

CHAPTER 3

Integrated Use of Organic Manures and Chemical Fertilizers and Principles



INTEGRATED USE OF ORGANIC MANURES AND CHEMICAL FERTILIZERS AND PRINCIPLES

This chapter is on Integrated Plant Nutrition Systems (IPNS) and concerns with its definition and its objectives. Practices of IPNS by farmers and pros and cons of using chemical fertilizer and organic manure, IPNS versus organic farming are also dealt. Socio-economics of IPNS, its impact on the environment, limitations of organic manure use, its practice in different cropping systems and the constraints of its practices in Sri Lanka are also discussed.

It is expected to achieve the following broad objectives

1. To know the meaning of Integrated Plant Nutrition and objectives of IPNS.
2. To know what went wrong with chemical fertilizer use.
3. To compare the use of chemical fertilizers with the use organic manure.
4. To familiarise with organic manure application and to know limitations.
5. To provide knowledge on organic farming against IPNS, managing nutrient balance in IPNS, socio-economics of IPNS and its impact on the environment.
6. To know IPNS practices for different cropping systems and drawbacks of IPNS in Sri Lanka.

INTEGRATED PLANT NUTRITION SYSTEMS (IPNS)

Definition of IPNS

- Integrated Plant Nutrition System is a holistic approach to plant nutrition by obtaining the nutrients from both inorganic and organic sources to maintain and sustain soil fertility and enhance crop productivity in a framework of an ecologically compatible, socially acceptable and economically viable situation.

Need for integrated use

- Organic manures sustain soil fertility at a low level of production.
- Chemical fertilizers have concentrated forms of nutrients. Application results in leaching, fixation and build-up of certain nutrients at the expense of others, resulting in nutrient imbalances.
- Fertilizer use efficiency (FUE) is low in all chemical fertilizers and organic manure when used singularly.
- Combined use of organic manures and chemical fertilizers increases FUE

Objectives of IPNS

- Increasing the fertilizer use efficiency.
- Increasing the return to investment on fertilizers.
- To use a balanced system of crop nutrition management.
- To account for the different amounts of plant nutrients, in a budget sheet giving the following:

1. Available in the soil.
2. Available from organic sources.
3. Available in crop residues.
4. Derived from biological fixation.
5. Derived from fertilizers and their residual effects.

When preparing a budget, a whole cropping system is looked into than a singular crop, over a long term.

What has gone wrong in fertilizer use?

- Before chemical fertilizers were introduced, organic forms were used.
- Green manures, crop residues and FYM were used in large quantities.
- A season of farming was followed by a fallow period for replenishment of soil fertility.
- Chemical fertilizers supplied sufficient plant nutrients for obtaining high yields. These fertilizers did not provide the crop requirement of all nutrients.
- The continuous use of chemical fertilizers destroyed the soil structure, turned the soil acidic and brought about nutrient imbalances resulting in nutrient interactions.
- The organic matter in the soil did not improve with application of chemical fertilizers resulting in erosion and loss of top soil.
- The yield increases obtained during the early years of chemical fertilizer use evened out and addition of extra fertilizers did not bring the desired benefits.

Farmer practices of IPNS

- Vegetables, potato and green leafy vegetables are cultivated using both organic and chemical fertilizers.
- Here farmers obtain higher yields than farmers using either chemical fertilizers or organic manures.
- Extension of this practice to other crops has resulted in increases of yield and sustainability of production at a higher level.

Chemical fertilizers or organic manures

- To sustain crop yields, the rate of removal has to be balanced by added amounts. Use of chemical fertilizers is necessary for supplying the nutrient requirement but without recycling of crop residues, yields will suffer.
- If only organic manure is used land will benefit but yield will be lower.
- Availability of nutrients from organic manure is slow but long lasting.
- Use of organic manure improves the physical, chemical and biological conditions of the soil.
- Singular use of chemical fertilizers has an adverse effect on the soil structure. If the organic matter is low the bulk density increases.
- Use of chemical fertilizers along with organic manure gives a soil rich in nutrients with good physical and microbiological properties. This will increase the availability of nutrients.

- Application of organic manure results in formation of water stable aggregates which could resist erosion.
- Combined use of chemical and organic fertilizers increases cation retention and improves nutrient availability.
- Addition of manure widens the C:N ratio in soil. Singular use of chemical fertilizers narrows this ratio.
- Addition of mineral N fertilizers results in instant increases of N but organic manures increases the available N.
- Fixation of fertilizer P could be reduced and effectiveness of fertilizer K can be increased when chemical fertilizer is combined with organic manures.
- High analysis fertilizers have low contents of micronutrients, but combined use with organic manure makes these nutrients available to plants.
- Combined use of manure and chemical fertilizers results in higher return to investment and better cost-benefit ratios.
- Thus it is beneficial to use both manure and chemical fertilizers for crop production.
- Obtaining green manure continuously from trees results in removal of plant nutrients from soils, which are not easily replenished. This results in poor growth of the green manure trees itself, which could result in a short fall of supply of the material. Thus a limitation to resource management occurs.
- Organic farming maintains the productivity at a low level. Where demand for food is becoming more increasing organic farming *per se* cannot meet the required demand.
- Plants obtain nutrient sources in the ionic form. Whether they come from organic or inorganic forms, the type of ions is the same.
- It is best to combine the use of both manure and mineral fertilizers rather than manage the singular use of manure.

Managing a nutrient balance in IPNS

Organic farming or IPNS?

- Organic farming systems do not use any synthetic form of plant nutrient. It also avoids the use of pesticides and weedicides. Organic manure of animal origin should not have artificial ingredients fed to animals and animals should not be treated with antibiotics or steroids as growth promoters.
- IPNS attempts to keep a balance between crop removal and nutrient addition to the soil. In this respect a book keeping exercise has to begin with the first step of how much the soil already has.
- Soil analysis for evaluating the nutrient availability and its limitations that could reduce the productivity, has to be done at the beginning.
- The yield goal of the cropping system of single or multiple crops that would be grown over time (say one year) has to be evaluated to arrive at the nutrient removal.

- The quantity of mineral fertilizers to be applied has to be decided on soil test values for P and K.
- The addition of organic manures to supplement the requirement of the minor and micronutrients has to be evaluated.
- Nitrogenous fertilizers to be used on crop demand rather than on blanket recommendations has to be practised.
- Limitations to FUE by drought, surface erosion, poor drainage are to be avoided.
- Correct application practices in basal and top dressing applications of both organic and chemical fertilizer have to be adopted.
- Crop residues have to be recycled to supplement the nutrient pool of the cropping system.
- If legumes are included in the cropping system, credit has to be given for possible biological nitrogen fixation (BNF).
- Organic manure for many farmers is not available in their own holdings. The holding size often limits animal husbandry. Transported material is too expensive and transport to the farm is laborious.
- Chemical fertilizers are easily available and literature on their use is more comprehensive. Organic manure and crop residue management has not been given the same importance.
- Use of FYM, poultry litter and other animal wastes is popular among farmers. But sewage, sludge and urban compost are not popular among them.
- Financial credit is available only for mineral fertilizers. There is no organized credit system to help the farmers to use organic manure and crop residues.
- Chemical fertilizer market is controlled with a standard product but organic manure is sold without any standards.
- Storage and retail marketing of organic manure is limited. It is not easily accessible to most farmers.
- Farmers who have domesticated animals do not have facilities to collect, store and market the animal waste.
- The scope for IPNS is limited to a few high value crops in the present circumstances. Farmers growing these crops may be encouraged to follow IPNS. However, a large number who have access to organic manure do not use them.

Socio economic side of IPNS - Scope and limitations

- Any IPNS practice has to be economically sound and socially acceptable. Organic manure should be available easily in acceptable forms and types.
- Crop residues are often burnt instead of recycling. Scarcity of labour, and the time gap between two crops may limit the use.

IPNS and the environment

- Chemical fertilizers are considered to be environmental pollutants. Nitrogen fertilizers when used in excess can be leached or washed through erosion into waterways and reservoirs. Eutrophication of reservoirs have been reported from time to time.
- Nitrogenous compounds in organic manures too are converted to nitrates. Any excessive use and leaching could bring the same environmental hazard as using excessive amounts of urea or ammonium sulphate.
- Nitrogen fertilizers can acidify soils, but when used with organic manure can buffer acid formation to a certain degree.
- Liming can change the pH and improve CEC. Liming can be a corrective measure to improve the crop environment.
- Excessive build-up of P and K in soils results in nutrient interactions. In high P built-up soils, both zinc and copper availability can be a problem. At high levels of K in the soil, magnesium becomes limiting. By following IPNS these excesses can be cushioned.
- Excessive use of organic manures can limit the availability of copper as the latter is lost through leaching. Following IPNS will benefit the situation.
- Combined IPNS, benefits the development of soil structure and reduces erosion hazards.

- IPNS practices produce more healthy plants which minimizes the necessity to use pesticides and fungicides, which are harmful to the environment.
- Excessive nitrate leaching into groundwater and drinking water is harmful. IPNS can increase the anion retention when mineral and organic fertilizer is used together.
- Ploughing and land preparation is easy on lands following IPNS. Ploughing deep to expose the sub-surface soil does not arise in these lands.

IPNS and fertilizer use efficiency

Chemical fertilizer in the form of salts, when added to soils gets converted into ionic forms after dissolving in the soil solution. Substances like urea under go extra cellular enzymatic decomposition to form ammonium compounds, which are either absorbed by the plant roots or converted to nitrates, which are absorbed or lost in leaching or converted to gases in the N cycle.

Organic manure produces organic acids (humic acid) which have the capability of holding cations and anions. Soils rich in organic matter can hold more cations than otherwise. Ammonium ion like other cations can be adsorbed to organic acid molecules after replacing H. This adsorption helps to release the cations slowly to the plants. If not for the organic molecules certain chemicals reactions can make most nutrients unavailable to the plants.

Most plant nutrients are available at certain pH ranges. Addition of organic manures can buffer pH, making more materials available to plants. Soil organic matter has a high CEC values and CEC is pH dependent. If liming is done to increase pH then the CEC will also increase. The CEC from organic manure is temporary.

Organic manure application and limitations

- Organic manures are of plant and animal origin.
- Plant materials have easily and slowly biodegradable materials. The variety, age and plant part determine the composition and the quickness of decomposition.
- Younger leaves and tender stems have more water, more N and less other minerals and decompose faster. Matured leaves and stems have more cellulose containing material, which takes a longer time to decompose.
- Crop residues such as straw have mature tissues with high C:N ratio. They take a longer time to decompose. Direct application will cause the temporary immobilization of soil N.
- Animal wastes have more N than plant parts. They decompose faster than plant materials. Application of N rich materials like blood meal will result in losses of N through volatilization.
- Composted material is suitable for direct application. But exposure of such materials to the elements results in nutrient losses through leaching.
- Care should be taken in using urban compost made out of sewage materials and industrial wastes. Such materials could contain both pathogenic microbes and heavy metals.
- Heavy metals such as cadmium, arsenic, lead and mercury are toxic to environment. These heavy metals are known to accumulate in the body.
- Organic manure decomposes faster in the soil. A crop residue takes one to two weeks to decompose depending on the moisture content of the soil and the type of material. Manure of animal origin decomposes within a few days.
- Application of organic manure should be timed in such a way to get the maximum benefits both in terms of plant nutrient supply and the addition of the carbon source.
- Incorporation to the soil is better than leaving at the surface. Some farmers give top dressings of well-decomposed manure, to crops.
- Poultry litter should not be applied immediately before seeding or transplanting as the ammonia gas released may increase the pH and kill the plants.
- Well-dried organic manure can be kept for a few months in polyvinyl bags.
- Liming should be done before adding organic manure in order to conserve N.

- Organic manure application to ill-drained soils could result in the formation of toxic compounds; particularly if the material is rich in sulphur.
- Recent findings indicate that rice straw can be added to bog soils. The silica content of the straw benefits the soils.

INTRODUCTION TO IPNS PRACTICES FOR CROPS AND CROPPING SYSTEMS

Suitable organic materials for IPNS

Many materials that are organic in nature are suitable for IPNS. Materials that can be used are classified into:

- i. Plant residues - Crop residues
Green manure
- ii. Animal wastes - Animal manure
Slaughter house wastes.
- iii. Compost - Consists of both plant and animal materials which are wastes which also includes city garbage.

Crop residues

Rice straw, corn stover and vegetable residues can be applied directly or after composting. Direct application is cumbersome and due to high C:N ratio of the materials, it takes a longer time to decompose in the soil.

Green manure

Are of two types

- Which are grown *in situ* and ploughed into the soil.
- Lopped leaves and tender stems which are applied to the soil.

Grown insitu

Plants like *Crotalaria juncea* and *Sesbania rostrata* can be grown before establishing crops and ploughed in at flowering during land preparation. Soils with low content soil organic matter will lose more carbon if N high green manure is used.

Animal wastse

- Animal dung and urine of large animals found mixed with bedding and feed stuff are used as farm yard manure (FYM). Poultry litter can be used both as a basal and top dressing. The material content of the FYM and litter varies considerably depending on many factors.
- Slaughter house wastes and fish meal are not available in Sri Lanka in large amounts due to poor collecting facilities. If collected and treated properly it could become an important source of organic manure.

City wastes

City garbage can be composted and used. It is high in extraneous materials like silica but is a useful material if properly composted. It can be used for floriculture and fruit culture in places close to cities.

Above materials are available for IPNS. The quantities that may be ideal for application would be comparatively larger than the rates of chemical fertilizer. But it is important to add any available amount of organic material available at appropriate times.

Some IPNS practices followed in Sri Lanka

Rice-Rice Cropping Systems

- Straw recycling is followed. The straw left behind after the previous crop is added to the next crop at recommended rates. Over 12-15% increases in yield are obtained.
- Supplementing straw recycling with cowdung at 2 t per ha. has increased the yields to 7.0-8.5 t per ha. This yield could be sustained through continuous application.
- Farmers of Matara district add 1-1.5 t of poultry litter per acre and 20%-40% yield increases have been reported.
- Farmers who use mineral fertilizers along with cowdung at 2t per/ac., green manure and burnt husk have given 10-10.5 t per/ha . These yields can be sustained through continuous application.

Rice – Other Field Crops (OFC) Cropping Systems

- Rice straw is added as mulch for chilli, onion, and vegetable crops. Addition of organic manure in the form of cowdung, goat dung or poultry litter is practised.

- Higher yields and less crop damage due to pests are reported.

Other Field Crops (OFC) - Food Crops Cropping Systems

- Chilli and onion farmers extensively practice the combined use of mineral fertilizers and organic manure.
- The farmers who have used larger quantities get better yields and quality crops.
- Farmers who have practised the addition of cowdung to irrigated and fertilized kurakkan have obtained yields of 1800-2000 kg. per acre in the Moneragala district.

Vegetable – Vegetable Cropping Systems

- Up country farmers often over use both mineral fertilizers and organic manures. Amounts of 30-40 t/ha of Farmyard manure (FYM) are used with three to four times the recommended rates of mineral fertilizers.
- Farmers who cultivate 'Keera' vegetables - use FYM, poultry litter and even pig dung to supplement the mineral fertilizers.
- Most farmers who venture into commercial vegetable production, use organic-inorganic fertilizer combinations. By this they get high yields than farmers who use only one of them.
- Farmers who cultivate 'Innala' use organic – inorganic fertilizer combinations.

Other crops

- 'Kiriāla', pineapple and banana crops are generally cultivated using mineral fertilizers. Farmers who have used organic sources in addition to mineral fertilizers have obtained better yields and quality products.
- Farmers growing ginger at commercial level follow IPNS to obtain higher yields.

Some shortcomings of IPNS practices in Sri Lanka

- Farmers following straw recycling in rice-rice cropping systems skip a few seasons-due to socio economic reasons. By this, the necessary fertility build-up is retarded.
- Some farmers expect a overnight yield increases through straw recycling after the first season of application. Not finding this, some give up.

- Straw is generally not applied to rice-fallow systems.
- No importance is given to the recycling of crop stover of maize, chilli, onion etc. This depletes the organic carbon in the soil.
- Certain vegetable farmers build up man made soil profiles by bringing new earth to fill the top soil.
- Farmers who go for high intensive vegetable production often apply micronutrient solutions as foliar applications. The imbalance of plant nutrition may have necessitated them to do so.
- Fertilizer practices carried out on sandy regosols of Kalpitiya have shown groundwater pollution. The overuse of N fertilizers has contributed to this. Addition of organic manure may not be the best way to reduce pollution. A more nutrient efficient FUE approach has to be followed.

Assignments

1. Study the present adoption of IPNS in your area in different crops and cropping systems.
2. List main sources of plant nutrients applied by farmers in your area.