MODULE 2.6

Integrated Plant Nutrient Management (IPNM) and Biofertilizers for Watershed Management

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Objectives

- To understand the concept, importance and utility of IPNM and biofertilizers in watershed management (WM)
- To identify components of IPNM and indigenous knowledge
- To understand the constraints and opportunities and the action needed for IPNM development in the context of WM in Asia

Why are IPNM and biofertilizers important in the Asian context?

IPNM and biofertilizers are important because of the following problems.

- Nutrient mining
- Unbalanced use of fertilizers
- Depletion of natural resources
- Soil erosion/nutrient loss
- Decrease in use of organic manure

The most crucial issues facing Asian countries today with regard to raising agricultural productivity by increasing plant nutrients through the use of fertilizers are

- fertilizer use cannot be increased much more because high prices and unavailability make it inaccessible to many farmers; and
- the natural resource base traditionally used for organic manure production has been degraded, and this degradation process cannot be reduced without raising and sustaining yield levels.

However, the demand for plant nutrients continues to increase due to intensification of cropping systems and cultivation of high-yielding varieties. This further accelerates nutrient mining in the soil leading to deficiencies.

Massive soil erosion is a major factor causing loss of soil fertility and plant nutrients. This problem is more acute in hill and mountain regions. Soil loss depends on land use, cropping pattern, terrace type, soil type and rainfall intensity. Results from various studies (ODA-NARC 1995; Carver and Nakarmi 1995; Maskey and Joshy 1991) show that soil erosion has caused the loss of topsoil ranging from 0.1 t/ha/yr to 87 t/ha/yr. As topsoil erodes, associated organic matter and plant nutrients are also lost.

An analysis of this situation reveals that it will be a great mistake to consider the sustainability of soil fertility and agricultural productivity with the use of fertilizers or organic manures alone without understanding the integration of all other related biophysical and socioeconomic factors.

What is the basic concept of IPNM and how is it defined?

The use of mineral fertilizers is an efficient way of increasing crop production. However, their rising cost, unavailability and improper use mean that it is not advisable for farmers to depend only on them alone. Hence a combination of mineral fertilizers with locally available organic and biological sources of plant nutrients is recommended. Such combined application of organic materials benefits the soil by supplying nutrients, improving physical and biological properties, and increasing nutrient and water-retention capacities.

As defined by FAO (1995) the basic concept of integrated plant nutrition management (IPNM) is the maintenance or adjustment of soil fertility and of plant nutrient supply to an optimum level for sustaining the desired crop productivity through the optimisation of the benefits from all possible sources of plant nutrients in an integrated manner. In other words it is an appropriate combination of mineral fertilizers, organic manures, biofertilizers, crop residues, etc, with proper crop rotation, soil conservation and agronomic practices — including water management.

The overall purpose of IPNM, therefore, is to supply and manage the required plant nutrients from different sources on a sustainable basis. In principle, it should embrace a total management plan based on balance sheets within a watershed. Use of fertilizers, manures, biofertilizers, crop residues, legumes, and losses such as leaching, gaseous losses of ammonia, erosional losses, crop removal, etc must be considered. Thus IPNM should focus on the farming system as a whole. We can also say that it is a balance between organic and inorganic fertilizers, traditional and modern technologies, and agriculture and the environment.

What is the importance of IPNM in PIWM and what are the components of IPNM?

The cropping pattern and intensity of land use in a watershed have many on-site and off-site implications for the farmer as well as the community. Farming is usually the most prevalent land use in a watershed followed by forest, rangelands and others. The products from these different land uses are interrelated as the farmer has to manage food, fuel and manure from these systems.

Within a watershed, farmers follow various farming/cropping systems. Each cropping pattern differs in its nutrient requirements within specific biophysical and socioeconomic conditions. The nutrient balance for a particular cropping pattern in a particular watershed may vary depending on farmers' soil and water management interventions and the natural resources' base. Plant nutrients are the basis for maintaining the biodiversity as well as bio-intensity which in turn helps to protect the landscape and conserve natural resources. Supply of required plant nutrients from a single source is impossible in the long run; an integrated nutrient management approach, therefore, plays an important role in watershed management.

Component of Integrated Nutrient Management

Biofertilizers

Biological nitrogen fixation occurs through the medium of bacteria which convert nitrogen from the air freely or in symbiosis with leguminous crops, shrubs or trees or with *Azolla* in wetland conditions. Potential microbial fertilizers are as follow.

Azotobacter: Recommended for cereal crops in the higher hills in association with organic manures. Yield increases of 3-29 per cent are expected. It is not useful in combination with mineral fertilizers.

Rhizobium: Recommended for pasture and grain legumes. A number of effective strains are identified and distributed. Yield increases of 10-70 per cent are expected in legumes. It can have significant residual soil fertility effects on succeeding crops. It is estimated that with legumes—soybean, chickpea, lentil— it derives 50-100 per cent of its requirements from the atmosphere. Division of Soil Sciences, NARC, Nepal distributes about 10,000 packets (200 gm each) of *Rhizobium* inoculant annually.

In India, goverment institutions, universities and private enterprises are involved in the development of bacterial and algal biofertilizers. Efficient nitrogen-fixing strains have been developed. At present about 800 t of rhizobial biofertilizers are produced and distributed. In addition, 15 million ha of rice-land are inoculated with blue-green algae. However, these efforts are still under research and at the pilot-plant stage (Biswas 1994). In the Philippines, microbial biofertilizers are marketed under the name of Bio N (*Azotobacter, Azospirillum*) and Nitrogplus (*Rhizobium*).

Mycorrhiza: In Nepal, work on mycorrhizal inoculants is still at the research stage. However mycorrhizal products are commercialised in India, the Philippines and Thailand. Mycorrhizal cultures are used in cereal and vegetable crops. Mycorrhizae are associations between soil fungi and plant roots. Approximately 126 genera of mycorrhizal fungi have been isolated. The most important species are *Glomus*, *Gigaspora* and *Acaulospora*.

Organic manures: A package on better methods of farmyard manure (FYM) compost preparation, storage and application is available. Also, technology for rapid composting (20-30 days) through the use of fungi *(Trichoderma)* is available. There is ample information on the synergistic effect of combined use of organic manures, fertilizers, and green manuring and fertilizers on various crops. Responses to 5 t/ha poultry manure, 20 t/ha FYM/compost and 100:40:30 kg/ha NPK fertilizer were found comparable. Improvement in quality of compost using various micro-organisms is worth exploring.

Legumes in rotation: Incorporation of legumes into the cropping system is beneficial. It is reported that legumes, at about a yield level of 1 t/ha, can provide a residual 20-40 kg N/ha to succeeding crops depending on the quantity of biomass returned to the soil.

Intercropping of maize with legumes is common practice in the hills of Nepal. However, the introduction of high-yielding varieties of maize and the use of chemical fertilizers mean that intercropping of legumes with maize is decreasing. In some districts, legumes are relayed with maize and, in western Nepal, relaying of lentils with rice is common.

Green manures: 30-60 kg N/ha can be supplemented through green manuring with *Sesbania canabina* in rice crops. Several plants have been identified as potential green manures. *Azolla*, a water fern, can be used where water management is good.

Inorganic fertilizers: Ample information has been generated in fertilizer use and crop responses. Increased fertilizer efficiency through integration with organic sources, balanced use, better methods of application and soil amendments should be given priority. Fertilizer recommendations for the major crops of Nepal on the basis of crop responses and soil analysis are given in Table 1.

Indigenous knowledge in INM

Farmers in Asia follow a number indigenous integrated plant nutrient practices for reducing soil erosion and maintaining soil fertility. Some of them are listed as in the following passage.

For soil fertility maintenance

- FYM/compost application
- Green manuring
- Terracing and slicing of terrace risers
- Flood water diversion to rice fields
- Inclusion of legumes in the cropping systems
- Slash and burn in shifting cultivation

For reducing soil erosion

- Terracing
- Retaining wall
- Intercropping
- Growing fodder tree on terrace riser
- Zero tillage soil management
- Intercultural operation
- Maintaining grass fields

Most farmers now use mineral fertilizers since traditional practices alone do not increase crop yields to meet their expectations.

What are the main constraints and opportunities in the application of INM?

The following are the main constraints (Pandey, 1995) limiting the implementation of IPNM at farm level.

- Already depleted natural resource base due to deforestation.
- Lack of institutions to regulate the production, supply and distribution of IPNS inputs.
- Lack of well-defined policies and plans of action.
- Lack of appropriate extension methods.
- Lack of adequate research information.
- Laborious and time-comsuming technology.
- Lack of appropriate and well-defined land-use policy.
- Increased compulsion to burn dung for household fuel purposes.

These constraints can be changed by making use of the following opportunities.

- Improvement of composting technology
- Utilisation of farmers' indigenous knowledge

Table 1: Fertilizer Recommendations for the Major Crops of Nepal

Crop variety	Optimum dose (kg/ha)			Expected yield (kg/ha)
	N	P^2O^5	K^2O	
Rice				
- Improved	100	30	30	3,811
Local	40	20	30	2,541
Wheat				
Improved	100	40	30	3,287
Maize				
- Improved	120	50	40	3,359
Barley				
- Improved	60	30	30	2,479
Sugarcane				
- Improved	120	60	60	65,300
Jute				
- Improved	60	30	40	3,231

- Promotion of high-value crops
- Promotion of agroforestry (fodder tree crops) and methane gas plants
- Promotion of soil and water conservation practices in agricultural lands

Conclusions and recommendations

It is recommended that future soil fertility improvement programmes should be oriented to IPNM with the following initiatives and approaches.

- Building on indigenous knowledge and skills
- Increasing farm incomes
- Reducing soil erosion
- Supporting biomass regeneration and livestock development
- Incorporating legumes into the farming system
- Increasing water availability
- Optimising external inputs such as fertilizers
- Improving compost quality
- Exploring and promoting production of organic fertilizers on a commercial scale
- Increasing nutrient-use efficiency
- Maintaining/enhancing agricultural productivity as well as environmental stability
- Agro-ecological zone model sites should be established for farmers' participatory innovations, verifications, training and demonstration of integrated soil fertility and plant nutrition management practices.
- IPNM trials/demonstrations should be designed to assess the plant nutrition balance sheet of dominant farming systems.
- Farmers should be motivated and organized to promote biomass-centred, local-resource-based and regenerative soil fertility management practices in combination with mineral fertilizers.

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