Food and Agriculture Organization of the United Nations
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What is Integrated Plant Nutrient Management?

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In these guidelines the term IPNM is interpreted in the much broader more holistic sense of “land husbandry”. It thus embraces soil, nutrient, water, crop, and vegetation management practices, tailored to a particular cropping and farming system, undertaken with the aim of improving and sustaining soil fertility and land productivity and reducing environmental degradation. Integrated Plant Nutrient Management aims to optimize the condition of the soil, with regard to its physical, chemical, biological and hydrological properties, for the purpose of enhancing farm productivity, whilst minimizing land degradation. There is now greater awareness that IPNM can, not only provide tangible benefits in terms of higher yields, but simultaneously and almost imperceptibly conserve the soil resource itself. The field level management practices considered under the heading of IPNM would include the use of farmyard manures, natural and mineral fertilizers, soil amendments, crop residues and farm wastes, agroforestry and tillage practices, green manures, cover crops, legumes, intercropping, crop rotations, fallows, irrigation, drainage, plus a variety of other agronomic, vegetative and structural measures designed to conserve both water and soil. The underlying principles on how best to manage soils, nutrients, water, crops and vegetation to improve and sustain soil fertility and land productivity and their processes are derived from the essential soil functions necessary for plant growth. The following are fundamental to the approach outlined in these guidelines:

1. Loss of soil productivity is much more important than the loss of soil itself, thus land degradation should be prevented before it arises, instead of attempting to cure it afterwards - i.e. the focus for IPNM should be on sustaining the productive potential of the soil resource.

2. Soil and plant nutrient management cannot be dealt with in isolation but should be promoted as an integral part of a productive farming system.
3. Under rainfed dryland farming conditions soil moisture availability is the primary limiting factor on crop yields, not soil nutrients as such, hence IPNM requires the adoption of improved rainwater management practices (conservation tillage, tied ridging, etc.), so as to increase the effectiveness of the seasonal rainfall.
4. With declining soil organic matter levels following cultivation, the adoption of improved organic matter management practices are a prerequisite for restoring and maintaining soil productivity (improved soil nutrient levels, soil moisture retention, soil structure and resistance to erosion).

Integrated Plant Nutrient Management at Farm Level

It is only after they have made improvements in the biological, physical and hydrological properties of their soils that farmers can expect to get the full benefits from the supply of additional plant nutrients, in the form of inorganic fertilizer, to their crops. At the farm field level IPNM therefore calls for an integrated and synergistic approach which involves:

- Matching the land use requirements of individual agricultural enterprises with the land qualities present in the areas where they are undertaken - i.e. the biological, chemical and physical properties of the soil, and the local climatic conditions (temperature, rainfall, etc.) ;
- Seeking to improve yields by identifying and overcoming the most limiting factors in order of their diminishing influence on yield;
- Better plant management, especially: (i) improved crop establishment at the beginning of the rains, so as to increase protective ground cover thereby reducing splash erosion, enhancing infiltration and biological activity; and (ii) timely weeding to reduce crop yield losses from competition for nutrients and soil moisture;
- Combinations of complementary crop, livestock and land husbandry practices which maximize additions of organic materials and recycle farm wastes, so as to maintain and enhance soil organic matter levels (ideally at levels of at least 50-75% of those under natural vegetation);
- Land management practices that ensure soil moisture conditions are favourable for the proposed land use (e.g. moisture

harvesting/conservation in low rainfall areas, drainage in high rainfall areas);

- The replenishment of soil nutrients lost by leaching and/or removed in harvested products through an integrated plant nutrition management approach that optimizes the benefits from all possible on- and off-farm sources of plant nutrients (e.g. organic manures, crop residues, rhizobial N-fixation, P and other nutrient uptake through root mycorrizhal fungi infestation, transfer of nutrients released by weathering in the deeper soil layers to the surface via tree roots and leaf litter, rock phosphate, inorganic fertilizer, etc.);
- Combinations of crop, livestock and land husbandry practices that reduce rainfall impact, improve surface infiltration, and reduce the velocity of surface runoff thereby ensuring any soil loss is below the 'tolerable' level for the soil type;
- Conservation tillage, crop rotation, agroforestry and restorative fallow practices that maintain and enhance the soils physical properties through maintaining an open topsoil structure, and breaking any subsoil compacted layer (hoe/plough pan) thereby encouraging root development and rainfall infiltration (e.g. use of ox drawn chisel ploughs, double dug beds, pasture leys, interplanting of deep rooted perennial crops/trees and shrubs);

Good agricultural practices for nutrient management

Integrated plant nutrient management also contributes to pest management (see section on Integrated Pest Management): stressed crops are more susceptible to disease and to the effects of pest attacks. Crops growing in poorly structured soil, under low or unbalanced nutrient conditions or with inadequate water supply or retention will be stressed. Responding to disease or pest attacks by applying pesticides is a costly symptomatic approach to a syndrome which is better addressed by improving the ecological conditions and systems within which the crops are cultivated. In addition, agricultural products with less pesticides residues are less risky to consume, and healthy plants with a properly balanced nutrient supply provide better quality feed and food, improving animal and human health.

Production efficiencies are gained through the integrated nutrient management practices promoting combined use of mineral, organic and biological resources in a reasoned way to balance efficient use of limited/finite resources and ensure ecosystem sustainability against nutrient mining and degradation of soil and water resources. For example, efficient fertiliser use requires that correct quantities be applied (overuse of Nitrogen (N) fertilizer risks disrupting the natural N-cycle), and that the application method minimizes losses to air and/or water. Options exist for incorporating fertilizer into the soil directly (rather than broadcasting). Equally, plant nutrient status during the growing season can be better monitored using leaf-colour charts, and adaptively managing fertilizer application accordingly.

Nutrients are in many ways linked to other practices that are related to sustainable crop production intensification. Nutrient cycling is the main focus of Conservation Agriculture, in which minimum soil disturbance, intercropping, crop rotations and a permanent soil cover minimize the need for chemical fertilizers. Crops with sufficient nutrients are also less susceptible to pests, thus contributing to Integrated Pest Management. High application of fertilizers can increase the occurrence of noxious weeds that compete with crops for nutrients. This means that Integrated Weed Management is promoted by improving the timing, dosing and application method of nutrients and thus minimizing the potential impact on weed growth. A better application of nutrients also reduces runoff, and by this the overall agricultural biodiversity and the pollination services.

Nutrient Management in Crop-Livestock Systems

The management of nutrients is one of the most important, but also complicated issues in crop-livestock systems. Nutrients can come from manure, legumes, and external inputs. A closed cycle – without external inputs - would be ideal from an environmental point of view, but might not always be feasible due to soil constraints, difficulties for growing legumes or other nitrogen fixing crops, or lack of options for spreading the manure around the farm (distance between plots or size of farm). Recycling can be done to effectively use both on-farm and off-farm wastage. For crop and fodder production a combination of mineral and organic fertilizers can be applied from on-farm and off-farm sources. The crop rotations in the crop-livestock systems would preferably also include crops that are beneficial from a nutrient point of view (e.g. legumes). A balanced nutrient level in the soil will contribute to sustainable crop (and livestock) production intensification – this means that a focus should be on farm level, and not on the fertilization of single crops. The focus of farmers should be on the total farm area and on the long-term effect of fertilization. This includes making a shift from static nutrient balances to nutrient flows in cycles.

Since the demand for livestock will inevitably continue to grow over the next decades, it will be very important to deal with this increased production in a sustainable manner. Integrating crop with livestock provides benefits to the environment by created a 'closed'-system for nutrients (see section on **Integrated Crop-Livestock Systems**) and to animal welfare by providing sufficient space for the animals to graze. Whereas the increased production in the past has mainly come from increasing the area for livestock and shifting towards industrial systems, both are facing increasing limitations; the area for expansion is limited and industrial systems are seeing increasing opposition due to the accompanying ethical dilemma caused by the perceived lower animal health and welfare in these systems. Managing crop-livestock systems in a way that they will be environmentally sustainable and have an increased stocking density will be one of the main challenges in agriculture development in the coming decades. This will include improving the livestock breeds and management of feed, land, and water. High pressures of livestock on pasture areas (which are often degraded crop-land), can cause further degradation of land and water resources and create conflicts with other sectors.