available soil remains problematic despite more than 60 years of extensive research. Analysis of North American experience shows that even the best soil test titrations account for less than one-third of the variance in crop response to added nutrients. This has implications for improving nutrient application rates. Factors such as soil texture, yield potential, specific weather conditions and differences between crop varieties make it difficult to obtain a clear relationship between soils. Acidic tropical soils represent a large mass of arable soil. Their management strategies should accomplish the dual task of neutralizing excess acidity (making the soil shape fit for plant roots) and correcting nutrient deficiencies.

Soil problem improvement

Among the many problem soils, acidic and alkaline soils are mentioned here as examples. Improving soil problem is a prerequisite for improving plant nutrition. This is because such soils cannot make the most of the nutrients applied in the absence of appropriate amendments. In fact, soil amendments must precede the application of nutrients. Once the soil is amended, the crops grown on it can make effective use of the applied nutrients and high yields can be obtained on a sustainable basis.

Alkaline soil amendment

Alkaline soils can be modified with several materials. Gypsum is the most widely used modification. The main purpose of these modifications is to remove excess exchangeable sodium from the root zone, thus also improving the physical properties of the soil. Once the soil is amended, rates close to the normal range of nitrogen (120-150 kg N / ha) can be applied to rice or wheat. In the first years after extraction, optimum yields can be obtained using nitrogen and zinc. Many alkaline soils contain a high level of soluble phosphorous, so phosphorous application is only required after several (5-10) years depending on the yield. Green fertilization of such soils is beneficial for improving plant nutrition and maintaining productivity. Without improving such soil, yields are low and nutrient utilization is wasted. Knowledge of crop tolerance to alkalinity can be applied advantageously to select crops most suitable for such conditions. Table 26 summarizes the relative tolerances of several crops to exchangeable sodium ratio (ESP). A sound strategy to improve the use of phytonutrients in such soils is to treat the soil with appropriate amendment and to choose a crop variety that is tolerant to salt. Choosing a tolerant crop is also beneficial as the soil cannot be amended enough. Amending acidic soils creates favorable conditions for better plant nutrient utilization by neutralizing excess acidity and improving the availability of several key nutrients and micronutrients. As a rule, soil amendment, in this case, should be preceded by the application of compost. Without soil acidity correction, no amount of balanced nutrients can result in a high yield or superior NUE. Thus, plant nutrition is an ingredient, not a substitute for good management. In many cases, investing in expensive fertilizers may lead to very small returns or even result in a loss soon after the initial success. The results of a long-term field experiment in acid alluvial red soil in Ranchi in eastern India clearly demonstrate this (Sarkar, 2000). In this field experiment, which began in the mid-1950s, plots were treated with N, N + P, N + P + K, or N. P + K + liming.

Nutrient recovery by crops and nutrient removal

An assessment of food additives, removals and balances in an agricultural production system yields useful practical information about whether the nutrient status of the soil (or area) is being conserved, accumulated or depleted. It also gives insight into the level of fertilizer use efficiency and the extent to which the crop absorbs the externally added nutrients and is used to produce yields. It can also warn of nutrient deficiencies that may worsen in the coming years and need attention. Most stocks in this figure also include nutrient recycling to varying degrees. For example, on the input side, a portion of the mineral fertilizers, especially N, S and K, can leak out, but can be recycled to the extent that the groundwater is pumped out for irrigation. At a higher level, nutrient loss in one field can become a food gain for another field (and for the farmer). Nutrients from the compost can enter the plant after mineralization. Atmospheric deposits (N and S) originate from N in air, gaseous losses and pollution. Likewise, inputs are often brought in through sedimentation by erosion from higher levels (outputs), and in many cases, they are actually transfers between sites (30 percent of soil and nutrients transported by water erosion ends up in the sea, and the remainder 70 percent stay on Earth).

The harvested crop fractions and crop residue yield valuable organic manure. Most estimates of nutrient removal by crops (from the soil) are overestimated because nutrient removal often equates to nutrient absorption. This is not the case in many cases. The proportion of nutrients ingested that constitute nutrient removal can vary from less than 10 percent (as in cardamom) to about a third (as in coffee) to as much as 90 percent as in many field crops when Leave only roots and roots behind. The feeder input and output estimates allow for the calculation of nutrient scales for both individual fields and geographic regions. It is a bookkeeping process, similar in many ways to maintaining a bank account. The extent of nutrient removal processes from the soil system can provide useful information to improve crop nutrition.

Nutrient uptake and removal

At harvest time, plants contain large amounts of nutrients in plant parts such as grains, hay, stems, beets, tubers, and fruits, but only a small portion is found in the roots. Depending on which parts of the plant are harvested and removed, the nutrients in them are removed from the field. In many developing countries where cereal crops are harvested manually, all nutrients in grains, hay or firewood can be removed from the field. In the case of green manure crops, all the plant nutrients in the biomass are returned to the soil and no nutrients are removed, except in cases where the legume pods are removed for consumption. Indeed, net soil fertilization occurs due to the contribution of BNF in the case of legume green manure. The balance sheet of feeders. Nutrient removal data are more useful when calculated on the basis of a single basic unit of harvest, for example 1 ton of grain or 1 ton of straw, so that the total removal at a given crop level can be easily calculated. Intermediate elimination data are helpful when nutrients are not absorbed in excess. When there is fancy nutrient consumption, the corresponding elimination data can be misleading. In intensive cultivation, the N and K data tend to be biased up due to this factor. Therefore, larger amounts can be determined to replace nutrient removal processes.

Nutrient uptake

The nutrient removal data reported in the literature for the same crop can vary widely. Table 28 presents some average nutrient removal data. These are primarily based on North American conditions. Nutrient removal data for Indian conditions, which are representative of tropical and subtropical regions, are presented in Tables 29 and 30 for general and comparison information. This data relates to absorption per ton of major products and includes nutrients found in by-products as well. A large proportion of nitrogen in legumes (legumes, soybeans, peanuts, forages, etc.) arises from BNF, assuming a satisfactory level of nodules and stabilization of N.

Crop nutrient uptake can range from less than 50 kg / ha to over 1000 kg / ha depending on yield, variety, nutrients, availability, growing conditions and the biomass produced. The major nutrients make up the bulk of the nutrients eaten. For example, the total amount of nutrients absorbed by wheat and rice (rice) per ton of grain production is about 82 kg and 74 kg respectively. Of this, N and K2O alone account for about 75 percent. On a component basis, S absorption is generally similar to that of P. The combined six micronutrients add up to about 1 kg / ha. Higher yields through higher crop density also greatly increase nutrient absorption, which can range from 400 to 1000 kg N P2O5 + K2O / ha / year. The share of N, P2O5, and K2O in nutrient uptake is generally 35 percent N, 17 percent P2O5, and 48 percent K2O, in the ratio 1.0: 0.5: 1.4. Thus, each ton of nitrogen is removed accompanied by removal of 0.5 tonnes of P2O5 and 1.4 tonnes of K2O on average. In addition to the main nutrients, a grain production level of 10 tons / ha through the rotation of rice and wheat (6 tons of rice + 4 tons of wheat) can absorb about 3-4 kg of iron or manganese, 0.5 kg of zinc, 200- 300g of copper or B but only 20g of Mo. Thus, at the same production level, the yield absorption can vary between nutrients by more than 10,000 times (260 kg K vs 20 g Mo). Within the same group of micronutrients, the absorption of iron and manganese can be 200 times that of Mo. To produce a successful crop, the crop must be able to reach and absorb the specified nutrients whether it is 150-200 kg of N, K2O, or 15-20 gmU. A crop's nutrient absorption depends on a large number of factors, whether controllable or otherwise. This is why there are large differences in a specific nutrient or crop even under similar conditions. Nutrient absorption can vary due to differences between crops, the genotype of the variety, the environment in which it grows, field fertility level, yield level, welfare consumption, nutrient imbalances, and post-absorption events such as habitation and leaf fall. Thus, for the production of one ton of grain, the uptake by a given yield can vary 1.7 times in the case of N, 2.3 times in the case of P and 3.6 times in the case of K between sites Arao, et.al. (2003)..

Fate of nutrients absorbed by crops

The nutrients consumed by the crop are distributed in different parts of the plant during its life time. In the case of cereal crops, 70-75 percent of nitrogen and phosphorus, 25-30 percent of potassium and 40-60 percent of absorbed S ends up in cereals, the rest remaining in straw / fermented. In rice, more than 70 percent of N absorbed is transferred to grains while a greater proportion of K, Ca, Mg, Fe, Mn and B remains in straw. The absorbed S, Zn, and Cu are evenly distributed in grains and straws. In peanuts, of the nutrients absorbed, the kernels contain 41 percent of N, 52 percent of phosphorous, 28 percent of potassium, 11 percent of magnesium and 1 percent of calcium. Leaves and stems contain 45-50 percent of the total NPK absorbed as well as the bulk of calcium and magnesium. In potatoes, the harvested tubers account for 80, 83-88 and 70-78 percent of the total N, P and K absorbed, respectively. In cassava, the nutrients absorbed in tubers is 23 percent nitrogen, 32 percent phosphorous, 38 percent potassium, 12 percent calcium, 11 percent calcium, and 29 percent magnesium .. In jute, the percentage of absorbed nutrients that return to the soil prior to harvest through leaf fall is particularly high. In tea, 50-65 percent of the absorbed N, P, K, and Mg are removed from the field. The number is around 35 percent for calcium, 25 percent for manganese and 25-50 percent for all the rest. In coffee, nutrients are removed according to the order: K> N> P> Ca> Mg> S. Grains remove one-third of the nutrients absorbed by the plant and the remaining amount is retained in the plant's biomass. Significant differences in nutrient absorption were observed between the Arabica and Robusta coffee varieties. In coconuts, the bulk of the nutrients absorbed ends up in nuts, leaves, and plants. Nuts alone account for 51 percent of nitrogen, 50 percent of phosphorus, 78 percent of potassium, 23 percent of calcium, and 41 percent of magnesium absorbed by the West Coast Tall cultivar (Bellay & Davis, 1963). In rubber, 25 percent of N, 33 percent of P2O5, and 8 percent of K2O absorbed through latex are removed. A large percentage of the absorbed nutrients are returned to the soil through leaf litter. In cardamom, less than 10 percent of the nutrients absorbed in the capsules are carried. In tree crops, large amounts of absorbed nutrients are retained in the trunk and branches. For practical purposes, these nutrients may be considered removed from the soil. These and other data underline the point that nutrient removal cannot equate to nutrient absorption, as is often the case for estimating nutrient removals and calculating balance sheets. Although the final economic output contains only a portion of what the crop absorbs, the overall need for the crop must be met by the soil and through external additives to improve plant nutrition. When crop residues are left in the field, the nutritional content of the residues (despite being part of the uptake) does not constitute removal. When crop residues are removed, they may be lost forever or returned in the form of animal manure / FYM as it is used to feed farm animals. The heavy losses from erosion highlight the need for large-scale soil and water conservation measures to reduce soil nutrient depletion. However, in many cases, these can be nutrient transfers between sites.

Crop recovery of added nutrients and their implications

The amounts of nutrients added through fertilizers and other sources are only partially used by the crop. There are four possibilities for what might happen to the added nutrient:

- Enter the set of available forms and are absorbed by the fertilized plants (the recovered part).
- It is not absorbed but remains available and is partially used by the next (remaining) crop.
- They are "persistent" and therefore removed from the nutrient cycle for longer periods.
- Lose from soil (through ammonia volatilization, filtration, and denitrification in the N state).

The recovery rate or utilization of the nutrient applied is part of the added nutrients that the plants take in. It is expressed as a percentage of the provided nutrient intake. A 50 percent recovery means that half of the fertilizer nutrients used have been used by the fertilized crop. The recovery rate for the applied nutrients is often high for potassium (up to 70 percent), medium for nitrogen (35-70 percent), relatively low for phosphorous and phosphorous (15-30 percent) and very low (less than 10 percent) for micronutrients. The nutrient recovery rate is an important indicator of fertilizer use efficiency although it may sometimes include the consumption of luxuries. The data on this topic are variable because recovery is influenced by soil, crop growth, root characteristics and production conditions. Nutrient recovery data are approximate with inherent differences. Moreover, the applied nutrient recovery rate can be seen with reference to different time periods, such as a specific growth period of a crop, a single-crop basis, or a crop rotation basis or for several years, as in the case of phosphorus and some micronutrients. The recovery rate also depends on the extent of the soil's nutrient supply, that is, whether the soil is defective or well-supplied. Moreover, a distinction must be made between true recovery and apparent recovery. Isotopic method (direct measurement): also requires an experiment, but recovery is only determined on one plot of land by isotope labeling of compost feeders in order to distinguish compost nutrients from soil nutrients. (For phosphates, the specific activity is the isotope ratio of 32P / 31P. The isotopic method is based on the assumption that fertilization does not affect the absorption of nutrients from the soil. However, this may not be entirely true. The fraction of nutrients absorbed from the soil may be reduced by fertilization in many cases and increased in others due to the so-called "primer effect", so that the method indicates a value higher or lower than the actual value. To date, no method has been developed for determining "true" values for nutrient recovery used by crops Arao, et.al. (2003).

P fertilizer application rate in the first year can be as high as 25 percent, especially with row placement for broad-spectrum crops, but only 10 percent or less with PR applied in unfavorable soil conditions or with a broadcast application. The rate of P use increases in the long term taking into account residual effects. When the fertilizer P application rate is 15 percent in the first year, the residual effect in the second year is about 1-2 percent, and about 1 percent in the following years. Cumulative values for longer periods are: about 25 percent for 10 years; And about 45 percent for 30 years. For very long periods of time recovery may approach 100 percent. Most farmers do not want to wait that long to adjust nutrient use rates even though this results in a long-term accumulation of nutrient capital for the soil. For K fertilizer, the first year utilization rate is around 50-60 percent but the long term rates are higher. The recovery rate of micronutrients applied to the soil is very low, and for nutrients such as copper and zinc, single use can be continued for several crops. The evaluation of the recovery rate over very long periods is meaningful only in relation to the outward use (as described below). The use of fertilizers on well-supplied soils is generally less than the use of weak soils, at least in the first year. This is because the soil already contains enough nutrients for the plants, and fertilization essentially replenishes the reserves Loncaric et al (2007).

Fertilizer amounts required according to nutrient removal and recovery

Optimal fertilization should be based on crop removal data in the case of nutrients such as N for which reliable soil testing methods are not available. There should be a requirement to deduct consumption of luxuries from the nutrient removal data, and effort should be made to strive for a high percentage of added nutrient recovery. The consumption of luxuries is particularly suitable for N and K but less important for P, S, Mg, etc. The best way to optimize the use of nutrients that have a significant residual effect is to administer them on a crop rotation basis. Fertilization on the basis of removing micro-nutrients in deficient soil is not recommended due to its extremely low application rate. The application of these nutrients should be based on the available nutrient status of the soil and the period during which a single application can have significant residual effects (so that applications of micronutrients are not repeated every year). For nutrients in which the soil application is not very effective (such as iron and manganese), the amounts required for foliar applications or in terms of chelates can be calculated Johnson, (1984).

Nutrient accounting via input/output balances

Sustainable crops should not deplete the soil's supply of nutrients but rather improve it to the extent possible. The extent to which this advice is followed depends on the farmer's perception of sustainability and the resources available to purchase the fertilizer. This is also an area where INM can play a role by enabling the farmer to recycle all organic waste available on the farm and off the farm. Quantitative knowledge of soil plant nutrient depletion may be helpful in developing nutrient management strategies. Nutritional balance exercises serve as tools to provide indicators of the sustainability of agricultural systems. The nutrient budget and nutrient balance methodologies using different approaches to different situations have been applied widely in recent years at a variety of scales: plot, farm, regional, national and continental. In agricultural developed countries, a farmer can check whether inputs by fertilization are compatible with nutrient removal in order to maintain soil fertility. At the farm level, the amounts of nutrients taking off the farm can be used as a benchmark for proper nutrient management. The inputs of both the sources of phytonutrients and the phytonutrients in the animal feed must correspond to the removal of nutrients by the crop and in the exported animal products. The input / output flows of plant nutrients (N, P and K) in a farm measured at the farm gate for purposes of equilibrium calculation. In this case, the nutrient losses and BNF are not shown. A farmer can make such calculations with the help of standard tables containing nutrient concentrations from fertilizers and forages. This account also provides information about unaccounted losses, which are required by some fertilizer laws in light of environmental pollution. The problem with this calculation is that the unaccounted differences may not only be caused by losses but also due to soil fertilization. Such exercises can be conducted by educated and knowledgeable farmers who maintain accurate record keeping of various inputs and outputs. Even so, they can benefit from consulting a local farmer's advisor or extension professional Johnson, (1984). When the nitrogen input is much greater than the nitrogen output, this indicates a low level of nitrogen use efficiency, which could be the result of large or small losses associated with enrichment of soil nitrogen reserves. When the output exceeds the input, there must be a significant gain from BNF or from depletion of N soil reserves. Phosphorous: In intensive crop cultivation, the optimum input for phosphorus is greater than phosphorous yield due to the low phosphorous utilization efficiency due to mineral and organic enrichment in the soil. This should be seen as a long-term positive effect. This enrichment or phosphorus accumulation could contribute to the nutrition of several crops respectively. This also has implications for the economics of P application .Potassium: The K balance depends to a large extent on the application rate of N and K, any fancy consumption of K, utilization of K soil reserves (especially from the non-exchangeable fraction) and K losses. K losses are a possibility in coarse soils under heavy rainfall. Calcium, Magnesium and Sulfur: Magnesium balance is similar to K balance, except for neutral and alkaline soils where Mg may be abundant. Ca homeostasis is generally considered of little benefit. The S equilibrium tends to be negative if the addition of sulfates from air or irrigation water is not included, or S-free fertilizers are used especially for crops requiring high S, such as oilseeds and forages. Micronutrients: Balancing micronutrients is illogical because their availability is of great importance (not any input / output account). However, in most cases, the nutrient balances for micronutrients are positive due to the low efficiency of nutrient utilization applied by crops (similar to P) Arao, et.al. (2003)..

Influence of soil water on crop nutrition

Soil moisture conditions have major impacts on productive processes such as accessibility, availability, absorption and utilization of soil nutrients for crop growth as well as on negative processes such as creating anaerobic conditions, loss of nutrients from the soil.

Water supplies

Soil water content available has a noticeable effect on many aspects of nutrient supply. Every soil has a specific WHC. This is the upper limit of the available water and depends on the depth of the profile, the soil texture and the organic matter content in the soil. Irrigation / precipitation over the WHC is a waste as the excess water is lost via runoff or drainage. Available water falls between the field amplitude and the point of wilting. Since adequate (but not excess) soil moisture leads to profuse and deeper root growth, both water and nutrients become within reach of plants from deep layers of soil where moisture is adequate. Where dry conditions restrict water uptake, for example during droughts, the rate of root extension decreases in soils of low fertility and the plant cannot reach deeper moist horizons in the soil. In most soils, the nutrient content is highest in the topsoil and this horizon dries up first. Although the plant is able to absorb some water from the ground, this may not be sufficient to obtain adequate nutrients for active growth. Phosphates play a major role in the growth and spread of the root system. When the soil is well supplied with phosphates before planting, the plant can develop a strong, deep root system before the onset of a mid-season drought. Even when the topsoil becomes dry, these roots are able to absorb water and nutrients from the deeper layers. In such cases, the application of phosphates can be considered as an insurance against dehydration. Not only does it increase crop growth, but it also allows more efficient use of stored soil water that would otherwise be out of reach of underdeveloped roots Russelle, & Birr, (2004).

Availability of water and nutrients

Soil moisture affects solubility and thus the availability of all nutrients. Biological activity in soil is particularly restricted under very wet (due to lack of oxygen) or very dry conditions. Under extremely dry conditions, the breakdown of organic matter slows down and with it the mineralization of organic forms of nitrogen and other nutrients into forms of minerals available to the plant. This may lead to a temporary shortage of nitrogen in the soil. Thus, in periods of severe drought, a slight accumulation of minerals occurs N. When it rains, there can be a large influx of mineralization, providing available nitrogen and other nutrients for plant growth, provided that subsequent downpours (as received during monsoons) do not leach out of the mineral nitrogen outside the root zone. Irrigation use can reduce fluctuations in soil biological activity during crop growth. An important effect of irrigation or moderate rainfall is to increase the supply of nutrients to the soil from organic sources. However, these increases are rarely sufficient to meet the additional nutrient demand resulting from increased plant growth. The mineralization of other nutrients such as P and S also increases with adequate soil moisture Russelle, & Birr, (2004). The availability of the mineral potassium (K +) and other cations was also improved by satisfactory soil moisture condition. In dry soil conditions, cations are generally more bound to colloids, and are not easily replaced, and therefore less available, or difficult to reach, to plants. In addition, because the volume of the soil solution is smaller, the amount of soluble nutrients, such as P, is reduced slightly, and the plants are unable to absorb them in the required quantities. In water-saturated soils, the concentrations of ammonium ions, P, Fe and Mn increase, but the nitrate-N content decreases due to leaching and denitrification. Rice's absorption of many nutrients such as N, P, Mn and Fe increases under water saturation conditions but the absorption of other cations may decrease. In this respect, the highland rice system is closer to most other grains and completely different from the submerged rice system.

Water and nutrient mobility

Since the nutrients need to move only a short distance, adequate soil moisture favors the mass flow of nutrients, especially N, with the soil solution to the root surface. Movement by diffusion within the soil solution is important for many nutrients including P and K and is supported by adequate soil moisture. Moreover, the nutrient uptake of crops is also enhanced as plants have a suitable hydrophilic state. The effective use of nutrients inside the plant for growth and metabolism also depends on a continuous satisfactory supply of water. In the absence of sufficient water, the transport of absorbed nutrients within the plant is restricted. This also restricts their use in metabolic activities and production of plant biomass, which could ultimately have a negative effect on the yield and nutritional content of the economic product.

Water and crop response to nutrients

Crop growth and response to fertilizer application is greatly influenced by the level of water saving. Crop response is a combination of different factors that affect crop growth, nutrient availability and nutrient absorption. The greater nitrogen response, as well as higher yields, with increased precipitation. These differences in precipitation greatly affect the optimal rate of nutrient application. For crops raised largely on stored soil moisture, estimating the moisture in the soil profile prior to planting is as valuable as an estimate of the nutrient status available for the soil. Consequently, more food inputs are needed to take advantage of a better water supply, and the optimal economic rate of nutrient use increases. When plants have access to adequate water but not sufficient nutrients, this amounts to underutilization of valuable water resources.

Efficient use of water and nutrients

In agricultural terms, NUE stands for increase in yield per unit of nutrient applied. It is the same as the response rate and can be calculated as follows: NUE = (yield of the fertilized plot - the yield of the control plot) / the amount of nutrients applied. Many aspects of crop management affect the level of actual production and response to the nutrients applied. In terms of water supply and management, NUE can be improved by reducing fertilizer losses from the soil resulting from poor water management, for example percolation or denitrification. NUE can also be improved by ensuring that lack of water does not significantly delay crop growth or nutrient uptake at any stage. Excess water can be a cause of nutrient loss, and water deficiency can limit a critical stage of growth and yield. It is also important that all other production inputs and management factors are adequate. The timing of water use affects NUE to a large extent through its effect on crop yields, which can be greatly reduced as water supply through irrigation or other deficiencies are at the most critical stages of crop growth. In most crops, it was found that the phase of active vegetative growth and the phase of reproductive growth are most affected by the lack of moisture FAO. 2003a.

Water and nutrient losses

There are three main ways in which water condition and water management can affect the loss of nutrients from the soil system and the plant. Heavy rainfall, or excessive irrigation, resulting in the passage of water through the soil sector through deep filtration will carry with it soluble nutrients, especially nitrates and sulfates and plague. It causes a significant loss by leaching out these nutrients. This is especially the case as large amounts of these nutrients may be present in the soil at the start of winter (due to the decomposition of crop residues at the end of the growing season). The amount of loss depends on the amount of water that moves through the soil profile and the stock of soluble nutrients. The extent of nutrient loss must be considered when determining nutrient utilization rates. Filtered nitrates can enter water bodies or be denitrified under anaerobic conditions within the soil profile. Such conditions can exist within pockets or compact areas within otherwise ventilated soil. Waterlogging causes loss of nitrogen through denitrification. In submerged rice soils, nitrate levels can be maintained low by placing an ammonium or amide source of nitrogen, such as supergrain urea granules (USGs) in the low-lying soil area and by proper water management. However, in highland soils, nitrate levels are often very high, such as periodic waterlogging due to heavy rainfall as in monsoons or excessive irrigation can lead to significant loss. Since soil without drainage becomes easily waterlogged, this risk is greater on highly clay, soft soil. Ammonia volatilization from urea and some ammonium-containing fertilizers is affected by temperature, soil reaction, and soil water condition. Under very dry conditions, little loss occurs, and in moist, stable soil conditions, ammonium remains in the solution. However, when the soil moisture condition is moderate, or where the soil or flood water rapidly loses water through evaporation, ammonia volatilization can be noticeable. This is particularly observed when urea is released to the surface without incorporating it into alkaline soil of insufficient moisture during periods of high temperature.

Crop nutrition influencing water demand

- Water requirement of crops
- Feed crops that influence water demand
- Crop water requirements
- Effective water management requires careful planning of crop production at the farm level. Water requirement means the amount of water needed for transpiration

From green plants, evaporation from soil and other water losses during application. Crops require 300-800 liters of water for transpiration to produce 1 kg of dry matter. The amount of water consumed depends on both the plant and the climate. It is also determined to a large extent by the nutrient supply and the size of the crop canopy or leaf surface. To reduce water requirements, various losses such as those that occur during irrigation water transport, runoff, and seepage by deep filtration, filtration, and waterlogging must be avoided. Water requirement (WR) must be met from water stored in soil profile (Sw) plus precipitation (Rw) plus irrigation (Iw). Therefore, irrigation water requirement (IR) = WR - (Sw Rw). Even when the total amount of water is adequate, this may not guarantee high productivity if there is a water deficit in the critical growth stages.

Crop nutrition and water demand

Also, a good supply of nutrients creates a higher osmotic pressure in plant cells, which results in better resistance to drought. Potassium ions (K +) play an important role in regulating stomatal action in leaves that control water loss. Hence, a good supply of potassium can conserve water. Phosphates promote early root growth, allowing better water access from deeper soil layers and also shortening the growth period. This leads to early maturity, which reduces water demand. To some extent, the lack of water can be compensated for by improving plant nutrition. Under reduced precipitation, the nutrient input, especially nitrogen, should be adjusted with the amount of soil water stored.

Water use efficiency

As with any production input, efficient use of water is also of practical importance. Water use in crop production is not limited to transpiration from plants. Additional water losses such as evaporation should be taken into account in the Water Use Efficiency (WUE) calculations. WUE is defined as the economic yield (Y) per unit of water the crop uses for evaporation (ET). It is expressed in kilograms of yield per milliliter of water used**:**

$$\mathbf{WUE = Y / ET \qquad kg/mm}$$

In recent years, WUE has increased significantly due to large increases in yields as a result of improved supply of nutrients, especially nitrogen, phosphorous and caffeine, as water supply is often a limiting factor in crop production and irrigation is costly and quantitatively limited, i.e. a practice that increases yield per unit of water important user. A good supply of nutrients should be complementary to irrigation; otherwise part of the additional water will be wasted, resulting in a decrease in WUE. Once the crop cover is fully achieved, the water use (ET) from the field is mainly controlled by the incoming solar energy, nutritional status, etc. In these circumstances, any input factor that increases the economic return improves the WUE. Optimizing plant nutrition should aim to maximize both NUE and WUE. The best way to achieve this will depend on the fertility condition of the soil and water system in a particular production system and moisture conservation practices such as mulching. For rain-fed dryland crops, plants often have to face moisture stress at a specific stage of growth. Whatever level of fertilizer is used, the factor that most often limits production is the water supply. Fertilizer rates should be determined with respect to the level of water supply from stored soil moisture and expected precipitation, which determine the yield. It is advisable to apply N in more than one division in order to take advantage of the precipitation expected during the growth of the crop. Under very "dry" conditions, applying too much fertilizer before planting or too early during crop growth may adversely affect the crop yield and WUE by stimulating excessive vegetative growth, which consumes limited water supplies leaving very little water for reproduction. And grains- fill the growth stages. This is the case where a stately crop stand can be counterproductive. For irrigated upland crops, fertilizer requirements are usually high and the amount to be applied can be determined in relation to soil fertility level, expected yield and local management practices. Both NUE and WUE will be maximized by providing adequate quantities of water and nutrient inputs to achieve full growth and yield. Their applications must be timed so that the needs for food and water crops are always met. In wetland rice, provided water management is good, yields are determined by climate, season, variety, management, and nutrients used. The amount of fertilizer, method of application, and timing are all important. In general, NUE and WUE are lower in such systems compared to upland crops due to the large volume of water required and the higher nitrogen content. Input efficiency can be improved by applying N in 2-3 splits during crop growth and by using effective N vectors. There is room for water consumption in submerged rice cultivation, because if the soil can be kept saturated, there may be no need for waterlogging or deep submersion FAO. 2003a.

Plant Nutrition and Resistance to Stress

The crop can suffer from several types of stress during its growth. They may be caused by soil, moisture, temperature, salinity, nutrient deficiencies or toxins, pests and diseases. The response of crops to different stresses is often affected by the state of their nutrients. Improving plant nutrition can enable the crop to withstand such stresses and yield with minimal yield loss. The role of some phytonutrients such as K in this regard has been studied in great detail. The topic of plant nutrition and its resistance to various climatic factors and other stresses is discussed here.

Plants withstand water stress

Plants are often subjected to water stress to varying degrees at some point even under irrigation conditions. However, it is more frequent in dryland cultivation and in areas without irrigation. Crops receiving balanced nutrition can explore a larger volume of soil for access to water and nutrients. Plants that experience moisture stress can also suffer from nutrient stress due to the very close association between water and nutrient availability. The main stress regarding N management is most likely the uncertainty in precipitation as no irrigation is available. When precipitation is heavy or intense, nitrogen is subjected to leaching or denitrification, while in drought it tends to remain in the soil, not used by the crop. P has a noticeable effect on root growth. Hence, crops deficient in phosphorous are unable to access water from deep soil layers due to poor root growth. Therefore, these crops are more susceptible to drought than crops with adequate phosphorous, and therefore a well-developed root system. In contrast, nitrogen-enriched crops develop too much for vegetative growth compared to root size. This results in a rapid loss of water from the plant canopy, which causes the soil water to be depleted faster than the crop receives a balanced fertilization. Such crops are highly vulnerable to drought. When the situation is not remedied by irrigation or precipitation in time, the net result is a significant drop in yields. In legumes, moisture stress severely delays the nitrate-reducing activity, protein synthesis, and N-fixation. K has an osmotic role in plants that enables the plant tissues to retain their water. The movement of K in and out of the guard cells surrounding the stomata on the leaves of the plant is responsible for opening and closing these cells, which greatly helps in reducing moisture loss when the plant faces moisture stress. When plants are deficient in K, the stomata cannot function properly and the water loss from plants can be very high. Application of K has been shown to enhance plant dehydration resistance under moisture pressure. While recovering from moisture stress, K can help the plant maintain higher growth rates FAO. 2003a.

Tolerance of plants to lodging

Plants bear habitat

Housing or displacement and breaking of the stem from its upright position is common on many crops, especially grains and grasses. Depending on the housing severity, the effect may be permanent or reversible to a certain extent. The critical growth stages in cereals that correlate with loss of yield as a result of habitation are the initial growth periods and early grains. Habitat in the case of traditional tall varieties of rice and wheat under nitrogen fertilization and their low genetic yield potential were some of the main reasons for the development of hardy dwarf dwarfs. These HYVs have a higher achievable yield potential because they can also respond to higher rates of N application without housing. Habitat is especially intense on windy days when plants with weak stems contain high levels of nitrogen which is an interactive effect of plant type, environmental conditions, soil texture and nutrient management. Plants low in K is prone to inhabiting because they have thinner stems due to insufficient K. Lignin from vascular bundles in stems is weak under K. deficiency. These plants usually have weak stems. Plants well-fed with K have thicker stems and greater stem stability. Housing resistance is mainly controlled genetically, but an adequate width of K reduces the propensity to reside. The role of K in enhancing the resistance of plants to habitability has been documented in many crops such as maize, rice, wheat, and rapeseed Johnson, (1984).

Plants tolerate saltiness and alkalinity

In saline and alkaline soils, exchangeable sodium is present in very large quantities compared to interchangeable Ca and K. Na is not an essential phytonutrient. There are indications of an association between the tolerance of a crop or crop variety to saltiness and K status. In general, salt tolerant crops were found to have more K than crops exposed to salinity. It has been shown that crop varieties that can absorb potassium in preference to sodium are relatively more tolerant to salinity and alkalinity. In a comparison between a salt-tolerant wheat variety (artichoke) and a salt-sensitive cultivar (HD 4530), it was observed that both cultivars produced similar yields at a 7 percent ESP. However, at 43 percent of ESP, the artichoke still yielded 2.5 tons of grain per hectare while HD 4530 produced 0.75 tons / ha. The Na / K absorbed ratio at 43 ESP was 0.43 in Kharchia and 2.59 in HD 4530. This indicates was able to absorb more K and exclude Na, but HD 4530 was not able to restrict Na absorption. In tomatoes, the K + / Na selectivity was also higher in the salt-tolerant variety compared to the non-tolerant cultivar. These results indicate that maintaining adequate levels of K and K + / Na ratios in plant cells is essential for normal growth under saline conditions Tyagi, (2000).

Tolerance of plants to cold

Plants tolerate cold

Nutrients can have both positive and negative effects on cold tolerance. Plants that are over fertilized or those that receive unbalanced nutrition produce soft leaf tissues that are susceptible to cold and frost damage. K plays a major role in regulating the concentration of cell sap and this helps plants withstand the cold stress caused by very low temperatures. Potassium-rich potato plants were found to withstand frost better than low-lying plants in K. In the northern plains of India, the frost injury rate was 36 percent in potatoes grown without applying K, 16 percent with an application rate of 50 kg K2O / ha and 2 percent an application rate. Use 100 kg K2O / ha. The high potassium content in the plants lowered the freezing point of the cell sap, enabling them to survive frosts. For a specific crop, susceptibility to frost also varies with the variety. Application of K can increase the frost resistance of frost sensitive varieties. Width B is sometimes associated with reduced frost damage. The best evidence for this came from eucalyptus and pine trees although some indications are also available for apples and grapes.

Resistance of plants to pests and diseases

Among the many nutrients whose role has been studied, N and K have been examined in great detail. Here is a summary of the nutrients' effects on disease and insect resistance:

- Nitrogen: Excess N results in abundant plant growth, making it more attractive to insects and susceptible to diseases and insects that feed on the leaves.
- Phosphorous: A good supply of phosphorous helps plants resist diseases, especially bacterial blight in rice, perhaps by counterbalancing the harmful effect of excess nitrogen, and a good supply of phosphorus also provides tolerance against infection with some bacterial or fungal crop diseases (such as potato plants)
- Potassium: Potassium improves disease resistance by keeping stomata tightly closed, preventing pathogens from entering the leaves. It also improves stem strength, which reduces housing, which in turn reduces insect and disease damage and crop quality.
- Calcium: Adequate calcium has been reported to reduce the occurrence of club root in cabbage crops.
- Boron: Plants that are deficient in vitamin B are more susceptible to powdery mildew. Appropriate vitamin B in plants reduces the occurrence of club root in cabbage.
- Manganese: Deficiency of manganese increases the incidence of black spot and eruption diseases.
- Copper: Plants deficient in copper are susceptible to airborne fungal pathogens.
- Chloride: The use of chlorine-containing fertilizers may reduce the incidence of "taking the whole" (root and crown rot) in wheat by inhibiting nitrate production and reducing the pH at the root surface.
- Silicon: High nitrogen absorption and low potassium reduce silicon absorption, which makes rice more susceptible to blast disease. The low silica content in the leaves makes them softer and suppler, making them vulnerable to attack by leaf feeding / sucker pests.

N and K are known to have a profound effect on the susceptibility or resistance of plants to many types of pests and diseases. It is known that the high N content in the leaf tissues makes plants vulnerable to a number of diseases and attack of pests. The deleterious effect of N can be neutralized to a large extent by providing balanced crop nutrition, especially optimal N: K ratios. In contrast, plants deficient in potassium are more prone to disease than those sufficiently fertilized with K.Rice plants deficient in K or with poor N: K balance are particularly susceptible to brown spot disease, stem rot, and bacterial leaf blight. The incidence of disease may also be affected by the amount of vegetative growth. Experiments with rice showed that the incidence of brown macula increased with N supply at all K rates. The problem was more serious as N was applied in the absence of K because stimulation of growth induced by N resulted in an internal dilution of K and increased likelihood of infection. An adequate supply of vitamin B is associated with a reduced incidence of ergot on barley. Treating seeds with B has been reported to provide resistance to tomatoes, capsicums, and cabbage against damping fungi Russelle, & Birr, (2004).

Nutrient Management in Different Cropping Systems

Plant feeding problems are rare as a small population uses a large area of fertile soil. In contrast, almost any nutrient input is justified in cases of low levels of production in relation to the food and fiber requirements of the population. There is a large variety of crop systems between these two extremes, each requiring a different nutrient management system. All crop systems have limitations imposed by natural and economic conditions. The aim of improving nutrient management is to optimize the use of soil and nutrients applied within the characteristics and requirements of specific agricultural systems to achieve optimal production with minimal depletion of soil nutrient status. Topics in this section relate to those in the previous section on strategies for improving nutrient management Russelle, & Birr, (2004).

Exploitative agriculture with a low level of production

Historically, growing crops without the use of external nutrients was a common occurrence in many parts of the world. Exploiting soil nutrients essentially means growing crops until available soil nutrients are depleted (exploration) and yields drop significantly. Ultimately, these fields must be abandoned and left to return to normal vegetation for regeneration. A typical example of cropping is the exploitation of shifting cultivation used by subsistence farming in some areas of tropical forests .This system is exploitative because nutrient losses are not compensated for by the inputs. However, it is fairly stable as long as there is no serious soil degradation during the crop period and there is sufficient land available for long regeneration stages under natural vegetation. For this to happen, there would have to be nearly seven times more land available than is actually needed to support the residents. The poor reputation of shifting cultivation as a misuse of soil resources is mainly the result of a deviation from the original concept by shortening the resting period of the forest, thus not allowing the soil enough time to regenerate. This often occurs as a result of increased population pressure. As the population increases, these systems must be replaced by more stable and productive types of farming systems.

Sustainable agriculture has low to average yields

The concept of sustainable agriculture has gained high priority. . It includes the successful management of agricultural resources to meet human needs while maintaining or improving environmental quality and conserving natural resources. Systems of this type involve complex interactions and require the integration of all factors of production. One of the prominent concepts of sustainable agriculture is Low-Input Sustainable Agriculture (LISA). LISA is supposed to improve the management and use of internal production inputs (mainly nutrient resources on the farm) in order to obtain satisfactory, sustainable crop yields and profitable returns. LISA is a subspecies of organic farming. It is a production that lies at the lower end of the crop response curve and is not expected to meet food and fiber needs in densely populated countries where most of the available arable land is already cultivated. With the continuous growth in population and the proximity of the stable agricultural area, LISA will not be able to provide adequate food and fiber for the growing population. Low-input agriculture and associated low to medium productivity may be required for both natural and economic compelling reasons. An example is large-scale sustainable agriculture (low inputs and low outputs) in large areas of developing countries. It can also be deliberately promoted and practiced for ideological reasons such as biodynamic or ecological agriculture in developed countries. It is definitely more suited to subsistence farming, to produce high-value products that a section of the population demands, and products with a "niche" market rather than satisfying the nutritional needs of the population as a whole. In areas with severely yield-limiting factors as in dryland cultivation areas, intensive agriculture with low inputs and low to medium yields still has its place. The main focus in this type of system is the use of packed soil nutrients and internal nutrient circulation through organic matter. However, the full course is difficult to achieve due to the unavoidable losses. Typical examples of this approach are small subsistence farms that do not have or have little means for nutrient input. In other systems, fertilizer inputs are deliberately kept low as their efficiency is known to be low under conditions of water stress and droughts. Harvesting and recycling rainwater on or off the farm is the key to improving crop nutrition and increasing crop yields Johnson, (1984).

Intensive sustainable agriculture at high yield level

Sustainable agriculture cannot be equated with the subsistence farming of the vast majority of the world's agricultural land. Sustainability is in no way limited to conditions of low inputs but can be achieved at any level of production where inputs and outputs are balanced and best land use practices are followed. These systems can be called sustainable agriculture with adequate inputs (AISA). As demonstrated in Western Europe and elsewhere, high but appropriate rates of nutrient use lead to sustainable production with high yields without significant adverse effects on soil fertility or the environment. Cultivation systems of this type vary somewhat, ranging from rainfed areas to irrigated areas, but there are many similarities in terms of nutrient management.

Research results from many parts of the world show that higher crop yields are sustainable through balanced and integrated nutrient management supported by appropriate modifications to address problems such as excess acidity or alkalinity. There is hardly any challenge or role for modern science and technology if sustainable agriculture is restricted to low-yield subsistence farming. Long-standing trials at Rothamsted in the UK have been around for more than 150 years. Results of more than 100 years of continuous cultivation (1952-1967) show an average wheat yield of only 1 ton / ha on an untreated plot and around 2.5 tonnes / ha in plots that receive either 35 tonnes per hectare fiscal year or only fertilizers at an average of 146 Kg N + 75 kg $P2O5$ + 100 $K2O$ / ha.

In the USA, the oldest experimental plots, known as the Morrow Plots, have been around since 1876 at the University of Illinois. Based on the results obtained over more than 100 years of these lands, well-treated soils can provide food and fiber continuously at high levels. The average yield of corn grains in the best rotation with optimum fertility management was 8.6 t / ha compared to 2.2 t / ha in untreated land under continuous Crimea. These findings contain an important message for countries that are constantly striving to meet the food and fiber needs of a growing population from a resource base that is expanding either slowly or not at all. In a long-term experiment in Aiza, Fukushima Prefecture, Japan, a set of fertilizer treatments began with and without compost and modifications in 1920. Even in the 1980s, the untreated plot was able to maintain rice yields of around 4 tons / ha, but it was produced. The plots that receive NPK through fertilizers only double that production. Nearly 70 years of continuous use of fertilizers have had no negative effect on the physical, chemical and biological properties of this rice soil. In a study to assess changes in agricultural soil properties over a period of 60 years, researchers in California, USA, analyzed 125 soil samples collected in 2001 and for which reference samples were taken around 1945. By comparing the analytical values obtained from the two years Of reference, their overall conclusions were that while increased clay content may indicate accelerated soil erosion, California soil has maintained its chemical quality over the past 50-60 years.The results began from a number of long-term field trials in India in the early 1970s using high-density crop rotations involving 2-3 consecutive crops per year under irrigated conditions. Overall, these experiments showed that high levels of crop yields (8-12 tonnes of cereal / ha / year) could be maintained by combining optimal and balanced fertilizer application rates with 10-15 tonnes per fiscal hectare / year. These experiments proved that fertilizers are the main input to increase crop productivity, but also the integrated use of fertilizers and FYM or lime when needed gives higher and more sustainable yields as it can also correct some micronutrient deficiencies and improve the physical and biological properties of the soil Bruulsema, et.al. (2004).Even under rainfed dryland conditions, medium to high crop yields can be maintained through the integrated use of fertilizers and compost. Results of a nine-year field trial with finger millet in dry lands in red soils in Bangalore, India, show that the best yields were obtained when recommended rates of fertilizers with 10 tons of FYM / ha were used. Only at this input level can 3 tonnes / ha and above be harvested in eight years out of nine years. A large portion of the potential return would have been lost if any of these inputs were omitted. The goal of intensive, sustainable, high-yielding agriculture is to benefit, as much as possible, from the yield potential of high-yielding crops by eliminating all nutritional restrictions through INM including fertilization and maintaining high soil fertility, while simultaneously protecting the crop from disease and insect damage. . However, there is a downside to nutrient management under these systems. This occurs when there is a high dependence on fertilizer inputs while neglecting soil nutrient reserves and those available in various organic sources. This tends to happen when cheap chemical fertilizers are readily available. This has led to the public misconception that intensive farming is essentially a "nutrient wasting" system. Maintaining crop productivity at a high yield has proven feasible in many progressive agricultural areas, even in parts of so-called developing countries such as Punjab, India. Fertilizer dependence continues to produce adequate food and fiber due to continuous population growth and little expansion in net crop area. Food production can be enhanced by improving nutrient cycling and preventing losses. However, the nutritional needs of a growing population cannot be met from organic sources alone or from fertilizers alone. It requires a pre-planned active INM approach. As part of integrated crop production, INM will be a critical factor in achieving the goal of sustainable high yields and profitable crop production without negative impacts on the environment Bruulsema, et.al. (2004).Harnessing BNF is an important component of INM and this is not limited to a specific crop system or yield level. Although large quantities of N can be fixed by legumes, whether or not this leads to N soil accumulation or the N feeding of the following non-leguminous crops, depends on the amount of constant N, the amount of N removed in the crop products and residues. In many cases, the rotation of legumes contributes significantly to the N feeding of the next crop. When crop yields are high and a large amount of N is removed in the harvested product, the effect may be minimal or negative. In grassy leguminous pastures, the transfer of nitrogen from legumes to pastures is minimal, and N from legumes to grass is mainly passed in manure and urine from grazing animals or after the decomposition of legume residues.

Biofarming and ecofarming

Biological farming and ecological farming are forms of organic farming. Refers to special farming regulations that exclude the use of synthetic mineral fertilizers or pesticides, but use natural minerals such as public relations, animal manure, manure and legumes as nutrients. These systems focus heavily on the nutrient cycle. It is claimed that with this production system better food quality is produced and the environment is better protected against unwanted contamination from agricultural chemicals. The system is viable due to the high prices of the realized products, which compensate for the lower returns generally obtained. The general term organic agriculture refers to a group of similar and different nutrient supply systems. Biodynamic agriculture excludes all commercial mineral fertilizers Russelle, & Birr, (2004). In contrast, major groups (such as Bioland) exclude mainly water-soluble mineral fertilizers, especially N fertilizers, but allow other major nutrient sources if they are natural products such as PR, crude salts of K and lime. Micronutrients are only allowed if there is an apparent deficiency. The rejection of the water-soluble N fertilizers, whether they contain nitrates or urea, has no scientific basis. It is an ideological concept based on the philosophy of returning to nature. Although the claims about food quality by avoiding chemical fertilizers and protecting chemical crops have not been proven, a limited number of consumers support this production of so-called "natural" foods by paying premium prices. Another claim that these types of biodynamic and ecological farming systems cause less pollution to water bodies must be questioned because they do not use any input of chemical fertilizers. Although less nitrogen filtration is achieved per unit of land, it is seldom true for each unit of crops produced, especially since roughly the land area is required for biodynamic and ecological agriculture compared to conventional farming Bruulsema, et.al. (2004).However, organic farming has a place as one of the many farming systems. It is more of a class institution, not a collective institution. They are best suited to produce organically grown products for which consumers are willing to pay the higher asking price. Based on belief more than reality, it automatically prefers to exclude certain techniques and inputs because they are in conflict with belief. This approach traditionally ignores the presence and operation of nutrient cycles in the soil through which mineral and organic nutrient forms are transferable (this is beneficial because plant roots only feed on mineral nutrient forms regardless of whether they are derived from mineral or organic sources). This division of nutrients into organic (natural) and mineral (synthetic) ignores the basic fact that these two forms not only coexist, but can be interchanged in soil. Organic farming faces the same environmental and sustainability problems with crop nutrient management as it does with mainstream agriculture: emissions of ammonia and nitrous oxide, nitrate leaching, energy use, and depletion of public relations resources Sudaric, et al. (2008).

Optimizing nutrient management in diverse cropping systems

There is a multitude of cropping systems in use throughout the world. These range in intensity from raising one crop per year (as happens in many rainfed dryland areas) to 3-4 crops per year in irrigated/assured rainfall areas on the same piece of land. Wherever adequate rainfall or irrigation is available and the climate permits, raising two grain crops in succession within a year is possible. In many areas, the whole cropping system or rotation is completed within one year. In other areas, a given system may be rotated after 2-3 or more years. Only some of the nutritional features of the main types of cropping systems are discussed here Bruulsema, et.al. (2004).

Annual crops in different rotations

Short rotations that include crops such as rice, wheat, maize, oilseed rape, barley, vegetables and fodders are highly nutrient demanding and, therefore, rely mainly on high external nutrient input. Except for N, especially where no legumes are involved, nutrient management is more concerned with the whole rotation than with individual crops. Fertilizers are applied to maintain a high nutrient supply utilizing both the direct (fertilized crop) and the residual effects. This is sometimes referred to as “rotation fertilization”. For example, in temperate climates, substantial amounts of mineral N often remain in the soil after oilseed rape, which is usually followed by winter wheat. The wheat crop utilizes the residual nutrients in autumn before the main leaching period. Longer rotations, which include crops such as sugar beet, potatoes or even legumes with their extra gain of N, often have more soil tillage, soil cover and, thus, nutrient mobilization than cereals. One of the most intensive and nutrient-demanding rotations in parts of South Asia is the rice-wheat rotation. In India, this rotation is practised on more than 10 million ha, primarily in the northern alluvial plains. Under optimal management, grain yields of 8-12 tonnes/ha/year can be harvested. Optimizing nutrient management in this system includes the application of NPK and other required nutrients such as S and Zn. The wheat crop must receive its optimal rate of P application while rice can benefit to a considerable extent from the residual effect of P applied to wheat. On highly P-deficient soils, P must be applied to both crops. Incorporation of green gram residues after picking the pods before planting rice is an effective green manuring practice in this system. In general, research recommendations provide for application of the full recommended rates of fertilizer to the wheat crop, while 25-50 percent of the recommended fertilizer to rice can be saved through the use of 10 tonnes/ha FYM, Sesbania green manure and crop residues. Information is also becoming available on INM in this highly intensive system Bruulsema, et.al. (2004).

Annual crops in monoculture

In many tropical and subtropical regions, high-intensity monoculture is practiced wherever rainfall is well distributed or adequate irrigation is available. Wetland cedar has its own problems in nutrient management due to the strong limiting conditions of submerged soils in which many stabilizers are moved. A major unresolved problem is the low recovery of the N fertilizer, which is mainly applied through urea in these systems. Typically, only 30-50 percent of the added nitrogen is taken up by the crop compared to about 70 percent in well-managed intensive wheat crops. The decrease in N efficiency is the result of losses of N by various methods. Extensive on-farm experimentation indicates that adopting appropriate crop management and feeding practices can reduce the effects of diminishing yields when nitrogen use rates are increased mainly due to nitrogen losses. In terms of importance, the determining factors that smallholder rice farmers using urea (or pellets) can address are: (1) Too few fractional applications, resulting in large nitrogen losses and thus insufficient nitrogen supply to meet crop requirements in Different growth stages; (2) Varieties which may be insufficiently responsive to N; And (3) the insufficient number of primary plants. A multi-site pilot / demonstration project on the farm for irrigated rice (1995-1998), funded by Japan and implemented by the Food and Agriculture Organization in Indonesia, the Philippines and Malaysia, showed that the deep US government allows for 21 percent nitrogen savings compared to 70 kg / ha of application Nitrogen in the form of urea is prepared in three sections .Nimin-coated urea, a commercial extract from neem seeds (Azadirechta indica) has been tested extensively, especially in India. This reasonably inexpensive biological product shows great promise for resource-poor farmers, with an average yield increase of 5--10 percent over unpolished urea. The super granules made of urea coated with Niemain and applied in depth show further improvement over USG technology. In many rice growing regions, where climate permits, 2-3 rice crops can be grown in a row within a year. For example, in India, the annual rotation between rice and rice is practiced on approximately 6 million hectares. Supplying N through BGA and Azolla / Anabaena symbiotic systems has some hope and could replace a portion of N fertilizer Bruulsema, et.al. (2004).

Annual crops with short-term relief

Mulching may be required for weed control in humid climates or to store water in soil in dryland cultivation. When crops are not removed, mulching also preserves packed soil nutrients, thus providing additional nutrient supply for the next crop. Felds can be bare or vegetated, depending on the main purpose. A bare stock is the period of accumulation of nutrients and water. In densely populated and land scarce countries, the land is rarely left by choice. It is more due to the inability of the farmer to raise an additional crop under low rainfall or insufficient stored soil moisture. Vegetation during the fallow period can be effectively used as mulch or even as green manure.

Multiple crop systems

The term polyculture refers to planting two or more crops in the same field per year. The concept of multiple crops includes cropping practices where single or mixed crops are planted sequentially, simultaneously, one by one, or with a staggered period. A distinction is made between sequential cropping and intercropping. A series crop can involve planting two, three or four crops per year in sequence or growing raton. Intercropping includes mixed / row / strip intercropping (simultaneously) or intercropping (intercropping).

Optimizing plant nutrition in multiple-cropping systems revolves around:

Adapting to residual effects of nutrients such as phosphorous, phosphorous and micronutrients (for example, applying P on priority for wheat and green manure over rice in alternating rice and wheat, and FYM on priority for corn in alternating corn and wheat); Prioritize fertilizer use for those crops in the system that have poor root system and poor users of applied nutrients (such as potatoes in the potato and corn system); Plan a short-term hunting crop that can feed on residual fertility in between two major crops (for example green gram in annual cycle of corn, wheat and green); INM practice taking into account crop characteristics (e.g. green manure wherever possible prior to planting rice or pollinating paddy fields with BGA / Azolla in rice-based cropping systems); Fertilizer application in phases between crops rotating so that maximum gains are obtained directly in addition to the remaining gains (for example, application of P on priority for wheat in cycles of rice, wheat, maize, wheat, sorghum / millet and wheat, application of S to crop of oilseeds in oilseeds - Grain rotation); In mixed crops, such as grains and legumes, the use of fertilizer is mainly determined by grains, and legume seeds can be pollinated by Rhizobium culture; Nutrient management in multi-crop systems must finally be decided by the economics of yield response to different nutrient applications, particularly when the component crops bring different prices in the market (for example, a yield response of 1 ton of oilseeds is more valuable than the yield response of 1 Ton beans). Depending on the nutrient management strategy used, the gains from multiple crops can vary widely. The results of many long-term trials using multiple transplant cycles showed for example the following Johnson, (1984): Intensive crops with only N inputs are a short-lived phenomenon; (2) Locations initially well supplied with P, K, or S become deficient over a period of time when they are continuously cropped with N alone or S free fertilizers; (3) In most cases, it was necessary to apply the optimum fertilizer + 10-15 tons of FY ha / year in order to maintain crop yields; (Iv) Soil fertility has improved or depleted according to input-output balances as well as according to soil properties; (5) Fertilizer rates considered ideal still lead to nutrient depletion from the soil at high productivity levels and in the process itself sub-optimal application rates have become. These experiments showed that the same field that produced 1,300 kg of grain / hectare from two crops grown without the use of fertilizers could give 7424 kg grains / ha when the crops received the optimum use of the required nutrients Bruulsema, et.al. (2004).

Optimizing Nutrient Management in Dryland and Irrigated Farming

The following sections discuss some aspects of managing nutrients under different water availability regimes. These range from dryland farming to traditional irrigated agriculture and finally to the flooded soil used for rice production in wetlands. The aspects discussed are general and applicable to the different types of cropping systems described above. All of this points to the need for integrated nutrient and water management in order to improve efficiency and return to nutrient application Johnson, (1984).

Nutrient management in dryland farming

In rainfed farming systems in dry lands, yield is usually limited due to lack of water, as precipitation is not only scarce but also variable and thus unreliable. The main nutritional problem is the total and available deficiency of N due to the low SOM content. In order to make optimum use of the scarce nitrogen resource of the soil at the time of sowing, the nitrogen requirements of the crop must be adjusted for the nitrate flow that occurs from the rapid mineralization at the beginning of the rainy season. In practice, this is not easy due to the uncertain start of the rainy season. There could also be some upward movement of nitrates from the ground via evaporation. A natural supply of nitrogen may be sufficient for lower yields, eg 1-3 grain tonnes / ha. However, for average yields, additional N sources such as farm waste material or even N metal should be added where there is sufficient moisture. Cereals yield of 3-4 tonnes / ha are sustainable under dryland cultivation where the system is properly managed, as shown in Table 33. The cultivation of forage grains and legumes is widely practiced in such areas. In order to obtain the maximum benefit, adequate phosphate use must be ensured and legumes should be vaccinated with the appropriate Rhizobium strain in order to maximize the gains from BNF Duarte, (2009). Covering is difficult in these environments due to a lack of organic matter. However, where possible, it can be used to protect soil or mixed into topsoil as a food source. In extremely hot climates, mulching can also reduce water loss from the soil and reduce soil temperature. Extremely low SOM is desirable, but the possibilities are limited due to high mineralization rates. The use of organic materials is often restricted by the competitive use of crop residues etc. for feed, fuel and roofing. Another possibility to preserve the natural nutrient supply and water available to the plant is to use bare stock. However, this may reduce SOM and risk soil loss due to erosion. In addition to N, the phosphorus supply is often insufficient due to either low available phosphorous in the soil or slow movement towards plant roots. Since phosphorus is especially required for root growth and because deep rooting may be crucial for crop survival during droughts, a good supply of phosphorus is important beyond its actual role as a nutrient. A good supply of potassium is also essential to reduce transpiration losses from crops. However, for cultivation in drylands in many arid soils, there is generally enough potassium for at least low to medium production levels and the same is true for Mg and S Russelle, & Birr, (2004). Poor availability of micronutrients in neutral to alkaline soils results in frequent deficiencies of iron and / or zinc. Some improvements in availability can be made by using highly acidic N fertilizers such as ammonium sulfate and, to a lesser extent, urea. However, the volatility of ammonia should be minimized under these systems. The great production potential still exists in dryland areas but can only be achieved through a combination of moisture conservation and rainwater recycling with an optimal supply of nutrients. The particular climate and vital stress factors must be taken into consideration while managing such soils. However, crop systems in semi-arid regions that use common agricultural practices may not always be sustainable. This is likely to be done by applying INM's current research knowledge and rainwater harvesting along with the farmers' accumulated experience.

Nutrient management in irrigated agriculture

Irrigation provides a vital input (water) for crop production and also brings with it some nutrients. It also stimulates SOM mineralization, dissolution and transfer of nutrients from low soluble nutrients to available inorganic forms. Watering significantly loosens the soil solution. This has the advantage of lowering the osmotic pressure, but the disadvantage of reducing the concentration of nutrients, which cannot be quickly replenished. There is a proportional increase in the concentration of monovalent cations such as K + in the soil solution resulting from cation exchange. The resulting increase in the supply of K may temporarily reduce the supply of Mg. The calcium concentration also decreases, but this has no harmful effects due to the large total supply. When the soil is saturated, the pore space occupied by the air is also filled with water, which creates anaerobic conditions. When saturation is temporary and followed by deep filtration, it leaches the soluble nutrients. When prolonged or leads to water saturation, chemically reduced conditions are set. This results in a more dense packing and replenishment of mineral nutrient reserves, especially at higher temperatures. Nutrients like iron and manganese are converted from unavailable forms to available forms due to the reduced conditions. As the severity of the reduction varies, so does the availability of these nutrients, leading to the appearance and disappearance of symptoms of iron deficiency during the irrigation cycle. When the redox potentials are permanently reduced, iron oxides can be reduced to the extent that iron toxicity can occur Anetor, & Akinrinde, (2006).

Aside from flooded rice soils, there are periods of drought between wet periods in most irrigated soils. This could be caused by a high rate of deep filtration, high evaporation transpiration or insufficient supply of irrigation water. Draining the soil during the dry phase between irrigation periods increases the concentration of the soil solution by evaporation, but reduces the rate at which these nutrients are transferred to the roots. The concentration of divalent cations such as Ca2 + increases relative to the monovalent K + cation. More intense drying ultimately fixation of the mobile feeders, that is, conversion from soluble and motile forms to the reserve fraction. Phosphate deposition, iron and manganese are oxidized, and thus are less available (unlike what happens during a flood). K has more strength, the degree of which depends on the content of clay minerals in the soil. However, these temporary deficiencies can be compensated for at the end of the dry phase by mineralization of plant nutrient reserves. These features of irrigated soils must be taken into account when determining optimal nutrient use rates as the relatively high level of production must be supported by intensive fertilization. Fertilizers can also be supplied with irrigation water through irrigation. Many of the aspects covered in the section above about integrated nutrient and water management also apply to this section Johnson, (1984).

Grasslands or permanent pastures and meadows

Growing either forage crops for grassland or arable crops for animals results in a special internal on-farm nutrient cycle that benefits arable crops. In these systems, the export of plant nutrients in meat or milk is less than that of harvested vegetable products. Fertilizing grasslands has two main objectives: high yield of palatable fodder for large production of milk, meat and wool. And good health (including good fertility) of the pet. The fertilization required depends on the goal of production (such as quantities of milk and meat), the supply of soil with nutrients and the system of grassland use, such as grazing or cutting forage for conservation Duarte, (2009).

Principles of pasture feeding

For the proper feeding of animals, almarai feed should contain large amounts of proteins, carbohydrates (energy carriers), vitamins and flavorings. It should also contain optimal amounts of mineral nutrients but not contain toxic organic matter or excess inorganic nutrients. Two different aspects must be considered to provide optimum nutrition for plants and animals. Firstly, the optimum mineral composition of the plant not only increases the content of valuable organic matter, such as amino acids, proteins, carbohydrates and vitamins, but also increases the supply of minerals. Only a limited amount of essential minerals can be given to animals directly. Secondly, the mineral requirements of plants and animals differ in some respects. Here they are:

- Similar requirements for plants and animals: P, S, Ca and Mg;
- Plant requirements are greater than animals: K, B and Mo;
- Animal requirements are greater than plants: Na, Cl, Ca, Mg and some micronutrients;
- Only required by animals: I, Co, Se, and Cr.

Knowledge of the forage composition (protein and mineral nutrients) at the time of grazing or hay making is a prerequisite for the efficient production of valuable forage. Milk production requires large amounts of energy and protein as well as high in minerals. Meat production at first requires very high protein feed, but later it takes more energy. Fertilization also controls the vegetative composition of pastures. The percentage of weeds in pastures increases with the increase of nitrogen and potassium amounts, while the percentage of legumes decreases. Soil interaction can and should be slightly less than arable field interactions of the same soil texture. In fact, mild to moderate acidity is often helpful. When liming is required, the reaction must be kept below neutral. Thus, the goal of nutrient utilization for grassland consists of supplementing natural concentrations until the optimum supply range is reached. Luxurious, or even excess supplies, may lead to problems such as reduced intake of other nutrients or reduced mineral absorption in the animal. The mineral concentration in the feed generally decreases with age due to the effects of dilution and maturation. Therefore, data on concentrations should indicate a specific growth stage. For grasslands there is a suitable reference stage shortly before the beginning of flowering Anetor, & Akinrinde, (2006).

Some aspects of grassland nutrient supply

The phosphorus concentration in the grass should be 0.3 - 0.4 percent. When phosphorus is a yield-limiting nutrient, a significant improvement can be achieved by applying P. This is because it promotes the growth of legumes and, consequently, the supply of N to herbs. P-shape selection is of secondary importance, especially in wet grasslands with good packing ability. PR is recommended for highly acidic soils. The natural supply of potassium should be sufficient to produce high forage crops in many situations. However, if feed is cut and removed, the application of K. may be required. Large quantities of K can be supplied with animal slurry, but excess K can reduce the supply of Mg. Potassium chloride is the preferred source for K.

The required large calcium concentration is not easily reached by herbs, which often contain only 0.4 percent of calcium. Many herbs, especially legumes, contain more than 1 percent of calcium. The ratio of Ca: P should be 1.5-2: 1. The calcium concentration can be increased by liming, but this should only be done until the optimum pH value, which is somewhat less than seven. Mg is often a limiting factor for lawn growth in acidic soils. Animals can suffer from tetany of the weeds (hypomagnesemia) where the concentration of magnesium in the grass is too low or the absorption of magnesium from the feed is prevented. The critical magnesium concentration in high performance dairy cattle feed is around 0.25 percent. Moreover, the ratio K: (Ca + Mg) should be less than 2.2: 1 (expressed in equivalents per kg). Magnesium sulfate or any other source of magnesium may be used. Copper deficiency leads to poor growth of livestock and a "lick disease". Cows require 1 µg / L of copper in the blood and for high milk yield; this is achieved with approximately 8 µg / g copper in the feed. Animals often prefer plants or plant parts that contain higher concentrations of copper. For correct use of copper by animals, the calcium concentration in the feed should be less than 0.8%, the Mo should be less than 3 µg / g, and the S concentration in the range required for optimum plant growth. Copper deficiency in grasslands for several years can usually be corrected by adding 3-5 kg copper / ha through any fertilizer containing copper. Adequate manganese, even for high requirements, is generally provided as the pH value of grasslands remains in the slightly acidic range. However, on neutral soils, the high concentrations of manganese required to increase milk production and animal fertility may not be reached. One simple way to increase the supply of manganese is to acidify the soil with an acid-forming N fertilizer. The zinc requirements for the production of large quantities of milk are much greater than the zinc requirements of plants. However, many types of soil provide an adequate amount of zinc. The Zn app is only required when the optimal Zn state has not been reached. Fe, B, and Mo are usually found in sufficient quantities in the forage, but Mo may need to be applied in acid soils to better stabilize N by legumes. Some herbs absorb only small amounts of sodium and contain less than 0.01 percent of sodium while some herbs, for example white clover, have sodium concentrations over 0.4 percent. It does not appear to be necessary to cover all the sodium requirements of animals with grass, but a relatively high concentration of sodium is recommended. Cholesterol deficiency is rare in acidic sandy soils, and it is often accompanied by copper deficiency. Deficiencies in and of themselves are more prevalent than previously assumed. However, care must be taken in general use of Se on all grasslands because its optimum range is narrow and high concentrations are toxic. Cr appears to be only required in extremely small quantities. Beneficial elements, such as V, Ni, Si and bromine, which are required in very small quantities, are generally supplied from the soil. Silic acid is present in many herbs in the form of needles, which can injure the digestive system of animals Campo, et.al. (2009).

Strategies For Optimizing Nutrient Management

Nutrient management can be viewed from various aspects, such as focusing on soil nutrient status, on crop yields, on nutrient scales or in terms of relationships between nutrients and water.

The ultimate goal for all aspects is: to improve crop production, maximize positive interactions, increase net yields, reduce soil nutrient depletion, and reduce nutrient losses or negative impacts on the environment. Achieving this goal is difficult, but not impossible. It requires application of the best available knowledge and inputs as part of a medium to long-term strategy. In most cases, the required knowledge and inputs are already available. The key is smart management of various resources.

From exploiting soil nutrients to fertilizing

Various strategies for managing soil nutrients in crop systems have evolved over time. These are related to different fertilization systems. Different strategies may find application simultaneously in the same area, and sometimes on the same farm, and thus are largely responsible for differences in fertilizer inputs per unit area. The four different strategies related to soil nutrients are:

- Exploitation: depletion of soil reserves, lack of fertilization, diminishing yields;
- Use: moderate withdrawals of soil reserves, no fertilization, stable yields;
- Substitution: maintenance of soil supplies, fertilization to compensate for removal, and steadiness of yields;
- Fertilization: enhancing soil resources, supplementary fertilization, increasing yields (high).
- Exploitation of soil nutrients
- Exploitation-based agriculture (the unwise use) of nutrients stored in the soil is the oldest agricultural production strategy. Exploitation agriculture uses the natural nutrient capital of the soil. It still plays an important role in crop production in many regions. A common feature of all exploitation systems is that rarely any enrichment or replenishment of nutrients takes place apart from the recycling of harvested residues and waste products. This leads to nutrient depletion through mining of soil reserves. As a result, the yield decreases from year to year. Available nutrients are consumed until they are depleted, either because the rate of mobilization of organic and mineral reserves is very low or because there are small reserves of soil nutrients remaining to be mobilized. Thus, the original fertility of the soil, which had improved over long periods, was depleted.

Typical examples of a rapid decline in soil fertility are found with shifting cultivation in moist forest areas. On newly developed lands with highly fertile soils, exploitation of soil nutrients may allow highly profitable crops to be grown for several years without fertilizer inputs. Even outside shifting cultivation, large numbers of farmers in many developing countries continue to grow crops relying primarily on soil nutrient reserves. Despite all objections to crop exploitation in this way, controlled exploitation may be economically beneficial and may be environmentally acceptable as a fixed form of land use, provided that the period of arable crops is limited and a period of rest for soil replenishment and fertility is included. This may not always be possible in highly cultivated and densely populated countries, particularly where there is sufficient irrigation or rainfall available to grow an additional crop. It is a feature of subsistence farming in which very little marketable surplus is generated. Long-term exploitation of crops can cause significant damage to soil fertility as serious soil degradation may occur. This serious damage cannot be completely repaired, but the cost of regeneration exceeds the short-term gains achieved. Crop exploitation with irreparable damage represents a destruction of the naturally available potential that humankind cannot afford, with its living space constantly shrinking. Such an approach is not sustainable to improve crop yields Anetor, & Akinrinde, (2006).

Take advantage of soil nutrients

This is a less dangerous version of the (mining) exploitation of soil nutrient reserves discussed above. Similar to exploitation, the use of soil nutrients implies a certain decrease in the nutrient capital of the soil without a significant decrease in fertility. This may create the impression of a sustainable agricultural production system without external nutrient inputs. These nutrient supply systems can only be practiced when nutrient removals are small and the range of available nutrients is large and also supported at a sufficient rate to mobilize nutrients from soil reserves.

In this system the soil is not significantly poor and yields remain constant despite annual nutrient removal. However, the fact that yields remain low in such a system makes it inappropriate when a farmer wants to improve his yield levels. Then this strategy will approach the exploitation strategy and will have to be replaced by a more balanced production / input system. No soil, even the most fertile, can continue to support nutrient removal indefinitely. Again, this system is not sustainable to produce high returns Duarte, (2009).

Soil nutrient replacement

The concept of substituting nutrients removed or lost from a field allowed for the cultivation of stable crops and was practiced in ancient civilizations. Examples include the natural nutrient substitution of Nile mud in Egypt, the systematic use of animal manure as fertilizer in ancient India, and the careful management of manure in ancient China. Today, especially in most soils of only medium fertility, compensation for all losses is essential to maintain optimum levels of crop productivity with minimal depletion of soil reserves. Soil fertility conservation can be partially achieved by using crop management practices to improve soil. These include using plants that accumulate nutrients such as legumes to accumulate nitrogen or by following crop cycles with different nutritional requirements and different root depths. Both organic and mineral sources of nutrients are suitable for soil nutrient replacement. Farm waste products and mineral sources like silt and marl can also be used as fertilizer supplements to obtain medium to high yields. Nutrient replacement strategy is only valid in cases of good primary fertility of soil or soil in which fertility has been built up to an appropriate level through repeated fertilization. It does not apply to poor or naturally depleted soils because fertilization on a removal basis only can increase depletion of this soil. The root cause of soil fertility depletion here is that only a portion of the nutrients absorbed by the crop is provided through external inputs and the remaining crop needs are met by soil reserves. Replacement strategy based cropping systems are rarely used to the fullest extent. It is very common in modified form where replacement of some nutrients (especially N, P and K) occurs but some others are used from soil reserves. This is the most common as the application of a balanced nutrient is limited in the narrow sense of an application of NPK. This strategy can allow yields to be maintained at medium or even high levels as long as nutrients other than N, P, and K are not limited Barbagelata, et.al. (2002).

Enrichment of soil nutrients

Natural soil fertility is often insufficient to maintain high yields and may decline further after a few years of intensive cultivation. For this reason, the level of some nutrients must be increased beyond the amounts needed to replace removals in order to achieve high returns. Soil fertilization with nutrients should extend primarily to those nutrients that can be formed and not necessarily all nutrients. This strategy includes three approaches: (1) increasing the supply of deficient nutrients beyond removals; (2) Replace removals if feeders are present in sufficient quantities; And (3) utilization of nutrients from soils having good reserves and capacity for nutrient replenishment. The improvement in soil fertility via nutrient enrichment is evidenced by the fact that in parts of Europe, sugar and wheat beets now produce high yields in soils that were previously considered too poor for these nutrient-demanding crops. Improved nutrient supply over the years and the resulting improvement in soil fertility in general have greatly increased the yield potential of these crops dictated by climate alone or other constraining factors that are difficult to correct. The enrichment of related nutrients can be very profitable due to higher yields. The investigator provided that economic resources are not an obstacle Anetor, & Akinrinde, (2006).For example, farmers practice fertilization strategy in order to increase soil fertility in Illinois and advanced corn production in the USA. Depending on the state of available P soil, it is recommended to use phosphates with twin goals to build available soil P to the optimum level and replace phosphorous removal processes by the crop at expected productivity levels. Once the available soil condition P has reached the optimum level, it is only recommended to replace the P removal. This is a case study of an approach to maintaining high returns. The concept of finite nutrient enrichment does not imply a permanent increase in soil P state, but only an increase up to an optimum supply level sufficient for high yields, and certainly not up to the luxurious supply, which would be unnecessary. Harmful in light of nutrient loss and imbalance. The fertilization stage is usually a transient stage followed by a permanent replacement stage, generally at a high level of productivity. A large number of farmers in many developing countries may not be able to adopt this approach in the first place due to insufficient financial resources, high cost of input purchased, and lack of perception about the need to enrich soil nutrient reserves. Many of these farmers work on a season-to-season basis or at most on a crop rotation basis. Their weak financial base forces them to look for short-term gains.

Economic and policy issues of plant nutrition

There are many complex economic and policy issues involved in nutrient management. Detailed discussion of the topic is outside the scope of this document and readers are referred to the publication on Fertilizer Strategies. Given the importance of the topic, some practical aspects are being discussed here.Before farmers are convinced to use purchased inputs such as mineral or organic fertilizers, they need to know these inputs and their effects on crop yields in both agricultural and economic terms. Once they are convinced of fertilizer use in principle, they have to make a complex decision about how much and which fertilizer to use. Their decision about the use of fertilizers in a particular crop is generally based on some form of economic judgment that includes past experience from using such inputs, available cash or credit, and potential product prices.While calculating the economics of fertilizer use is relatively simple, the economics of using nutrient sources such as animal manure, compost, crop residues, green manure crops, and urban waste are more complex. The critical elements in calculating the economics of using these products are their variable nutritional composition, residual effect and cost and availability of labor to access, process and apply them. These factors are often overlooked when advocating for different nutrient management strategies. For practical use, all agricultural data related to crop responses to nutrients should always be subjected to economic analysis in order to account for differences in input and output prices and address the fundamental issue of whether and to what extent fertilizer use will be profitable to the farmer. The discussion here uses mineral fertilizers as an example, but the issues also apply to other sources of nutrients. Information on factors affecting returns from nutrient application has the same value in decision making FAO. 2003c.

Factors Affecting Decision-Making

- The main elements of production economics as applied to fertilizer use consist of:
- The response to physical yield of fertilizers used, the price of fertilizers and crops including transport, handling and marketing costs as well as the cost of loan service;
- The ability of individual farms to make decisions and take risks.
- The following economic and institutional factors have been identified as important in influencing the economics of fertilizer use :
- The price relationship of the fertilizer and the crops in which it is used with the market expectations for these crops, which largely determine the profitability and incentive for fertilizer use.
- Farmers' finances along with availability and cost of credit, which largely determine whether farmers can afford the necessary investment in fertilizers.
- Conditions of land tenure, which determine the degree of incentive for farmers to use fertilizers.
- Adequate supplies and distribution facilities in order to ensure that the right types of fertilizers are available to farmers at the right place and time.
- Although the relative importance of these factors varies with local and seasonal conditions, they are highly interrelated. All of them could be positively or negatively affected by government policies, financing facilities, and marketing regulations in the country.
- Farmers will only use phytonutrients when their beneficial effects on crop yields are profitable. The decision to apply external plant nutrients to a particular crop is generally

based on the economy (price and affordability), but is conditional on the availability of resources and the production risks involved.

Ideally, farmers' pursuit of higher income through higher yields should be balanced with the need to preserve soil fertility and avoid soil degradation. Most farmers in developing countries have no choice but to face a certain amount of soil fertility depletion each year. Therefore, the long-term profitability of INM accreditation must be considered as the improvements in soil conditions associated with superior NUE tend to only appear after several planting seasons.

Climate is one of the most difficult factors to consider when deciding on nutritional additives for crops and pastures. In some developed agricultural areas, soil moisture and probability of precipitation are taken into consideration using data provided by meteorologists. In irrigated areas, water availability can usually but not always be predicted. In many developing agricultural regions, such information is not available and farmers must rely on their own experiences and those of others. In this case, the risk is much higher than in developed regions. . The rainfall pattern has a major influence on the response of crops and hence on the economic returns to nutrient use. In a dry year, no fertilizer should have been applied, while in a year with above average rainfall, even the normal rate of application was insufficient to achieve maximum yield. In those developing countries where irrigation facilities are well developed (such as India and Pakistan), the uncertain water supply component is reduced Anetor, & Akinrinde, (2006).

Yield maximization vs profit maximization

The prerequisite for profitable crop production is to produce an agricultural crop that can increase net returns. Even the highest return will not be of use if its production is not cost effective. Most farmers want to maximize the net gain from whatever investment they can make in inputs. However, they should realize that the highest profits are only possible with optimal investment, the right decisions and the right weather. Whether a farmer aims to achieve maximum economic return or maximum agricultural return depends on conditions. A farmer in a poor agricultural area with little or no purchasing power will generally try to produce enough food for the family's needs with minimal risk. These farmers are forced to work at a subsistence level of farming. In these cases, maximum returns are not considered and even maximum economic returns are a far-fetched goal. On the other hand, farmers in developed regions (even within developing countries) who have access to cash and / or credit in general will try to maximize their return on invested capital and be more willing to take some risks. The response function to fertilizer use is an essential tool linking the amount of crops that can be produced in relation to the amount of fertilizer and other farm inputs applied. In other words, there will be a ceiling that can be obtained from crop production for any given amount of fertilizer and other agricultural inputs used. This is greatly influenced by the state of soil fertility and that is why optimal economic rates of nutrient use should generally be based on soil tests and crop removal.

In theory, the determination of the response function should take into account all variables, such as the use of other inputs that affect crop yields. In the response function, crop yield is a function

From several factors: $Y = f(X1, X2 \ldots$

$Xn)$, where Y = crop yield, and $(X1, X2 \ldots\ldots Xn)$ = Inputs included in the response function as having a significant production impact.

However, the usual practice in fertilizer response function studies is to restrict the variable inputs to the rate or level of the applied fertilizer nutrient while keeping all other factors constant. At the farm level, this can be a limitation as it does not take into account factors such as labor costs and weather fluctuations. The important information provided by the response function is the increase in crop yields (grains, tubers or fruits) that can be obtained from the increased levels of fertilizer use. This information is necessary to determine the optimal fertilizer application rate (i.e. the most profitable level of fertilizer use). This level is not valid for all times even for a specific crop on a particular farm. It is constantly changing depending on input costs, production price, and crop response rate per unit of input. The classical production function usually shows stages of increase, decrease and negative returns according to the law of diminishing returns, where successive increases of the inputs, beyond the initial linear range, lead to a decrease in the response rate per unit of fertilizer applied. Farmers are concerned only with the first and second stages of the response function. Their specific interest depends on whether their main consideration is profit maximization or the net rate of return (BCR) from the money spent on fertilizers. This position is conditional on the available resources and their opinions of risk and uncertainty. When the response function of a given input is known, as shown in Fig.46, it is possible to calculate the optimum economic and agricultural application rates. Using N as an example, the response function is as:

$= -0.1136X2 + 35.837X + 1929.3$

Where Y = yield of wheat grains of US \$ 0.25 / kg, and X = rate of nitrogen used as fertilizer at a cost of US \$ 0.90 / kg of nitrogen.

In order to calculate the N rate of maximum agricultural yield, the first derivative of the response function should be set to zero: $dY / dX = 0 = -0.228X + 35.84$, $X = 157$ kg N / ha (for maximum yield).

The optimum gain rate for N is calculated by setting the first derivative of the response function for the ratio of fertilizer price to grain price, i.e. (0.90 USD / 0.25 USD): $0.228x + 35.84 = 0.90 / 0.25$; $X = 141$ kg n / ha (for maximum profit).

The rate of yield increase for the nutrient application (i.e. nutrient) will be somewhat higher than the rate of profit maximization (157 versus 141). This is because the additional return from the economic maximum to the agricultural economy is uneconomic. Unless the farmer aims to win the highest competition in yields, the rate of profit maximization for nutrient application should not be exceeded.

While analyzing the economics of fertilizer use, the main considerations are the increase in production attributable to fertilizers (or physical response), and the relationships between fertilizer cost and product price. When the goal of the farmers is to obtain the optimum economic value from the use of fertilizers, their interest is to work within the second stage of the response function where the return obtained from the fertilizer unit increases (marginal return) but at a diminishing rate. In simple terms, the YMD is always somewhat higher than the gain-maximizing dose (PMD) (close to 125 kg N). The small fraction between PMD and YMD consists of a positive but not economic response. For farmers in general, PMD is important FAO. 2003c.

Maximization of net returns or value-cost ratios

The question sometimes arises as to whether a farmer should aim to achieve maximum net returns from fertilizer use or a maximum total rate of return as shown in the value-to-cost ratio (VCR).A farmers' decision to use fertilizers at their VCR level is based on their profitability criterion. However, the general rule is that a VCR of at least 2: 1, that is, a yield that is at least 200 percent higher than the cost of fertilizer treatment, attracts farmers. However, the absolute net return should also be considered because, at lower fertilizer use rates, the VCR may be too high due to the small cost of treatment and the associated high response rate. However, at lower application rates, the net yield will also be small and unattractive to farmers. Additionally, other factors should be taken into consideration. These include the potential for obtaining the expected yield, product storage facilities, a guaranteed market for the crop, and the assured availability of fertilizers to farmers. This aspect is discussed below. Due to the changing ratio of crop and fertilizer prices, the amount of fertilizer used also needs to change in order to maintain optimum economic returns. The extent of change depends on the shape of the response curve. The concept of optimum economy based on marginal rate of return is illustrated in Fig. 47 using data from India. It is important to have information on marginal yield and prices for fertilizers and crop products. Such calculations can be made for any situation. Most farmers, especially in developing countries, often use below recommended rates of fertilizer, and they also do so in an unbalanced way. This is due to a number of factors which include: their perception of the role or importance of each food item and the price and unit price; Expected increase in yield; Projected crop prices; Cost and availability of fertilizers; Level of financial resources and availability of credit; Land tenure Considerations. Degree of risk, uncertainty, and farmers' ability to tolerate them. Therefore, it is natural for growers to exercise caution and build a fair margin of safety when deciding what level of fertilizer to use. Farmers can operate on a wide range of fertilizer application rates and utilize them to an optimal level. In this respect, sources of plant nutrients are very different and very flexible compared to other agricultural chemicals (pesticides and herbicides) that can only be effective when applied at a single critical rate. In general, farmers with adequate resources can use fertilizer rates that are at or close to the optimum in terms of economic returns. On the other hand, the rates of fertilizer use of interest to small farmers with limited resources, who are concerned with the economic return of the money they spend on fertilizers, are those in the steepest part of the response curve where the BCR rates (discussed below) are higher. However, these farmers will sacrifice a large portion of the yields and profits that can be made through suboptimal employment FAO. 2003c.

Economics of Fertilizer Application

For a simple analysis, the minimum data required for an economic analysis of fertilizer use consists of the following: (1) Fertilizer cost; (2) Value of additional yield resulting from fertilizer application; (3) Rate of increase in yield per unit of nutrient used or response rate. For nutrients that leave a residue and benefit from more than one crop, the cost of the nutrient should be distributed among the crops benefiting.

Economy calculation

Aside from calculating economically optimal nutrient use rates associated with maximum net returns, the profitability rate of fertilizer use can be determined using either a VCR or a BCR. The VCR is obtained by dividing the value of the additional yield resulting from the cost of compost or other nutrient source. The BCR is obtained by dividing the net value of the additional yield produced (after deducting the cost of the fertilizer) by the cost of the compost. Therefore, VCR is an indicator of the total rate of return, while BCR indicates the net rate of return. In a simple way, BCR = VCR - 1. Economic analysis can also be used to determine the units of crop production required to pay for one unit of fertilizer feeder or, alternatively, in a given price system, the response rate required for a generally acceptable minimum VCR. When 3 units of grains are required to pay for one unit of nutrient, a response rate of 6 kg of grains per kilogram of nutrients for a VCR 2 should be obtained: 1. this also has implications for NUE as improving efficiency will lead to higher VCR of The same investment. Several fertilizer experiments - with empirical data - do not allow for the computation of the response curve for different nutrients due to the design used. However, when the range of treatments is wide enough, net yield and VCR can be determined. This example is illustrated in Table 40 (based on data from the FAO Fertilizer Program). In the example in Table 40, the lowest N-P2O5- K2O treatment (40-40-40) gave the highest response and highest net return with a higher (but not the highest) VCR of 4.3. On the other hand, the highest nitrous oxide (N-P2O5- K2O) treatment (80-80-80) did not give the highest response or economic return. The highest VCR was obtained from treatment 40-0-0 and ERR was just lower than treatment 40-40-0. Assuming these results are economically representative, the 40-40-40 treatment can be recommended for use by well-off farmers and the 40-0-0 treatment by those who have limited resources to purchase fertilizers. The true optimal economic rate is somewhere between 40-40-40 and 80-80-80 treatments, and this should be calculated statistically. Depending on the level of soil fertility, it can be indicated that the rate of profit maximization is 80-60-60, 80-80-40 or 80-40-60.

Calculating the economics of residual value of nutrients

The use of a number of nutrients, particularly phosphorous, zinc and copper, benefits more than one crop in a row. P is the most well-known example of a major trace nutrient. On repeated applications of P, unused P from the first application remains effective in the soil and can contribute to the P supply of the next crop. In most cases, the economics of phosphorylation in many developing countries continue to operate on a one-crop basis. When the experiment of fertilizers with a nutrient such as P is performed with repeated applications made in three consecutive years, the response curve appears to shift to the left. The reason for this is that P remaining from first year application contributes to supplying P in later years. This means that as soil P condition improves as a result of repeated applications, lower P application rates are required in subsequent years to obtain optimal yields. This allows the accumulated phosphorous to be exploited on a limited scale. The increased P condition of soil should be reflected in a good soil test report so that the optimal P application rate can be adjusted. The same principle applies to all nutrients that leave behind a significant residual effect (zinc and copper on a long-term basis, and S on a relatively short-term basis) Barbagelata, et.al. (2002).

Ideally, a monetary value should be allocated to the remaining P contributions, and interest can also be charged on funds withheld in these P. This may not be acceptable in all cases, for example. Where the farmer argues that newly applied soluble phosphorous is more valuable (more potent) than the less soluble residual P. For practical purposes, it is essential to know how many crops will benefit most and the amount of benefit (response). Where four consecutive crops benefit from the initial application and their successive share of the cumulative yield increase is taken as 100, and then the cost of phosphorus fertilizer for each crop can be divided according to its contribution to the cumulative response. The challenge is to allocate the cost of applying P to the different crops being raised in a sequence that represents the potential beneficiaries. In theory, if the effect of applying P continues for four years and the percentage of each crop in the total yield increase obtained over four years is 50, 30, 15 and 10, then the cost of applying P initial in this ratio can also be allocated to this ratio for economic analysis On the basis of the crop system. For example, only 50 percent of the cost of phosphorus can be assigned to the crop receiving it because the remaining 50 percent of the yield response is observed in the following three crops. This also helps in adjusting application rates to build up soils that ultimately reach phosphorous replacement (removal) values FAO. 2003c.

The direct and residual response to P was evaluated in several systems of double-cropping involving two consecutive crops per year in India. The mean was calculated on several field experiments with grains, from the total turnover response to P, the direct component was 60 percent and the residual component was 40 percent. Phosphorus was added to the rainy season grain and the winter crop was grown on the remaining phosphorus, and the total turnover response consisted of 57 percent directly and 43 percent remaining. When the same amount of P was applied to the winter crop, the turnover response was 63 percent direct and 37 percent residual. This indicates that even in a one-year cycle, the division of the phosphorus cost between the two crops is justified. These divisions between direct and residual effects should be based on local research. The economics of P application also improves as the higher response is also for a crop with a higher market value (eg wheat versus millet or oilseeds as opposed to grains). Thus, an economic analysis on the basis of the crop system can be started by allocating only 60 percent of the cost of phosphorus fertilizer to the first crop (fertilized directly). Otherwise, the yields from applying P to the directly fertilized crop will suffer a penalty while the crop fed residual P will receive a reward in terms of P residue, the detailed analysis should include more than one crop benefiting from the residual effect, as shown below.

Calculating the indirect costs of applying fertilizers

When fertilizers are applied to soil, much of it affects soil pH and other soil properties. When acidifying fertilizers that lower the soil pH are used, the resulting acidity must be corrected by using lime materials. When the same fertilizers are applied to alkaline soils, the effect of acidity may lead to additional benefits, such as an increased availability of certain nutrients (such as P and Zn). It is possible to assign a value to this purpose although not directly but in terms of equivalent return. In principle, this means that the cost of fertilizers should be calculated not only in terms of the nutrients they provide but also for their positive and negative effects on soil health. When using AS a source of nitrogen, the cost of lime needed to neutralize the acidity produced by AS should be added to the cost of AS. Likewise, since SSP is used as a fertilizer in S deficient soils, its cost should be divided between P and S. In the case of crops like peanuts, where the calcium component of SSP also plays a role in pod formation, the cost should be split SSP between P and S and Ca, especially in acidic soils. These are the issues that warrant examination as one transitions from one-sided economics to multi-faceted economics of nutrient application.

Economics of Organic Manures And Biofertilizers

Calculating the economics of organic fertilizers and bio-fertilizers is more complicated than calculating the nutrients used through mineral fertilizers, especially N (which leaves little or no effect) FAO. 2003c.

Compost

The organic bulk compost has more profound effect on improving the physical properties of soil compared to the nutrient supply. It is not easy to estimate the monetary value of the improvement in soil conditions. However, the physical and chemical advantages of using compost are expected to increase crop yields. Therefore, it is easy to calculate the economics of compost by treating it in the same way as fertilizers which give a direct and residual benefit. It is easiest to cost organic fertilizers on the basis of material cost plus application cost without dividing the total amount into individual nutrients. Another complication arises in trying to divide the cost of compost between nutrients and organic matter, which mainly affects the physical properties of the soil. The higher yield is expected to reflect the improvement in the physical conditions of the soil as a result of fertilization as well Russelle, & Birr, (2004).

Green manure

Green manure brings in organic matter produced by photosynthesis but otherwise recycles nutrients from the soil it absorbs. Green legume manure brings net N input. This can be calculated in terms of fertilizer parity N (if we assume similar use efficiencies) or green manure raising cost and the additional yield produced can be used to account for the economy. Here again, residual effects have to be taken into account.

Vital fertilizers

The economics of bio-fertilizers or microbial vaccines can be calculated either by calculating the bio-constant cost of N in terms of the cost of the fertilizer N that produces a similar increase in yields, or by deducting the cost of the pollen plus the cost of its use from the value of the additional yield produced. It is not easy to calculate the residual benefit of a constant N as a result of pollination except in terms of the value of the additional crop produced. It is imperative not to lose sight of the many ways a farmer can end up with low yields or even lose out with fertilizers. Among the most prominent of these are: (1) Continuous use of an imbalanced nutrient; (2) Cultivation of low-yielding crop varieties; (3) Ineffective use of fertilizers; And (iv) the use of fertilizers without addressing other soil health limitations such as strong acidity or alkalinity. In order to maximize the profits from fertilizer use, it is necessary to devote equal attention to factors and inputs other than fertilizers Duarte, (2009).

Policies for Effective Plant Nutrition

Long-term planning and monitoring of plant nutrient use needs to reconcile four objectives: (1) agricultural and economic efficiency to maximize agricultural production from the available food supply; (2) Maintaining and enhancing the productive capacity of the natural resource base. (3) Conformity with the general economic objectives of the country; (4) Protection of social security and the ability of rural people to earn a living. Consideration of these issues in a timely manner is essential for planning and implementing a coherent and comprehensive policy in the short and long term. Fertilizer policies should evolve into INM policies so that diversified sources of phytonutrients find their rightful place in meeting a country's total nutritional needs. This policy, besides being a tool to reduce soil fertility depletion, would provide judicious use of locally available fertilization resources, keep soils in good health, ensure good yields on a sustainable basis, and reduce the negative impacts of mineral nutrient resources on the environment Hungria, & Campo, (2004).

Planning

Effective management of phytonutrients requires appropriate participation and planning in a wide range of areas. Ideally, these tasks should involve government, cooperatives and the private sector. Having a focal point for advising and planning on various sources of plant nutrients is essential to creating a well-integrated plant nutrition policy including fertilizer policy. This should be well coordinated with the country's agriculture and food security policies. An advisory unit with these functions can provide the required inputs for formulating pricing and marketing policy. This unit can be made responsible for forecasting demand and identifying linkages with industry, research, extension services, and farmer associations.

Nutritional needs assessment

Careful assessment of plant nutrient requirements is the basis for planning the use of domestic sources of nutrients and for deciding on domestic production and / or import of fertilizer products and raw materials, including the ultimate use of foreign exchange to finance imports. Fertilizer demand forecasts are an assessment of the volumes of plant nutrients that will be required to meet agricultural production targets. Against this potential demand, actual demand refers to the quantities that farmers are most likely to demand. For example, in the case of N, in areas with large areas under legumes and wetland rice, the N contribution of appropriate biofertilizers must be taken into account to end the total needs of N. These must also take into account the nutrients expected to be provided by the organic resources on Realistic basis. Policies for the effective use of phosphates should include the use of a wide range of substances ranging from fully water-soluble fertilizers to effective performance rates depending on soil pH, crop duration, availability of local resources, and distribution logistics. Likewise, policies regarding potash requirements must take into account the scale of recycling of K-rich crop residues, organic matter and final fertilizers Barbagelata, et.al. (2002).

Quality control

Establishing fertilizer quality standards is an important part of fertilizer policies. Many countries have fertilizer legislation and enforcement mechanisms. The Fertilizer Act deals with product specifications in terms of nutrient contents, inert material, physical properties, weight, packaging and labeling requirements, and measures to enforce the legislation. Although the scope of fertilizer legislation varies from country to country, it usually has the following features:

- It defines the term "fertilizer" and provides a list of substances that can be classified and sold as fertilizers. This means that any material not listed cannot be classified or sold as a fertilizer even though it may technically be an excellent fertilizer.
- It establishes quality standards for listed fertilizer products and quantitatively determines their physical and chemical properties to maintain quality. Aside from the nutrient content, specifications regarding moisture content, particle size, and permissible limits for unwanted ingredients have been clarified.
- It defines packaging and labeling requirements and specifies the information to be provided on a fertilizer bag or other type of packaging.
- It defines the procedures and regulations for the registration and licensing of manufacturers, importers and distributors, along with the details of the mandatory information that they have to submit to the regulatory authority at specific time periods or when required, in addition to specifying the individuals entrusted with implementing the legislation and their duties and powers.
- It specifies the procedures for collecting samples, research procedures, disposing of substandard stocks, seizing stocks, issuing notifications in case of violating legislation, and starting legal procedures.
- It specifies the detailed standard analytical methods for fertilizer samples for quality inspection.

At present, most of this legislation is limited to mineral fertilizers. In many countries where quality standards for organic and biological fertilizers have been developed or are being developed, these are not always considered part of the legislation. In such cases, quality standards cannot be enforced by law - a situation INHM's policies need to address Hungria, & Campo, (2004).

Hashtag

Product labels are generally specified in fertilizer legislation in many countries. It is imperative to provide correct product information to merchants, extension workers and farmers. Labeling also allows fertilizer legislation to be enforced. In many countries, detailed directions are provided to manufacturers on what and what not to appear on the label or sachet. The information to be printed on a compost bag usually consists of the following: Name of the manufacturer / importer; (2) Brand name and trademark; (3) the name of the fertilizer. (4) Nutrient content in percentage based on dry weight (N-P2O5-K2O) and (5) gross and net weight. In the case of phosphates, the total and water-soluble P2O5 contents are usually determined. Most bags also mention the phrase "does not use hook" to obtain information on farm workers and others to ensure that the bag and the product inside is protected from potential damage during handling. Label specifications can change to reflect changing needs. For example, until a few years ago, manufacturers of S containing fertilizers (such as AS and SSP) in India were not allowed to print the S content of fertilizers on the bag. This has now changed and it is mandatory to print the specified S content on the bag. In the case of bio-fertilizers, the expiration date of the product is usually stated on the package. Failing to do so, it should be mandatory.

Packaging

Packaging specifications are usually a part of appropriate legislation and quality control. Proper packaging should ensure ease of handling and transportation, reduce losses and ability to withstand unfavorable weather conditions, while keeping product prices affordable within the terms and restrictions of the distribution system. At the same time, it must convey the correct information to the users. Fertilizer distribution systems, storage and transportation requirements (including moisture) determine the quality of fertilizer packaging. It must also take into account the chemical and physical properties of the products and the storage conditions, especially at the end of the distribution chain Barbagelata, et.al. (2002).

Pricing and subsidies

Pricing is an important factor affecting a farmer's acceptance of a product in terms of required investment and expected returns. The pricing of the inputs must always be viewed in relation to the potential prices of the output in order to ensure that their use is remunerative. The choice between product price incentives and input support to stimulate production has long been a controversial issue. the majority From developing countries in Asia subsidies for inputs such as fertilizers, modifications and strength in agriculture, while developed countries support agriculture using other mechanisms, often with indirect or invisible impacts, and are not always designed to stimulate production. Other incentives for fertilizer use are in the form of guaranteed support prices for agricultural products, duty-free imports of fertilizers, and tax breaks for credit, investment in fertilizers and crop production. These measures affect the profitability of applying exogenous nutrients and provide the economic incentive required to increase crop production. Subsidies provided directly or indirectly to farmers for fertilizers and other agricultural inputs have been the most important factor of pricing policy in many developing countries. Its effect in increasing the demand for phytonutrients can be easily and clearly identified. In some cases, a specific nutrient is supported (most commonly N) while other nutrients are not. This leads to a distortion in the use of balanced nutrients as farmers tend to use fortified nutrients in preference to more expensive, unsubsidized nutrients regardless of the nutrients needed by the soil and crops. Not only does this result in unbalanced and ineffective nutrient use, but it also encourages the extraction of soil nutrient reserves from the nutrients that are not supported, thus depleting soil fertility. In the long run, subsidies like these become counterproductive as depletion of other nutrients begins to limit crop response. Therefore, it is important that fertilizer policies do not treat every nutrient in isolation, but rather take a comprehensive view Hungria, & Campo, (2004).

Financing

Creating conditions conducive to adequate financial support for the trade and distribution of fertilizers (along with credit facilities for farmers) should be one of the main objectives of an effective plant nutrition policy. Fertilizer demand is often seasonal. The seasonal demand pattern differs for nutrients such as P and K, which are introduced before planting, compared to N, which can be presented in several divisions during the growth of the crop. Therefore, the cash flow requirements of fertilizer dealers are high, and involve large sums of money for which adequate commercial credit must be available in order for supplies to reach rural markets well in advance of the ordering season. In many cases, manufacturers or other suppliers provide inputs to distributors on credit for varying periods. Both distribution credit (credit given to merchants) and production credit (credit given to farmers) play a very important role in the marketing and distribution of agricultural inputs. Interest rates and other terms and conditions established by financial institutions have a strong influence on the acquisition of credit. One of the major recent initiatives in farm finance is the provision of private credit cards to farmers in India.

Transport and storage

Proper transportation and storage is part of the basic infrastructure needed to ensure efficient use of fertilizers. Product planning and relocation to an area, taking into account soil nutrient deficiency and crop pattern, has a major impact on achieving a balanced and efficient use of fertilizers. This requires effective coordination between research, extension and trade. In order to enhance INM, suitable transportation and storage facilities are needed, especially in the case of bio-fertilizers. This is particularly important for the viability of microbial vaccines in tropical and subtropical regions. The costs involved are an important factor in determining the priorities that should be set aside for the use of alternative transportation. Often this depends on the distance between the production site and the area of consumption. In many cases, a compost bag may require manual handling six or more times between the plant and the farm. In such cases, handling costs can exceed transportation costs. Proper logistics and efficient handling and transportation of materials can reduce storage costs by reducing storage period. Effective policies should focus on developing an effective and efficient transportation and storage network to serve the needs of the region.

Marketing

Establishing and promoting a viable system of marketing of agricultural inputs should be one of the main objectives of the plant nutrition policy. Fertilizer marketing usually includes three or four phases starting at the factory or port before the material reaches the farms. The actual system used varies from country to country and even company to company. The marketing chain consists in most cases of: producer - wholesaler - retailer - farmer. The number of links used in the marketing chain is generally less in the case of private firms than in the case of government or institutional agencies. Fertilizer marketing systems should basically meet the demands of the farmer while being profitable to the marketer. These systems require careful design and implementation of policies, as the right balance must be found between government and private participation in the production, import and distribution of fertilizers. This is a crucial issue that relies heavily on the national economic and political conditions in many developing countries. Effective marketing systems should promote efficient use of fertilizers through balanced supplies supported by good extension advisory services. Farmers should be encouraged to consider recommendations based on soil testing and translate them into appropriate fertilizers with the help of extension services and agronomists in the industry. Since the efficiency of the use of plant nutrients also depends on the state of other production inputs, a very positive development in many countries is the establishment of multi-input distribution companies and farm service centers. Initiatives such as these, in which a range of inputs (besides sources of nutrients) and services are available to farmers under one roof, need to be encouraged by policy makers and financial institutions Hungria, & Campo, (2004).

Extension and training

Extension and training systems consist of demos, training sessions, training materials, and extension efforts on effective and nutrient crop production.

Management techniques

Management techniques are essential components of farm support policies. Policy measures, especially for developing parts of the world, must have a strong orientation towards increasing extension and training facilities. The extension requirements and services should be properly assessed on a country-specific basis in order to match the technological level and expertise of the agricultural community. Appropriate technology packages, including balanced use of mineral fertilizers, should be introduced as part of INM and basic knowledge of the economics of fertilizer use. Farmers should be brought in to assess the contribution of sources other than mineral fertilizers and how they could be used to adjust fertilizer recommendations. Research and extension efforts should provide an incentive to increase farmers' participation in developing, testing and adopting new technologies. It should also provide for the ability to receive and take into account feedback from the field on a regular basis.It would be desirable to train the farmers so that they could calculate the nutrient balances on their farms. By doing so, they can adopt INM practices that will reduce depletion of their soils and also use locally available nutrient sources more productively in a pre-planned manner. Extensive efforts will be needed to train extension workers in the field in managing international migration so that basic expertise can be provided to farmers. All of these technologies to be transferred must meet the criteria of being technically sound, practically feasible, economically attractive, socially acceptable and environmentally safe.

References

1. Anetor MO, Akinrinde EA (2006) Response of Soybean [Glycine max (L.) Merrill] to Lime and Phosphorus Fertilizer Treatments on an Acidic Alfisol of Nigeria. Pakistan Journal of Nutrition, 5: 286-293.
2. Arao T, Ae N, Sugiyama M, Takahashi M (2003) Genotypic differences in cadmium uptake and distribution in soybeans. Plant and Soil 251:247-253.
3. Barbagelata P, Melchiori R, Paparotti O (2002) Phosphorus fertilization of soybeans in clay soils of Entre Rios province. Better Crops International 16:3-5.
4. Bruulsema TW, Fixen PE, Snyder CS (2004) Fertiliser nutrient recovery in sustainable cropping systems. Better crops with plant food, 4:15-17. Norcross, USA, PPI.
5. Campo RJ, Araujo RS, Hungria M (2009) Molybdenum-enriched soybean seeds enhance N accumulation, seed yield, and seed protein content in Brazil. Field Crops Research 110:219-224.
6. Casanova EF (2000) Phosphorus and potassium fertilization and mineral nutrition of soybean in Guarico state. Better Crops International 14:6-9.
7. Duarte HSS (2009) Potassium silicate, acilbenzolar-S-methyl and fungicides on the control of soybean rust. Cienc. Rural (online) 39:2271-2277.
8. FAO (2003a) On-farm composting methods, by R.V. Misra, R.N. Roy & H. Hiraoka. Land and Water Discussion Paper No. 2. Rome. 35.
9. FAO (2003c) Economic and environmental impact of improved nitrogen management in Asian rice-farming systems, by R.N. Roy & R.V. Misra. In: Sustainable rice production for food security. Proc. 20th Session International Rice Commission, Bangkok, 23-26 July 2002. Rome.
10. Fontes RLF, Cox FR (1995) Effects of sulfur supply on soybean plants exposed to zinc toxicity. Journal of Plant Nutrition 18:1893-1906.
11. Franzen DW, Richardson JL (2000) Soil factors affecting iron chlorosis int he Red River Valley of North Dakota and Minnesota. Journal of Plant Nutrition 23:67-78.
12. Ganesh KS, Baskaran L, Chidambaram AA, Sundaramoorthy P (2009) Influence of chromium stress on proline accumulation in soybean (Glycine max L. Merr.) genotypes. Global J. Environ. Res 3:106-108.
13. Hansen NC, Schmitt MA, Anderson JE, Strock JS (2003) Iron deficiency of soybean in the Upper Meadwest and associated soil properties. Agronomy Journal 95:1595-1601.
14. Hungria M, Campo RJ (2004) Economical and environmental benefits of inoculation and biological nitrogen fixation with soybean: situation in South America. Proceedings of World Soybean Research Conference VII, 488-498, ISBN 85-7033-004-9, Brasil, March 2004, Foz do Iguassu.
15. Johnson J (1984) Fertilizer reduces yield loss from weather stress. Potash Review, Subject 6, Suit 49, No 6, 1-3.
16. Kant S, Kafkafi U (2002) Potassium and abiotic stresses in plants. In N.S. Pasricha & S.K. Bansal, eds. Potassium for sustainable crop production, 233-251. Gurgaon, India, Potash Research Institute of India and International Potash Institute.
17. Lavado RS, Porcelli CA, Alvarez R (2001) Nutrient and heavy metal concentration and distribution in corn, soybean and wheat as affected by different tillage systems int he Argentine Pampas. Soil & Tillage Research, 62:55-60.
18. Loncaric Z, Popovic B, Karalic K, Rastija D, Engler M (2007) Phosphorus fertilization and liming impact on soil properties. Cereal Research Communications 35:733-746.
19. Messick DL (2003) Sulphur fertilisers: a global perspective. TSI-FAI-IFA Workshop on Sulphur in Balanced Fertilisation, New Delhi.
20. Mondal SS, Pramanik CK, Das J (2001) Effect of nitrogen and potassium on oil yield, nutrient uptake and soil fertility in soybean (Glycine max) - sesame (Sesamum indicum) intercropping system. Indian J. Agric. SCi 71:44-46.
21. Mottaghian A, Pirdashti H, Bahmanyar MA, Abbasian A (2008) Leaf and seed micronutrient accumulation in soybean cultivars in response to integrated organic and chemical fertilizers application. Pakistan Journal of Biological Sciences, 11:1227-1233.
22. Putwattanaa N, Kruatrachueb M, Pokethitiyooka P, Chaiyaratc R (2010) Immobilization of cadmium in soil by cow manure and silicate fertilizer, and reduced accumulation of cadmium in sweet basil (Ocimum basilicum). ScienceAsia, 36:349-354.
23. Rodriguez FA, Duarte HSS, Domiciano GP, Souza CA, Korndorfer GH et al. (2009) Foliar application of potassium silicate reduces the intensity of soybean rust. Australasian Plant Pathology 38:366-372.
24. Russelle MP, Birr AS (2004) Biological nitrogen fixation: Large Scale Assessment of Symbiotic Dinitrogen fixation by Crops: Soybean and Alfalfa in the Mississippi River Basin. Agronomy Journal 96:1754-1760.
25. Sarker SK, Chowdhury MAH, Zakir HM (2002) Sulphur and boron fertilization on yield quality and nutrient uptake by Bangladesh Soybea-4. Journal of Biological Sciences 2:729-733.
26. Shamsi HI, Jiang L, Wei K, Jilani G, Hua S et al. (2010) Alleviation of cadmium toxicity in soybean by potassium supplementation. Journal of Plant Nutrition 33:1926-1938.

27. Singh G, Singh H, Kolar JS, Singh H (2001) Response of soybean (Glycine max (L) Merrill.) to nitrogen, phosphorus, potassium and zinc fertilization. Journal of Research Punjab Agricultural University 38:14-16.
28. Stipesevic B, Jug D, Jug I, Tolimir M, Cvijovic M (2009) Winter wheat and soybean zinc uptake in different soil tillage systems. Cereal Research Communications 37:305-310.
29. Sudaric A, Vratarić M, Duvnjak T, Majic I, Volenik M (2008) The effectiveness of biological nitrogen fixation in soybean linked to genotype and environment. Cereal Research Communications 36:67-70.
30. Sugiyama M, Noriharu AE (2009) Differences among soybean cultivars with regard to the cadmium-accumulation patterns in various organs. Proceedings of the XVI International Plant Nutrition Colloquium, UC Davis, California.
31. Tyagi NK (2000) Management of salt-affected soils. In G.B. Singh & B.R. Sharma, eds. Fifty years of natural resource management research 363-401. New Delhi, Indian Council of Agricultural Research.
32. Zheng H, Chen L, Han X, Ma Y, Zhao X (2010) Effectivenss of phosphorus application in improving regional soybean yields under drought stress. A multivariate regression three analysis. African Journal of Agricultural Research 5:3251-3258.

Citation: *Gayar AE (2021) A study on: Nutrients in Sustainable Cropping Systems. Adv in Agri, Horti and Ento: AAHE-144.*