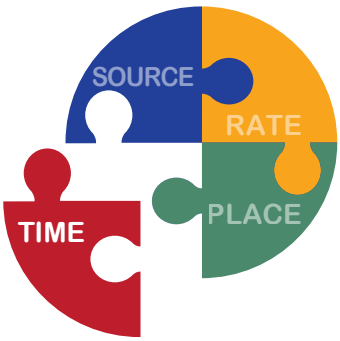
4R NUTRIENT STEWARDSHIP GUIDEBOOK

LEARNING MODULES FOR EXTENSION AGENTS

MODULE 3
RIGHT TIME



RIGHT TIME:

MATCHING NUTRIENT APPLICATION WITH THE TIMING OF PLANT NUTRIENT UPTAKE.

AFRICAN PLANT NUTRITION INSTITUTE

4 Solution

1. SCIENTIFIC PRINCIPLES BEHIND RIGHT TIME

After the right source and right rate of nutrient application have been determined, nutrients should be applied so as to match the timing of plant uptake. Matching nutrient application with plant uptake ensures that plants can access nutrients during periods when they most require them. This ensures efficient use of applied nutrients, and results in optimal crop growth and yield benefits.

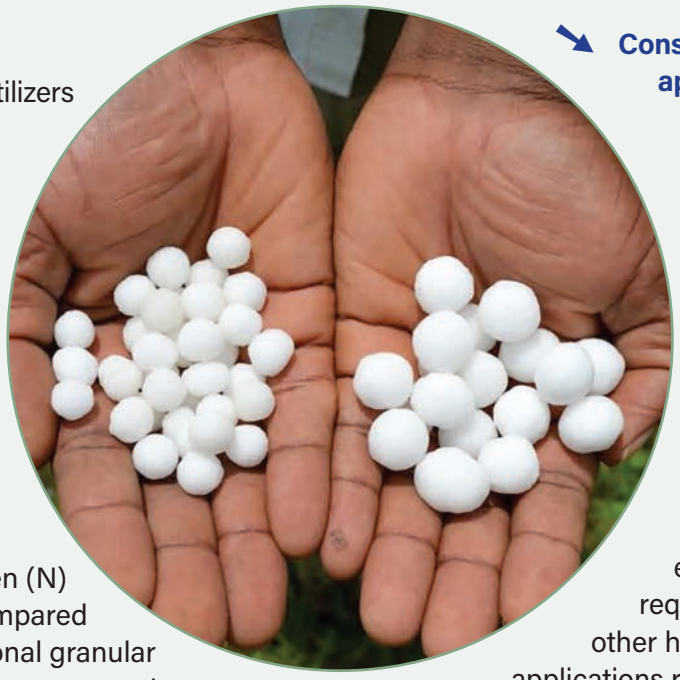
To determine the right time, the following scientific principles should be considered:

- Consider source, rate, and place of nutrient application.
- Assess timing of plant nutrient uptake.
- Assess dynamics of soil nutrient supply.
- Assess the risk of soil nutrient losses.
- Evaluate logistics of field operations.

1.1 Consider source, rate, and place of nutrient application

Consider the source of nutrients: Nutrient sources differ in their rate of nutrient release, and this has an influence on the right time of nutrient application. For example, organic nutrient sources such as manure release nutrients slowly compared to mineral sources such as fertilizer. Therefore, when using organic sources as the nutrient source for annual crops such as maize, their application should be done well in advance of the planting time (e.g., 2 to 3 weeks before planting) to ensure good synchrony between the release of nutrients from the applied manure, and plant uptake by the growing crop. On the other hand, when using mineral fertilizers as the source of nutrients, their application can be at the time of planting or a few days after emergence.

Slow release fertilizers can extend the period of time that nutrients are made plant-available compared to conventional fertilizer types. For example, urea fertilizer in the form of urea super granules releases nitrogen (N) more slowly compared to the conventional granular urea fertilizer. For crops such as rice, the use of urea super granules can reduce the frequency of applications required to provide sufficient N. Therefore, fertilizer application timings should be adjusted based on the selected form of mineral fertilizer.



***Urea super granules** release N more slowly compared to conventional urea fertilizer.*

Consider rate of nutrient application: The planned rate of nutrient application has an influence on the right time of nutrient application. High nutrient application rates of mobile nutrients such as N may require more than one application timings in order to split the total amount into smaller amounts that match plant demand. Split applications are a way to manage nutrient losses and enhance nutrient use efficiency. For example, where the planned N application rate for cereals such as maize, rice, wheat, and teff is greater than 40 kg N/ha, it is recommended to split the application so that part of the N fertilizer is applied as a basal application at the time pf planting, and the rest as a top dressed application after the crop is growing. This practice enhances the recovery of applied N fertilizer by plants, and minimize N losses.

Consider place of application: The selection of the nutrient application method has an influence on the proper timing of nutrient application. For example, foliar fertilizer applications allow for rapid uptake of nutrients by plants and can therefore be applied at the exact time that plants require nutrients. On the other hand, soil based fertilizer applications require more time for the nutrients to become both plant available and physically accessible to be taken up by plants. As a result, applications to soil should be applied a few days in advance of the desired uptake period.

1.2 Assessing timing of plant nutrient uptake

Assessing crop nutrient uptake dynamics is an important component in determining the right timing of nutrient application as the rate of plant nutrient uptake is not constant throughout the season. Most crops take up nutrients slowly during the early stages of growth, with nutrient uptake increasing to a maximum during the rapid growth phase, and declining as the crop matures. This uptake pattern follows a sigmoid or "S" shaped curve (**Figure 1**).

Nutrient applications timed correctly at specific growth stages are beneficial to crop yield and the quality of the grain produced by cereal and legume crops. Particularly for cereals, application of nutrients such as N based on growth stages helps to match nutrient application with peak nutrient uptake stages. Well timed applications also help to minimize nutrient losses.

For example, in wheat and teff, application of top dress N fertilizer at early tillering stage helps to enhance N uptake and increase yields. For rice, split applications of top dress N fertilizer at tillering stage and at panicle initiation helps to enhance N uptake and increase yield.

For legumes such as groundnuts, additional calcium (Ca) application when groundnut pods are developing is recommended so as to ensure good seed development particularly where soils are deficient in Ca. Application of Ca fertilizers can therefore be timed to coincide with the period just before flowering.

To simplify recommendations for split N applications in cereals, recommendations for split applications are often made in terms of weeks after planting, with the number of weeks after planting selected to match with key growth stages of peak N demand. For example, split N application for maize is often recommended as:

- A third of the recommended N fertilizer rate at planting
- A third of the recommended N fertilizer rate at four weeks after planting
- A third of the recommended N fertilizer rate at eight weeks after planting

However, as crop growth and development differ based on crop variety and growing environment, care should be taken to ensure that time-based recommendations are well in line with specific growth stages for a given crop variety and growing environment.

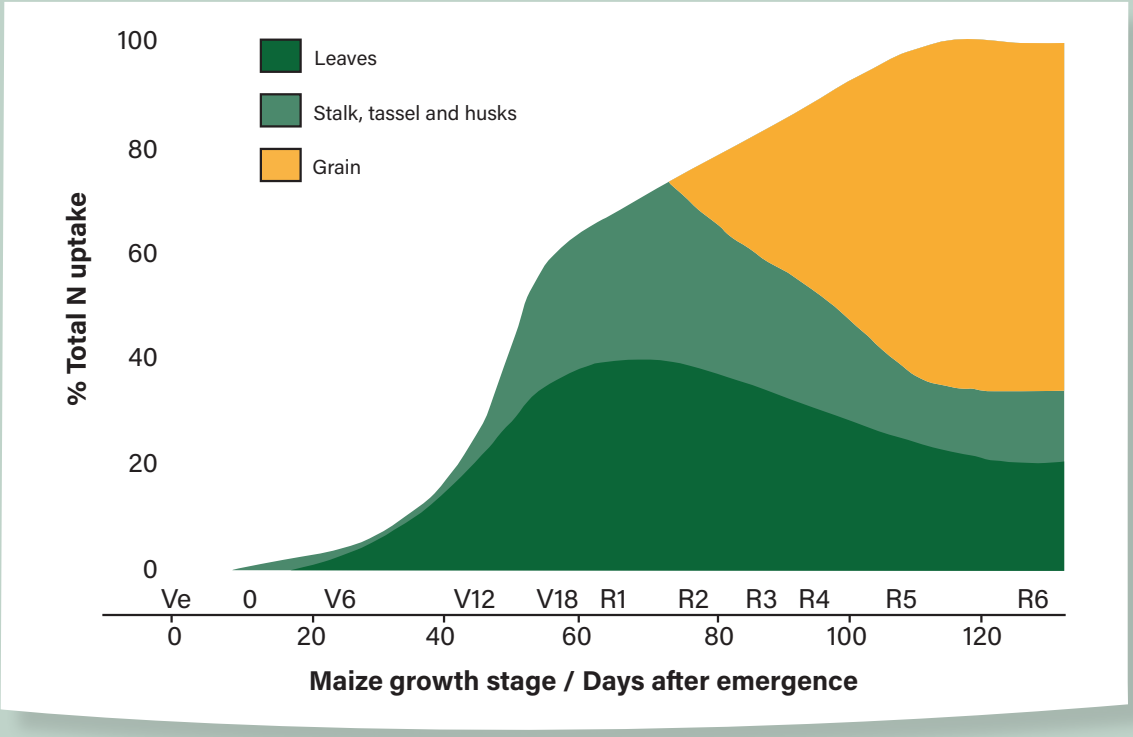


Figure 1. Cumulative maize N uptake divided by plant organ. Adapted from: How a Corn Plant Develops, Iowa State, University Special Report No. 48, Nov. 2008

Maize fertilizer N application *(counter clockwise) at planting, at four weeks after planting, and at eight weeks after planting.*

1.3 Assessing dynamics of soil nutrient supply

Most soils have the capacity to supply at least some of the nutrient requirements of a crop. Different soils however possess different capacities to supply nutrients required by crops. In general, sandier soils store and supply less nutrients than soils with finer textures. The same is true for soils that have been cultivated for longer periods with little addition of mineral fertilizer or organic nutrient resources.

While the soil nutrient supplying capacity mainly influences decisions about the right nutrient application rate, it also has an influence on the proper timing of nutrient applications. Generally, the greater the soil's capacity to retain and supply a particular nutrient throughout the growing season, the less the need for critical timing emphasis for the application of that nutrient.

Certain soil properties such as high **phosphorus (P) fixation capacity** also strongly influence the ability of a particular soil to continuously supply plants with applied nutrients. This additionally influences decisions on the right time of nutrient application. A good understanding of the transformations of different nutrients in the soil under different soil and climatic conditions is therefore fundamental to assessing the dynamics of soil nutrient supply, and in making decisions on nutrient applications timing. For example, in many agricultural soils, large applications of P fertilizers can be effective at supplying the P needs of crops grown over several cropping seasons. In such soils, the applied P is held by the soil but remains available to crops grown in the next season. However, acidic soils that are common in high rainfall areas of Africa usually bind the P provided as fertilizer and make it unavailable to plants grown in the subsequent season. In such soils, seasonal application of P fertilizer must be done at planting to enhance uptake by plant roots.

Within a given soil, plant available N is supplied by either mineralization of soil organic matter or by residual nitrate (NO_3^-) and ammonium (NH_4^+). In arid climates, nitrate can accumulate in soils and be carried over across multiple seasons. Where rainfall is higher, nitrate is more readily removed from soils

by leaching and/or denitrification. Losses of applied N are therefore often higher in regions with high rainfall, and application timings in such areas therefore need to be well timed to minimize losses. For example, top dressed N fertilizer application should not be conducted during periods of heavy rainfall or when heavy rains are eminent.

1.4 Assessing the risk of soil nutrient losses

Fertilizer applications based on 4R principles should aim at reducing losses of applied nutrients from the soil. Losses of applied N and P from cropping systems are generally of the greatest concern since the loss of each of these nutrients not only has negative economic impacts, but can create specific environmental problems. Understanding the loss mechanisms of each of these nutrients can help in devising application timings that can help to reduce nutrient losses from the soil.

Nitrogen can be lost through several ways including leaching whereby N in form of nitrate is washed through the soil by rain or irrigation water. Nitrogen can also be lost through surface runoff from fields, and or lost into the air as gas. Applied P is mostly lost through surface runoff, with minimal losses through leaching.

Losses of applied P from the soil are therefore best managed through right placement of fertilizer P below the soil surface. On the other hand, losses of applied N can be managed through right timing of N fertilizer applications. For example, sandy soils in high rainfall areas have a high potential for N loss through leaching. To minimize loss of applied N in such environments, application of nitrogen fertilizers should be split into several applications at low rates. Timing of nitrogen fertilizer application should also aim at avoiding periods of very heavy rainfall so as to minimize the risk of leaching losses of applied N.

1.5 Evaluating logistics of field operations

The logistics of fertilizer distribution, field operations, and household operations are important factors affecting decisions on right timing. It is important to consider any of these factors, which may affect the timing of fertilizer application when making decisions on the right application time. Specific considerations may include:

- The labour availability for fertilizer application and other field operations. To ensure efficient use of labour, basal fertilizer applications can be conducted during planting so as to make use of the same labour force available during planting.
- Decisions on the specific types and quantities of fertilizers to be used in a particular cropping season should also be made in good time so as to ensure timely purchase of fertilizer. For example, any planned soil or plant analysis to determine fertilizer requirements for the upcoming cropping season should be carried out well in advance.
- The timely availability of fertilizer can be a problem in many smallholder farming areas of Africa. If fertilizer is not available at the time it is required to be applied, it will not be possible to ensure the right application timing. Fertilizer should therefore be purchased well in advance to ensure that the required types and amounts of fertilizer are available for use at the right time.
- The timing of fertilizer applications should also consider weather conditions. For example, top dressing of N fertilizer should be avoided when the soils are dry, during periods of heavy rains, or when heavy rains are imminent. Nitrogen fertilizers should be applied when the soil is moist to enhance uptake by the crop. An assessment of current weather conditions should therefore be used to guide the final decision on the right time for top dressing fertilizer.

Notes

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Module 3: Right Time Quiz

1. What does the right time of nutrients application mean?

   a) Applying nutrients when fertilizers are available
   b) Applying nutrients during planting only
   c) Applying nutrients when deficiency symptoms occur
   d) Applying nutrients when the crop requires them

2. Which of the following is part of the core scientific principles that define right time for a specific set of conditions.

   a) Apply nutrients just before the grain-filling stage
   b) Evaluate logistics of field operations
   c) Assume slow mineralization of soil nutrients
   d) Apply nutrients just before leaching risks increase

3. Which of the following is not important when considering the right time to apply fertilizers?

   a) Consider plant spacing
   b) Consider availability of fertilizers
   c) Consider weather conditions
   d) Consider form of fertilizer available

4. When is the right time for the application of manure as a source of nutrients to a maize crop?

   a) Two weeks after planting
   b) During planting
   c) Two months before planting
   d) Two weeks before planting

5. Timing of nutrient application is most important for

   a) N
   b) P
   c) K
   d) Ca

6. In areas with high rainfall, nitrate is readily removed from soils by

   a) Leaching
   b) Nitrification
   c) Immobilization
   d) Volatilization

7. In soils with very high P fixation capacity, an appropriate timing of P application is

   a) Annually after crop emergence
   b) Annually at planting
   c) Once every two years
   d) Once every three years

8. Which one of the following is not an indicator of a soils' nutrient supply capacity?

   a) The soil's sand content
   b) The size of the farm
   c) The soils capacity to retain applied nutrients
   d) The amount of organic resources previously added

9. Which one of the following most strongly affects the ability of a soil to supply crops with applied phosphorus?

   a) Volatilization of applied phosphorus
   b) Leaching of applied phosphorus
   c) Surface run-off of applied phosphorus
   d) Fixation of applied phosphorus

10. Which of the following is a key logistical consideration when making decisions on the right time for fertilizer application?

    a) The source of fertilizer
    b) Weather conditions
    c) Total crop nutrient uptake requirements
    d) Target yield

For the answers, take the on-line quiz at:

https://www.apni.net/courses/4rs-for-extension-agents/

ABOUT **The 4R Solutions Project**

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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