4R NUTRIENT STEWARDSHIP GUIDEBOOK

LEARNING MODULES FOR EXTENSION AGENTS

AFRICAN PLANT NUTRITION INSTITUTE

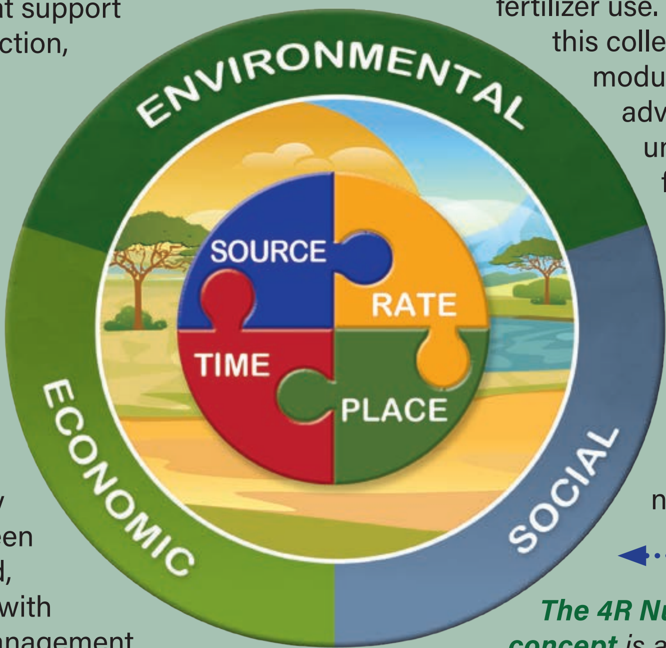
Solution

THE 4R NUTRIENT STEWARDSHIP CONCEPT

Effective fertilizer use, as guided by 4R Nutrient Stewardship, is important for developing sustainable smallholder cropping systems that support improved food production, increased income for farmers, and enhancement and maintenance of soil fertility.

Fertilizers supply the nutrients required by crops. More and better-quality food and cash crops can be produced with fertilizers. The fertility of soils, which has been largely over-exploited, can also be restored with fertilizers. Correct management of fertilizers based on the 4Rs can therefore result in better social, economic and environmental outcomes for farms, villages, communities, and entire countries in Africa.

This guidebook has been developed as a resource for extension agents, agro-dealers and other stakeholders working with smallholder farmers in Africa. It provides a detailed overview of each of the 4Rs of fertilizer use. The purpose of this collection of learning modules is to ensure these advisors have a good understanding of the four principles of 4R Nutrient Stewardship, thereby equipping them with the knowledge required to communicate the best ways for farmers to use fertilizers and other nutrient resources.



The 4R Nutrient Stewardship concept *is an approach that was developed to communicate the Right ways to manage fertilizers based on four principles: applying the right source of fertilizers, at the right rate, at the right time in the growing season, and in the right place. It provides a basis for defining strategies for effective use of nutrients.*

4R NUTRIENT STEWARDSHIP GUIDEBOOK

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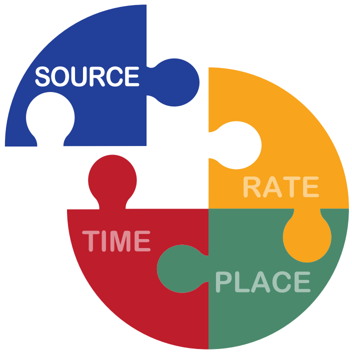
4R NUTRIENT STEWARDSHIP GUIDEBOOK

LEARNING MODULES FOR EXTENSION AGENTS

MODULE 1
RIGHT SOURCE



RIGHT SOURCE:

APPLYING THE CORRECT FERTILIZER AND ORGANIC RESOURCES THAT PROVIDE GROWING CROPS WITH ALL NUTRIENTS REQUIRED FOR GOOD GROWTH AND MATURITY.

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1. SCIENTIFIC PRINCIPLES BEHIND RIGHT SOURCE

Different soil conditions and farming practices require the use of different nutrients for best results. To determine the right source, the following scientific principles should be considered:

Scientific Principles to Determine the Right Source are:

- **Consider rate, time and place of application:** The rate, time and place of application has an influence on the right source of fertilizer. For example, where high nutrient application rates are required, fertilizers with high nutrient concentrations are best suited. Where fertilizer application is required at planting, such as for cereal crops like wheat and maize, compound NPK fertilizers that supply a wide range of nutrients are best suited. For top-dressed applications, straight fertilizers such as urea that only supply N are best suited.

  With regard to place of application, solid fertilizers are best suited for soil-based applications, while liquid fertilizers are best suited where foliar (leaf) applications are required.

- **Supply nutrients in plant-available form:** Right source should ensure that nutrients are applied in plant-available form, or are in a form that converts into a plant-available form in a timely manner to ensure quick and efficient uptake by plants.

- **Suit soil physical and chemical properties:** Right source should consider differences in soil physical and chemical properties for different soil types and farm environments. For example, surface application of urea should be avoided on high pH soils so as to reduce N losses in form of ammonia.

- **Recognize how the application of one nutrient affects the availability or uptake of another nutrient:** Right source should ensure enhanced availability and uptake of other nutrients. For example, the co-application of N and P enhances the uptake of P. The complementing effects of using both manure and mineral fertilizer sources should also be considered.

- **Recognize blend compatibility:** Right source should consider compatibility of nutrients when mixing different nutrients. For example, certain combinations of nutrient sources attract moisture when mixed, limiting uniformity of application of the blended material. During blending, it should also be ensured that fertilizer granules are of a similar size to ensure uniform application in the field and prevent segregation of blended fertilizers.

- **Recognize benefits and sensitivities to associated elements:** Most nutrients often have an accompanying ion that may be beneficial, neutral or harmful to the crop. For example, the chloride (Cl^-) that accompanies K in muriate of potash is beneficial to maize, but can decrease the quality of of some crops (e.g., tobacco and some fruits).

2. ESSENTIAL PLANT NUTRIENTS

Essential plant nutrients refer to nutrients that are required by plants to effectively complete their lifecycle. All plants require at least **17 essential nutrients.**

Each of these essential nutrients has unique functions for metabolism and plant growth. However, the amount of each specific nutrient required by plants varies greatly.

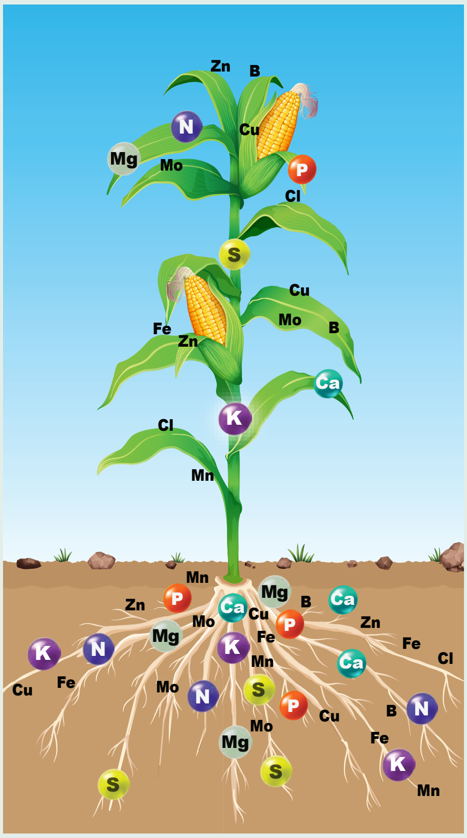
Of these essential nutrients, **carbon (C), hydrogen (H) and oxygen (O) are derived from the air and are referred to as non-mineral nutrients.**

The other **14** essential nutrients are referred to as **'mineral nutrients',** and are derived from the soil or supplied through fertilizers or organic manure.

Mineral nutrients are divided into two main groups namely **macronutrients** and **micronutrients**.

Table 1: List of essential plant nutrients, their primary plant-available form, and main form in soil reserves.

Nutrient	Chemical symbol	Primary form for plant uptake	Main form in soil reserves
Macronutrients			
Nitrogen	N	Nitrate (NO_3^-) or Ammonium (NH_4^+)	Organic matter
Phosphorus	P	Phosphate (HPO_4^{2-}, $H_2PO_4^-$)	Organic matter, Soil minerals
Potassium	K	Potassium ion (K^+)	Minerals
Sulphur	S	Sulphate (SO_4^-)	Organic matter, Soil minerals
Magnesium	Mg	Magnesium (Mg^{2+})	Soil minerals
Calcium	Ca	Calcium ion (Ca^{2+})	Soil minerals
Micronutrients			
Chlorine	Cl	Chloride (Cl^-)	Soil minerals
Iron	Fe	Iron (Fe^{2+})	Soil minerals
Manganese	Mn	Manganese ion (Mn^{2+})	Soil minerals
Zinc	Zn	Zinc ion (Zn^{2+})	Soil minerals
Copper	Cu	Copper ion (Cu^{2+})	Organic matter, Soil minerals
Boron	B	Boric acid (H_3BO_3)	Organic matter
Nickel	Ni	Nickel ion (Ni^{2+})	Soil minerals
Molybdenum	Mo	Molybdate (MoO_4^{2-})	Organic matter, Soil minerals



2.1 Macronutrients

Macronutrients are required by plants in large quantities for good growth and productivity. They are divided into two sub groups namely **primary macronutrients** and **secondary macronutrients.**

Primary macronutrients include:

nitrogen (N), phosphorus (P), and potassium (K), and are required by plants in larger quantities (i.e., >30 kg/ha).

Secondary macronutrients include:

sulphur (S), magnesium (Mg), and calcium (Ca), and are required by plants in smaller quantities (i.e., 5 - 30 kg/ha).

2.2 Micronutrients

Micronutrient are required by plants in very small quantities. However, plants must have them when and where they need them for good growth and yield.

Most soils usually have sufficient quantities of micronutrients and they often don't need to be applied in the form of fertilizers. A shortage of macronutrients or micronutrients causes plant deficiencies and eventually leads to a decline in crop growth, yield and quality.

Micronutrients include:

chlorine (Cl), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo), and nickel (Ni).

Where the application of micronutrients is required, special attention and care is needed since there is a narrow margin between applying too much or too little to meet the needs of a crop. Often special compound NPK fertilizers can be prepared to contain combinations of micronutrients designed to fulfill the requirements of crops grown on soils that are known to be deficient.

In many cases, micronutrient shortages are caused by a low (acidic) soil pH, or more often by a soil pH that is too high (neutral to alkaline), thus a change in soil pH may improve the availability of micronutrients.

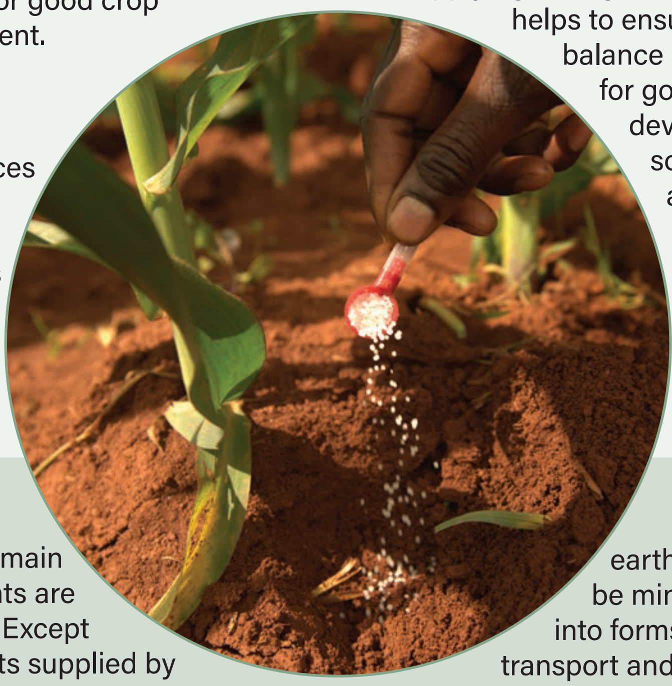
3. SOURCES OF MINERAL NUTRIENTS

Plants require a balanced uptake of all the essential nutrients for good yield and quality. Most soils often lack the appropriate balance of nutrients required for good crop growth and development.

Continuous cropping without application of external nutrient sources such as fertilizer or manure also depletes soil available nutrients that might have been initially available in sufficient quantities.

Soil and plant analysis can help to identify specific nutrients that may be inadequate.

Applying the right source of nutrients helps to ensure the appropriate balance of nutrients required for good crop growth and development. Nutrient sources that are available to farmers include: **fertilizer, animal manure, compost manure, green manure,** and **crop residues.**



3.1 Fertilizer

Fertilizer is one of the main forms in which nutrients are brought into the farm. Except for N, all other nutrients supplied by fertilizers are derived from naturally occurring earth minerals that can be mined and processed into forms that are easy to transport and more available to plants.

3.2 Legumes

Air contains 79% di-nitrogen gas (N_2) which cannot be used directly by plants. However, grain legumes (such as soybean, groundnut, pigeon peas, cowpeas, and beans) and green manure legume plants (such as mucuna and crotalaria) are capable of converting N_2 from the air into a form usable by the plants. These legume plants have nodules on their roots which act as 'small factories' that manufacture the nitrogen that they use for their growth (**Fig. 1**). When legumes are added back to the soil, they decay and release N that can then be used by other crops in the rotation, and can also contribute to building soil organic matter.

Cereal crops like maize, rice, wheat, and teff cannot manufacture their own N as they do not have these special nodules in their roots. Such crops can benefit from N fixed by the rotated legumes crops, but still require external sources of N fertilization to achieve high yields.

Figure 1. Nodules are 'fertilizer N factories' on the roots of a legume crop.

3.3 Animal manures and composts

Animal manures and composts are good sources of plant nutrients when used correctly. Manures contain all nutrients required by plants, but the quantities are usually small compared to the amounts required by plants for high yields.

The amount of nutrients in manure, particularly N, can be increased by feeding livestock with good quality pastures and reducing losses of nutrients during storage and handling.

3.4 Other organic materials

Other organic materials such as crop residues release nutrients that they contain during their decay. The quality of an organic material is determined by the nutrients it contains. Organic materials can contain a wide range of nutrients although the amounts are generally small.

Most organic materials found in smallholder farms are of poor quality, and contain small amounts of major nutrients. Despite this low nutrient quality, organic materials are still valuable as a source of organic matter.

Heathy maize crop provided with a balanced supply of nutrients.

4. BALANCED NUTRITION AND RIGHT SOURCE

Balanced nutrition is the key to higher crop yields and is the basis of selecting the right nutrient source.

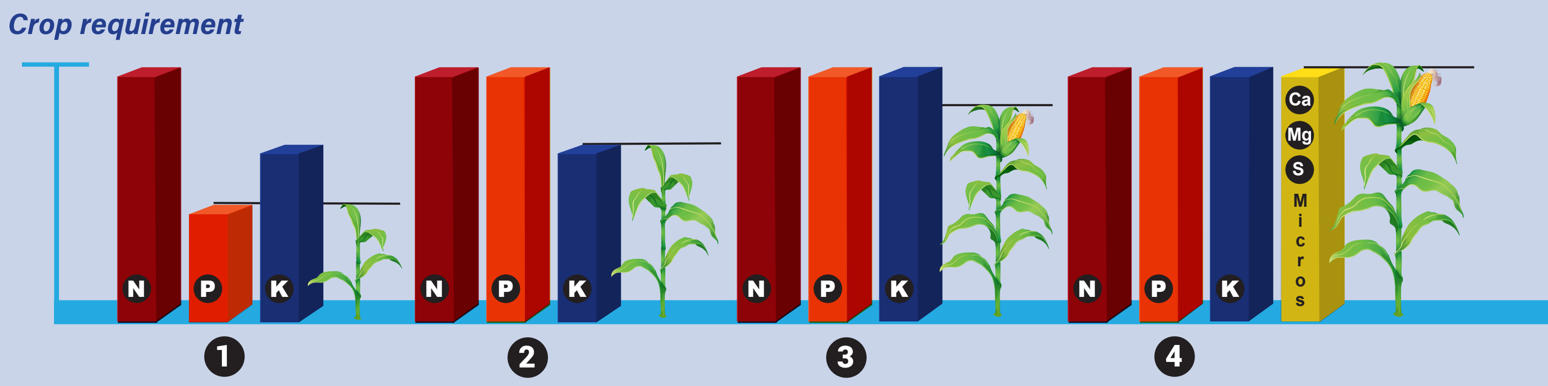
The concept of balanced nutrition indicates that a crop requires an adequate supply of all nutrients for optimum growth. If more than one nutrient is in short supply, crop growth is determined by the nutrient that is in lowest supply.

The concept of balanced nutrition is based on Liebig's law of minimum which states that if one of the essential nutrients is deficient, plant growth will be poor even when all other essential nutrients are in sufficient supply.

When a deficient nutrient is supplied, yields may be improved to the point that some other nutrient is needed in greater quantity than the soil can provide. External nutrient sources will then be required to supplement soil supply.

Simplified illustration of the law of minimum and balanced nutrition concept.

1. When a plant has ample supply of N, moderate supply of K, and low supply of P, crop growth and yield is then proportional to the amount of the most limiting nutrient—in this case P.
2. When the supply of P is improved but the amount of K remains low, crop growth improves but is then limited by the lower supply of K such that crop growth and yield is then proportional to the amount of K which is in this case the limiting nutrient.
3. When available K is enhanced through external supply, all three macronutrients are now available in sufficient quantities and crop growth and yield increases to match the soil nutrient supply.
4. Often secondary macronutrients (S, Ca and Mg) and micronutrients need to be provided in addition to primary macronutrients (N, P and K) in order to remove all nutrient limitations and achieve the attainable yield.



Leibig's Law of Minimum Illustrated with Nutrients

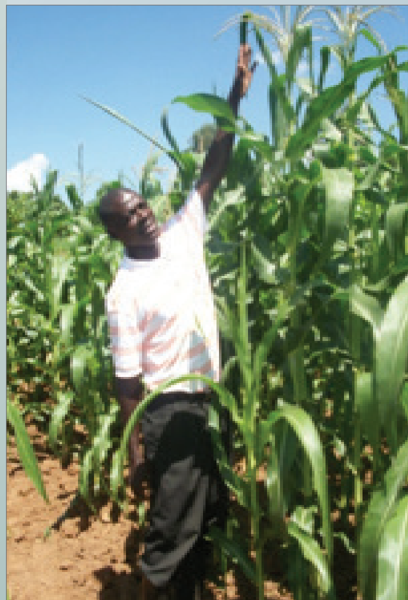
No Fertilizer

P & K

N & K

N & P

N & P & K



An on-farm study in western Kenya demonstrating the need for balanced nutrition in line with Leibig's law of minimum as illustrated by maize growth in plots with and without nutrients applied. Images were taken on the same day and farm at 7 weeks after planting.

5. KNOW YOUR FERTILIZERS

5.1 What is fertilizer?

Fertilizer refers to material containing at least one of the essential plant nutrients in chemical form that is soluble in the soil solution phase when applied to the soil and 'available' for plant root uptake.

For a material to be classified as a fertilizer, it should contain at least 5% of one of the essential nutrients in an immediately plant-available form.

5.2 Forms of fertilizer

Fertilizer is usually available in solid or liquid form. Most fertilizer is usually supplied in solid form.

Solid fertilizers are usually in the form of granules though others can be in form of pellets or powders depending on the manufacturing process.

Liquid fertilizers are widely used in horticultural and irrigated cropping systems.

5.3 Fertilizer nutrient contents and labeling

Fertilizers are normally sold with a grade or guaranteed minimum contents.

The nutrient content of fertilizers is usually indicated on the bag's label as a series of numbers (**Fig. 2**). The first three numbers always refer to the primary nutrients N, P and K. These nutrients are expressed as percent N-P_2O_5-K_2O, where the contents of P and K are commonly indicated in oxide form (i.e., P_2O_5 and K_2O). For example, a compound fertilizer labelled 17-17-17 means that the nutrient content of the fertilizer is 17% N, 17% P_2O_5 and 17% K_2O. Similarly, a fertilizer labelled as 18-46-0 contains 18%, 46% P_2O_5 and no K.

If any other nutrient is present, an additional number is given, followed by its chemical symbol. For example, a fertilizer product labelled 15-20-22-0.5B is guaranteed by the manufacturer to contain a minimum of 15% N, 20% P_2O_5, 22% K_2O, and 0.5% B.

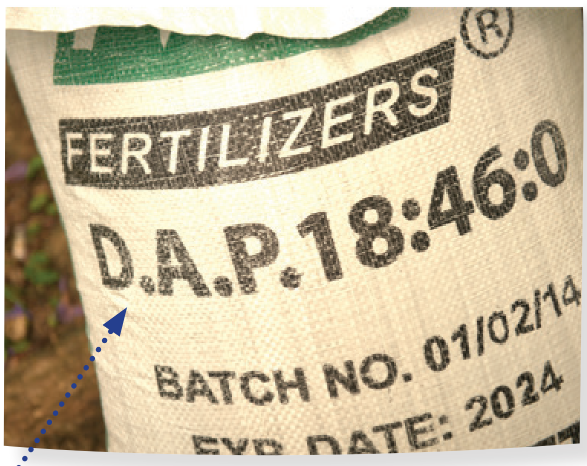


Figure 2. Some fertilizer products with labeling showing nutrient contents and concentrations.

NOTE: The P and K contents of fertilizer are always presented in the oxide forms. To convert the oxide forms of P and K to their elemental forms, use the following conversion factors:

For phosphorus:

$\%P = \%P_2O_5 \times 0.44$

Therefore, for a fertilizer containing 14% P_2O_5, calculate the %P as: %P = 14 x 0.44 = **6.2**

For potassium:

$\%K = \%K_2O \times 0.83$

Therefore, for a fertilizer containing 14% K_2O, calculate the %K as: %K = 14 x 0.83 = **11.6**

These conversions mean that the molecular weight of P_2O_5 is 44% P with oxygen (O_2) making up the difference; similarly the weight of K_2O is only 83% K.

Labels on fertilizer packaging also indicates the weight of the bag and sometimes includes recommendations for correct handling and storage. Additional labelling details can include the manufacturing date, and the expiry date.

One should be keen to read and understand all details included on the fertilizer bag label to ensure the right source is selected.

5.4 Classification of fertilizers

Fertilizers are often classified based on the nutrients they contain, or the method of their formulation.

Fertilizer classifications based on nutrient content include: **single nutrient** or **straight fertilizers, complete fertilizers,** and **incomplete fertilizers.**

Examples of fertilizer classification based on formulation include: **bulk blend fertilizers** and **compound fertilizers**.

Single nutrients or straight fertilizers

These contain only one of the major nutrients (N, P or K). Examples include Urea (46-0-0), Calcium ammonium nitrate or CAN (27-0-0), and Triple superphosphate or TSP (0-46-0).

Straight fertilizers are economical for addressing the shortage of a single macronutrient which is considered as most limiting.

Some straight fertilizers can be easily blended to meet the nutrient demands of a particular field or crop.

Complete fertilizers

These contain all of the major nutrients. An example is NPK fertilizer (15-15-15).

Incomplete fertilizers

These contain only two of the major nutrients. An example is Diammonium phosphate or DAP (18-46-0), which contains only N and P.

Bulk blend fertilizers

These are a physical mixture of two or more fertilizers. Different combinations of dry fertilizers are mixed to meet specific crop and soil conditions.

Bulk blends are adjusted to differing ratios of nutrients for individual crop and soil conditions.

Bulk blends are popular for their lower cost because the lowest costing fertilizer materials can be combined using inexpensive materials. However, not all solid fertilizers are compatible for mixing.

The individual fertilizer components must be chemically and physically compatible for mixing and storing.

Care is also required when handling bulk blends to avoid separation (segregation) of the individual components during handling and spreading.

Compound fertilizers

These fertilizers contain two or more nutrients that are chemically combined within a single particle. Each fertilizer granule therefore contains a mixture of nutrients.

Compound fertilizers provide a uniform distribution of nutrients from each particle.

Compound fertilizers are easier to handle or apply. They offer simplicity in making fertilizer decisions where application of multiple nutrients is commonly required.

Compound fertilizer granule types (cross-section)

Table 2: Properties of common fertilizers, their agricultural use and management.

Fertilizer	Properties	Agricultural uses	Management
Calcium ammonium nitrate (CAN)	- Contains 27% N; also supplies small amounts of Ca - Grey or light brown in colour depending on the coating used	- Can be used as a basal source of N but is mainly used as a top-dressing fertilizer - Most suitable N fertilizer for semi-arid regions	- Should be stored in a closed dry room - Must be covered with soil at application
Urea	- Contains N only at 46% N - Most concentrated solid N-supplying fertilizer - White in colour with round granules - Usually has a lower cost per unit than other N fertilizers - Highly water soluble - Hygroscopic (readily takes up and retains moisture)	- Good for topdressing	- Must be covered by soil at application to avoid volatile losses of ammonia to the air - Should be incorporated it into the soil immediately after application - Should be packed in moisture proof bags and well stored
Ammonium sulphate	- Contains 21% N and 23% S - Usually white in colour with small sugar like granules	- Very useful where there is need for both N and S - Preferred for use in irrigation systems such as rice systems where nitrate-based N fertilizers such as CAN are not suitable due to denitrification losses under water logged conditions - Useful in increasing the effectiveness of post-emergence herbicide sprays in weed control - Can be applied at sowing but best suited for top dressing after crop emergence	- It should not be applied in highly acid sulphate soils due to risk of sulphide injury - Should be incorporated into soils upon application to avoid losses
Single superphosphate (SSP)	- Contains 16 to 20% of P_2O_5, 12% of S and 18 to 21% Ca - Is grey ash in appearance with good storage qualities	- Good source of P, S and Ca	- Requires no special handling procedures - Phosphorus does not move fast with water in soil, and so should be applied near root zone of plants
Triple superphosphate (TSP)	- Contains 46% P_2O_5 and 15% Ca - The most concentrated form of straight P fertilizer - Soluble in water - Usually grey in colour with large granules	- Is suitable on most soil types - In addition to P, it also supplies calcium	- It contains traces of free phosphoric acid hence must be properly packed - Should be applied at the right rate, time and well covered to minimize losses to water bodies through surface runoff - Does not move fast in soil hence should be applied near root zone of plants
Diammonium Phosphate (DAP)	- Incomplete compound fertilizer - Contains 18% N and 46% P_2O_5 - Most widely used P fertilizer - Usually dark brown with large round granules - Highly soluble and dissolves quickly in soil to release plant-available phosphate and ammonium	- Suitable for basal supply of N and P	- Should be well stored under dry conditions - Avoid placing high concentrations of DAP near germinating roots to avoid damage to seedlings and plant roots
NPK	- Complete compound fertilizer - Available in different compositions with varying amounts of N, P and K as per region- or crop-specific nutrient requirements	- Suitable for basal supply of N, P and K	- Should be well stored under dry conditions - Care should be taken to confirm nutrient contents as per the label and composition of NPK fertilizers vary compared to those of other common fertilizers which are usually constant

Examples of Common Fertilizers

6. NUTRIENT UPTAKE AND RIGHT SOURCE

Nutrients need to be in their plant-available forms for plant uptake to occur.

Nutrients are only taken up by roots when they are dissolved in the soil water. Insoluble nutrients are not immediately useful for plant nutrition.

Since plant roots can only acquire nutrients that are dissolved in water, their solubility is an important consideration for plant nutrition. Therefore, the total nutrient content of a soil does not always reflect the soluble nutrient supply available for uptake.

Factors that restrict root growth will also reduce nutrient uptake. For example, soils that are cold, dry, acidic, or compacted may all result in reduced nutrient uptake.
Plants mostly take up inorganic forms of nutrients, and the source of the nutrient makes no difference during uptake by the root or for plant growth. For example, nitrate comes from many sources in the soil, but the plant does not distinguish between them (**Fig. 4**).

Once taken up by the plant, the nutrient source is no longer important. Addition of organic matter can change soil properties, but the nutrients that are mineralized (i.e., P, S and micronutrients) are the same as those from fertilizer.

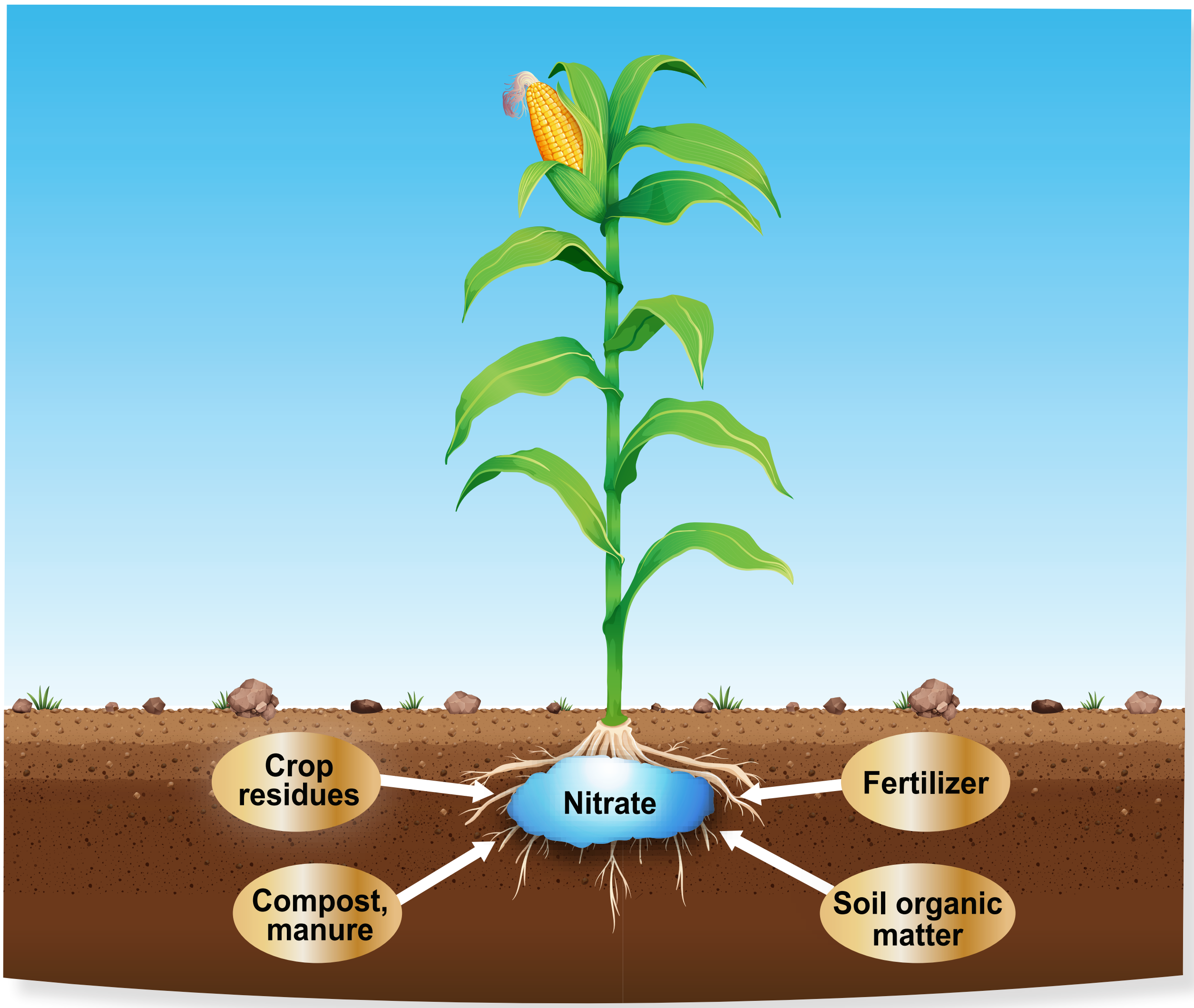


Figure 4. Once in the soil, the source of nitrate makes no difference during uptake by roots for plant growth.

7. KEY CONSIDERATIONS FOR RIGHT SOURCE

There is no one "right source" for every soil and crop condition. Each crop, soil and farmer has different needs and objectives. When deciding on the right source, a variety of local and site-specific factors must be considered. These individual economic, production and site-specific issues will be different for each farmer and perhaps different for separate fields too. The factors to consider include:

- **Consider the rate of application:** Different fertilizers and organic resources contain different types of nutrients and at different concentrations. For example, fertilizers usually contain higher concentrations of nutrients such as N compared to organic resources. Therefore, when high nutrient rates are desired, fertilizers may serve as a better source compared to organic resources.

- **Consider time of application:** Different nutrient sources release nutrients at different rates. For example, organic resources such as manure release nutrients slowly compared to fertilizers. Therefore, where nutrients are required to be applied several weeks before planting, organic resources may serve as the right nutrient source whereas fertilizers would be the right nutrient source where application is required at planting time.

- **Consider the place of application:** Depending on where nutrients are required to be applied, different sources may serve as the right source. For example, for foliar applications of micronutrients, fully soluble straight micronutrient sources would serve as the right source. When field application of micronutrients is required, granular compound fertilizers containing micronutrients would be the appropriate source.

- **Soil physical and chemical properties:** For example, avoid nitrate application in flooded soils or surface application of urea on high pH soils.

- **Nutrient interactions:** Application of one nutrient can affect availability or uptake of another nutrient. For example, N application increases P uptake.

- **Beneficial versus potential harmful effects:** Most nutrients often have an accompanying nutrient ion that may be beneficial, neutral, or harmful to the crop. For example, the chloride (Cl) that accompanies K in muriate of potash is beneficial to maize but harmful to crops such as tobacco.

- **Fertilizer availability:** Ensure that recommended sources are available to the farmer. It is not practical to recommend fertilizers that are not available in a farmer's area.

- **Cost of Source:** Sources that give best value for money in terms of kilograms of nutrients supplied per unit cost offer best value.

- **Nutrient availability:** Ensure that the selected source matches nutrient release with peak periods of plant demand.

- **Balanced Nutrition:** Avoid focusing only on macronutrients, although they are required in the largest quantity.

- **Other soil conditions:** Correct other problems that may limit nutrient uptake, such as acidity, compaction or salinity.

Photo Gallery

Effects of phosphorus-limiting conditions on maize growth in the foreground as demonstrated by the stunted maize growth and phosphorus-deficiency symptoms, compared with maize growth under sufficient phosphorus-supply conditions.

Effects of potassium-limiting conditions on maize growth in the foreground as demonstrated by the weak maize growth and potassium-deficiency symptoms, compared with maize growth under sufficient phosphorus-supply conditions.

Benefits of applying the right source as demonstrated by good maize growth on the left compared with poor maize growth under no nutrient's application in under low soil fertility conditions.

Notes

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Module 1: Right Source Quiz

1. Which are the 4R rights of fertilizer management?
   a) Right fertilizer, right seed, right time, right place.
   b) Right time, right source, right farm, right place.
   c) Right source, right rate, right time, right place.
   d) Right source, right rate, right time, right price.

2. What does the right source mean?
   a) Applying the right amount of fertilizer and organic nutrient resources.
   b) Applying fertilizers and organic resources at the right time.
   c) Applying fertilizers and organic resources in the right place.
   d) Applying the correct fertilizer and organic nutrient resources.

3. Which of the following is one of the core scientific principles that define right source?
   a) Apply only plant-available forms of nutrients.
   b) Suit soil physical and chemical properties.
   c) Avoid applying associated elements.
   d) Ignore blend compatibility.

4. An element is considered essential to plant growth if
   a) The soil contains only small amounts of it.
   b) Plants require it in its elemental form.
   c) It is capable of being taken up by plants.
   d) All plants require it to complete their life cycle.

5. Which one of the following is not a macronutrient?
   a) Nitrogen
   b) Calcium
   c) Zinc
   d) Potassium

6. Which one of the following is not a micronutrient?
   a) Iron
   b) Magnesium
   c) Boron
   d) Copper

7. Which one of the following is a straight fertilizer?
   a) DAP
   b) UREA
   c) CAN
   d) NPK

8. Compound fertilizers can be useful for
   a) Single-nutrient applications.
   b) Supplying differing ratios of nutrients to meet specific needs.
   c) Eliminating potential segregation of nutrients.
   d) Supplying macronutrients without micronutrients.

9. What are the nutrient contents of a fertilizer labeled as 10-23-12-5S?
   a) 10% N, 10% P, 10% K and 5%S
   b) 10% N, 23% P, 12% K and 5%S
   c) 10% N, 23% P, 10% K and 5%S
   d) 10% N, 10% P, 10% K and 0.5%S

10. What would be the proper labeling for a fertilizer that contains 7% Sulphur, 13% Phosphorus, 12% Nitrogen and 15% Potassium to the nearest decimal?
    a) 7-13-12-15S
    b) 7S-30P-12N-15K
    c) 12N-30 P_2O_5-18 K_2O-7S
    d) 12-30-18-7S

For the answers, take the on-line quiz at:
https://www.apni.net/courses/4rs-for-extension-agents/

ABOUT **The 4R Solutions Project**

4R Solution

www.4rsolutions.org

The 4R Solutions Project is funded by Global Affairs Canada to improve the livelihoods of 80,000 smallholder farmers in Ethiopia, Ghana and Senegal by improving agricultural productivity and farm income through incorporation of 4R Nutrient Stewardship into local farming practices. 4R Nutrient Stewardship supports best management of plant nutrients based on four key practices: Right Source, Right Rate, Right Time, and Right Place.

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