# Integrated Plant Nutrient Management

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**Concept**

The basic concept of integrated nutrient management (INM) or integrated plant nutrition management (IPNM) is the adjustment of plant nutrient supply to an optimum level for sustaining the desired crop productivity.

The Integrated Plant Nutrition System (IPNS) is ‘the management of all available plant nutrient sources (organic, inorganic and microbial), to provide optimum and sustainable crop production conditions within the prevailing farming system’.

It involves proper combination of chemical fertilizers, organic manure, crop residues, $N_2$-fixing crops (like pulses) and oilseeds such as soybean and biofertilizers suitable to the system of land use and ecological, social and economic conditions. The cropping system rather than an individual crop, and farming system rather than an individual field, is the focus of attention in this approach for development INM practices for various categories.

**INM use five major sub-concepts, viz.**

1. Plant nutrients stored in the soil.
2. Plant nutrients, those present in the crop residues, organic manure and domestic wastes.
3. Plant nutrients purchased or obtained from outside the farm.
4. Plant nutrient lossed e.g. those removed from the field in crop harvest and lost from the soil through volatilization (ammonia and nitrogen oxide gases and leaching (nitrate, sulphate etc.)
5. Plant nutrient outputs e.g. nutrient uptake by the crops at harvest time.

**Goals of INM**

- To maintain soil productivity
- To ensure productive and sustainable agriculture
- To reduce expenditure on costs of purchased inputs by using farm manure and crop residue etc.
- To utilize the potential benefits of green manures, leguminous crops and biofertilizers.
- To prevent degradation of the environment.
- To meet the social and economic aspirations of the farmers without harming the natural resource base of the agricultural production.

**Components of the INM**

The three main components of INMS as defined by FAO (1998) are:

1. Maintain or enhance soil productivity through a balanced use of fertilizers combined with organic and biological sources of plant nutrients
2. Improve the stock of plant nutrients in the soils
3. Improve the efficiency of plant nutrients, thus, limiting losses to the environment.

The main objective of the INM is to efficiently utilize all the sources of the

- Plant nutrients
- Soil nutrients.
- Chemical fertilizers.

- Organic manure, soil amendments and crop residues, Green manure.
- Biological nitrogen fixation.
- Biofertilizers.

**Elements of IPNS**

The following elements of IPNS can be considered.

**1. Natural resources**

Soil supply, water supply (irrigation), deposition by rain or dust and natural BNF.

**2. Organic nutrient sources**

***Crop residues:*** Crop residues are important for recycling of a good percentage of nutrients taken up by the plant, which are gradually returned to the soil. Besides, it will also apply organic matter to the soil.

***Green manure:*** Green manure increases the working capital of nutrients by nutrient mobilization (by taking up nutrients from the soil and making them available to the following crop through decomposition, N-fixation or by saving nutrients from leaching). Organic material will be added to the soil as incorporation of green manure.

***Nitrogen fixation:*** Nitrogen fixation by bacteria and other microorganisms through biofertilizers is an important source for non-inorganic nitrogen supply to the cropping system.

## Biological Nitrogen Fixation

The conversion of atmospheric elemental nitrogen into organic combination or forms readily utilizable in biological processes by some microorganisms is known as biological nitrogen fixation.

Two classes of microorganisms for biological nitrogen fixation:

1. Symbiotic
2. Non-symbiotic

1. Symbiotic nitrogen fixation:

The association in which two dissimilar organism /living being live together with mutual benefits from each other is known as symbiosis. The organism involved is called symbiotic organism. The nitrogen fixation is bought out by this organism fixation; the phenomenon is called symbiotic nitrogen fixation.

There are some agents for symbiotic biological nitrogen fixation:

a. Root nodule bacteria
   e.g; Legume + *Rhizobium* / *Bradyrhyzobium*
   Non-legume + *Frankia* (Actinomycetes)
b. Algal association
   e.g; *Azolla* + *Anabaena*
c. Bacteriorhyza
   e.g; rice root + *Azospirillum*

2. Non- symbiotic nitrogen fixation:

When nitrogen fixation is bought out by some free living organisms **independently**, the process is known as symbiotic biological nitrogen fixation.

e.g; *Azotobacter*, *Clostridium, Bacillus*

Blue Green Algae (BGA)

e.g; *Nostoc*, *Anabaena*, *Aulosira*, *Gleotrachia*, *Scytonema*, *Plectonema*, *Oscillatoria*, *Calothrix*, *Tolypothrix.*

***Organic matter management:*** Organic matter management Preservation and application of organic matter from manures (e.g. cowdung, poultry manure, FYM) or compost (e.g. water hyacinth). Important criteria of organic matter sources are the dry matter content, total and quick-acting nitrogen, C/N ratio, etc.

***Organic waste management:*** Organic waste management Other organic wastes can also be considered for supplying plant nutrients and/or organic matter, e.g. pressmud from sugarcane, oilcakes, etc. Night soil or (treated) sewage sludge is already in use in some countries, although care should be taken in terms of hygiene and crop and soil quality (polluting agents).

**3. Mineral resources**

Inorganic fertilizers.

**Principles of INM**

INM is based on the following principles:

1. Maximize use of organic materials
2. Judicious use of inorganic fertilizer
3. Minimize losses of plant nutrients

There are no fixed answers with regard to the choice of INM technology, as this depends on various factors such as access to markets, price ratio of inputs and outputs, availability of inputs, alternative use of organic material, labor cost, farmers' knowledge base, etc. However, local adaptation is always necessary. In the following section, these factors will be discussed in relation to the three principles listed above. (FAO uses the term Integrated Plant Nutrition Systems (IPNS) which has very much the same meaning.)

There has been a lot of debate regarding which approach to follow for soil fertility management. Often, there has been a great divide between those favoring low-input agriculture, and those in favor of high-input agriculture. Integrated Nutrient Management avoids to take a dogmatic position, but adopts a flexible approach - realizing that different farmers have different needs, and that there is a great variation in natural resource base and socio-economic conditions.

***Principle 1: Maximize the Use of Organic Material***

Agriculture in the tropics is highly dependent on the release of plant nutrients from soil organic matter and from organic manure. Soil organic matter plays a critical role in maintaining the fertility of the soil by increasing water holding capacity, reducing surface crusting, increasing cation exchange capacity and acting as a buffer against pH changes in the soil.

However, there are also limitations to the use of organic fertilizers, such as:

- Too low quantities are available to meet the requirements of a moderate yield
- Only a limited amount of phosphorus is supplied
- The application of manure is much more labour-intensive, as the N-content of manure is only about 1−4 %, whereas fertilizer N-content is normally in the range of 20−48 %.
- Release of nutrients from organic sources is often not well synchronized in time with plant demand for nutrients

The quality of organic fertilizers differs greatly, and their use should therefore differ accordingly.

***Principle 2: Judicious Use of Inorganic Fertilizer***

Experiences throughout the tropics show that where yields have increased, it has been where fertilizer is used in combination with improved crop varieties. Factors affecting the use of fertilizers are availability;

access to capital; yield response; relative prices of fertilizer and produce; and yield and price risk. Availability is often limited by poorly developed local infrastructure, and thin markets.

Inorganic fertilizers have an immediate effect, and the release of nutrients is often well synchronized with plant growth. Uptake of nutrients from fertilizer is more efficient than from organic sources of fertilizer.

Inorganic fertilizer should be combined with the use of organic materials. This will reduce the acidifying effect of fertilizers, and also improve soil physical characteristics. But relying only on inorganic fertilizer for soil fertility maintenance is not a sustainable practice.

***Principle 3. Minimizing Losses of Plant Nutrients***

Losses of plant nutrients from the agricultural system can be in the form of harvested product, soil erosion, gaseous losses, and leaching. Soil erosion can be in the form of water erosion and wind erosion. Soil erosion does not only remove plant nutrients, but will also reduce topsoil depth and soil water holding capacity. Erosion is a selective process, as the eroded materials contain the finer particles of the soil that are often rich in plant nutrients. But soils differ in their ability to tolerate soil erosion - the effect of soil erosion on crop yield will depend on parameters such as topsoil depth, rooting depth of plants, crops cultivated, distribution of plant nutrient within the soil profile, water-holding capacity of the different soil layers, and the amount and intensity of rainfall. Hence, the term 'soil erosion' indicates very different effects depending on the prevailing conditions.

**Implementation of INM activities**

Different stages of implementation of INM are as follows:
1. Diagnosis phase: collection of background information.
2. Analysis of constraints.
3. Preparing potentiality and feasibility summary.
4. On-farm demonstrations.
5. Evaluation of INM activities.

In the first stage of diagnostic phase information with regard to the following is collected and analyzed:
- Farming/cropping systems,
- Crop varieties grown,
- Awareness about soil fertility problems,
- Use of chemical fertilizers, lime/dolomite and other agro-chemicals,
- Use of organic manure,
- Availability of fertilizer and other inputs,
- Irrigation sources and practices,
- Soil testing service facility.

**Constraints in the adoption of INM technologies**

Constraints in the adoption of INM technologies The INM technologies must be compatible with the local farming system if they are to find acceptance and adoption. Therefore, attention must be paid to examine the interactions among different components of INM and the management of crops and animals that form the farming system.

**Common constraints encountered by the farmers in adoption of INM technology are as follows:**
- Non-availability of FYM
- Difficulties in growing green manure crops
- Non-availability of biofertilizers
- Non-availability of soil testing facilities
- High cost of chemical fertilizers
- Non-availability of water

- Lack of knowledge and poor advisory services
- Non-availability of improved seeds
- Soil conditions
- Non-availability of credit facilities